A roadmap to double ENERGY PRODUCTIVITY
in Agriculture
by 2030

AUTHORSHIP OF THIS ROADMAP

This roadmap is published by the Australian Alliance for Energy Productivity (A2EP) and was developed by an expert agriculture working group comprising representatives of agriculture industry associations and researchers. The 2xEP program is led by a steering committee comprised of leaders from business, industry associations, research organisations and the non-government sector. A2EP supports the steering committee to promote the program to government, support the implementation of measures, and monitor and report on progress towards the objective - doubling energy productivity by 2030. The roadmap will continue to be developed into a platform that a wide range of agricultural organisations and businesses will be invited to support. A2EP would like to thank members of the 2xEP agriculture working group for their generous, considered and vital contributions.

ACKNOWLEDGEMENTS

A2EP acknowledges the Commonwealth Department of Industry Innovation and Science for the provision of financial support towards development of the agriculture sector overview and roadmap. Note: this support does not indicate agency endorsement of the content or recommendations included in this report.

The views expressed in this text are those of A2EP and not necessarily those of our collaborators, supporters and partners. All responsibility for the text rests with us.

Level 11, UTS Building 10, 235 Jones Street, Ultimo, NSW 2007, Australia
email: info@a2se.org.au phone: 02 9514 4948
web: a2se.org.au, 2xep.org.au ABN: 39 137 603 993

Executive summary

The 2xEP program seeks to lift the overall economic productivity of agriculture and the agricultural value chain through a focus on energy. Our aspiration is to double energy productivity across the Australian economy by 2030, from 2010 levels. Agriculture, agribusiness, food and fibre have a vibrant future in Australia. Steps can be taken to optimise energy use, innovate in supply and demand, maximise yield and and increase profitability.

To achieve these goals it is important to understand the farming systems within the industry and to accept that there is no 'one-size-fits-all' strategy that could be implemented generically across firms and farms.

Australian agriculture is a complex sector comprised of over 128,000 businesses managing 411 million hectares in 32 agricultural production zones, which have 16 FAO[1] soil groups overlaid with 10 distinct agro-climatic zones. The food and fibre produced within these regions include 10 broadacre crops (including cereals, pulses and oilseed crops), intensive plant industries such as sugar and nurseries, cut flowers, cultivated turf and 24 major fruits, vegetables and nuts and 7 major extensive and intensive animal groups (including cattle, sheep, poultry and pigs) (ABARE., 2013). Each farm employs an average workforce of 2.29 people (National Farmers Federation, 2016) — a workforce largely focused on production-related issues, leaving a short fall in farm development capacity.

Measuring energy productivity

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 approach used in the 2xEP program to develop a preliminary estimate of the scale of the task involved in doubling Australia's energy productivity by 2030 is presented below:

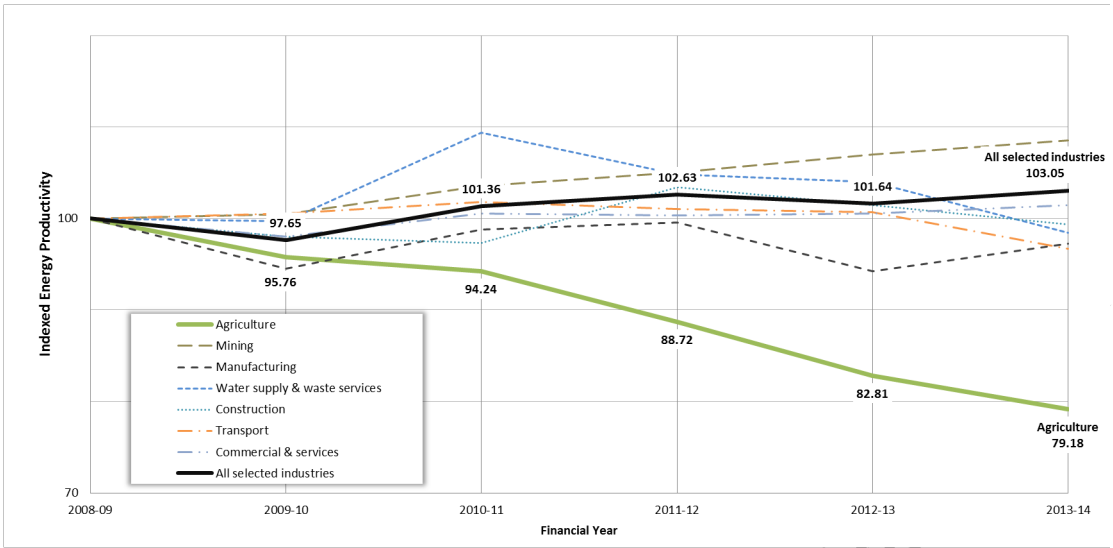
$$Energy\ Productivity\ = \frac{Real\ GDP\ (2010Aus\$)}{Primary\ Energy\ Consumption\ \ (GJ)}$$

The problem - Energy productivity in agriculture

Despite investments in energy efficiency, the energy productivity of Australia agriculture is declining – more than 21% since 2008 (Eyre, 2016). This decline is due to a steady increase in diesel consumption (the dominant energy source in agriculture) with no compensating increase in the value of production. Doubling agricultural energy productivity through 2xEP depends, therefore, both on increasing diesel efficiency and also, we argue, substituting diesel with electricity and renewable energy sources. This substitution cannot happen under present

[1] Food and Agriculture Organization of the United Nations, http://www.fao.org/soils-portal/soil-survey/soil-classification/world-reference-base/en/

electricity policy and network charges, and would rely on a rationalisation of electricity pricing and a more strategic deployment of renewable generation.



There may be a perception in some sectors of government that the key to energy productivity in agriculture is extension and attitudinal change. While extension and demonstration are important with regard to the commercialisation and adoption of solutions, the working group believes that the central barriers are structural and can only be addressed via innovative policy, and the systematic identification of synergies across infrastructure, planning, water and transportation, environment and regional development portfolios. Individual enterprises, agricultural cooperatives and irrigation corporations understand the cost of energy and are highly motivated to reduce exposure to energy-related business risk. They are looking to adopt renewable generation and participate in localised energy supply and load shifting solutions. They need financially viable solutions and supportive government policy, however, to make progress in these areas.

Within an effective policy and programmatic framework, energy savings of 20% or more are achievable through farm vehicle fuel efficiency in broadacre industries, electricity use in intensive farm operations such as horticulture and dairy, and in irrigated sugar and cotton systems. There are also significant opportunities for the strategic deployment of renewable energy technologies. Of equal importance is the fact that farm energy efficiency goes hand in hand with the deployment of broader efficiency technologies that improve water, soil, fertiliser and agrichemical productivity. A major barrier to energy productivity improvement in agriculture is the lack of comparative information on energy use and performance: information is currently only collected at a national level. Farm level benchmarking information across major energy loads such as farm vehicles and irrigation pumping is crucial to inform future policy and program delivery, and industry investment.

Producers stand to gain significantly from an energy productivity agenda, as would the entire food and fibre value chain. Whilst many farm enterprises already include processing, packing, distribution and marketing functions, a more pro-active approach by the agriculture sector can unlock further business opportunities along the value chain, up- and downstream, in areas such as waste management, transport logistics and demand side response.

2xEP target

The roadmap will guide government and challenge our agricultural industries to reverse the current situation of declining energy productivity. A successful outcome from the A2EP 2xEP Roadmap process will be a realistic but challenging energy productivity target in agriculture for 2030 (from the 2010 baseline). The plan developed for agriculture requires support from a broad spectrum of our industry stakeholders, who must each take a role in assisting change in the sector. The roadmap requires significant policy support at a national, state and local level to ensure inefficiencies from markets such as electricity do not take away the productivity gains made within the agriculture sector.

2xEP is a purely voluntary target for agriculture. It is a stretch target that will require significant changes in farming systems, attitudes and practices, and the adoption of technological innovations aimed at energy productivity. Against this background, the 2xEP initiative asserts that agriculture can make a major contribution to the general aim of doubling Australia's energy productivity by 2030. The following points justify the 2xEP target:

- 2xEP is the minimum level of energy productivity improvement that will at least maintain our energy productivity in the future.
- The doubling target ensures that we don't focus on incremental improvement and skip tougher step changes (including major infrastructure investments) required to restore our competitiveness. It provides a common goal, guiding the alignment of policies, strategies and, ultimately, resources to execute plans.
- Innovation and technology improvement will make a significant contribution to energy productivity. Our strategy needs to facilitate development and transfer of these technologies into the Australian market.
- Improvements in big data will assist all farmers, industry stakeholders and government to coordinate the achievement of best practice. A 15-year target period to 2030 allows implementation of best practice technology during the business as usual (BAU) cycle of farm equipment replacement.
- An energy productivity target provides greater scope for improvement than an energy efficiency target, and some improvement will be driven simply by growth in the value of output over time. Modelling indicates that energy productivity projects generate total benefits typically two and one-half times the energy savings.
- 2xEP aligns with the voluntary target that has been adopted in the USA. In June 2015 the 'Global Alliance for Energy Productivity' (GAEP) was established to extend 2xEP aspirations to India, China and Europe.

Summary of measures for the agriculture sector

Measures are not ranked in priority order. Measures to accelerate investment in energy productive technology under item 3, 4 and 8 are critically important and available for immediate implementation. Measure 2 is also critical but reliant upon data collected through from measure 5. A detailed analysis for these initiatives can be found in Section 7.

Initiatives for the agriculture sector and governments jointly

1. Conduct a thorough review of 'farm to plate' energy productivity opportunities along the entire supply chain;
2. Build on-farm capacity to deliver energy productivity improvements with an emphasis on farm-use and supply chain diesel;
3. Develop sustainable value chain precincts incorporating renewable energy, advanced manufacturing and logistics;
4. Develop a national energy and water productivity program that aligns water policy with energy policy and enables adoption of water efficient irrigation technology;
5. Deliver practical and relevant agriculture-specific energy productivity information including benchmarking data across production systems and energy solutions;
6. Deploy on-farm digital technology to optimise energy use and generate data needed to inform energy efficiency improvement;
7. Accelerate investment in energy productivity technologies, including through an effective, nationally consistent energy efficiency certificate trading scheme
8. Establish a voluntary commitment and recognition program for businesses in the sector – the '2xEP Challenge';

Initiatives for governments and policy-makers

9. Reduce risk of early adoption of new technologies and practices for improving energy productivity through enhanced research, development and demonstration;
10. Extend energy performance standards for on-farm equipment and require vendors to provide access to data streams generated by the equipment they sell;
11. Develop efficient and effective energy markets that serve the interests of consumers, price fairly, facilitate innovation and reward investment;

Initiatives for the agriculture sector

12. Build on the existing role of agriculture industry associations in delivering integrated energy innovation information, demonstration and extension services.

In December 2015, the COAG Energy Council (including Commonwealth, state and territory energy ministers) approved a framework for energy productivity – the National Energy Productivity Plan (NEPP) — with a 40% energy productivity improvement target during 2015–2030. This remains a difficult target for agriculture, given the current decline in energy

productivity. This should not deter our stakeholders from striving to achieve this target in view of the importance of energy to our industry.

The 2xEP steering committee and agriculture working-group congratulate COAG on this initiative, and see the NEPP as a valuable framework for change. We are pleased that there is support from all major parties for such energy productivity measures, and we seek to gain long term commitments from governments to ensure the rapid implementation and long term continuity of NEPP measures.

This roadmap will promote leadership in agriculture, and recommended government measures should be considered for incorporation in the NEPP (and by states in their policies where measures fall under state jurisdiction). The agriculture sector also wants to see governments take action to address energy prices, encourage competitiveness and rebuild confidence in markets. The existing NEPP framework references many of these actions.

Contents

Tables

Equations

Figures

1. The purpose and limitations of this roadmap

The 2xEP Agriculture Roadmap is an important initiative that outlines the path to turn around declining energy productivity for many agricultural industries. The agriculture roadmap is one of six roadmaps covering each of the major energy-using sectors of the Australian economy, all of which involve joint investment from government and industry. The 2xEP Roadmaps for agriculture, built environment, manufacturing, mining, transport (freight) and transport (passenger) should not be seen in isolation, but as a joint pathway for all Australian business to improve their energy productivity.

Most businesses, including the majority of agricultural businesses, operate within more than one of the ANZSIC sectors. For example, there will be recommendations and initiatives from the manufacturing and transport (freight) roadmaps that would have an impact on the ability of the agricultural sector to reach the set target. Initiatives recommended across the six roadmaps should be coordinated to ensure cross industry initiatives are aligned to create synergistic, win-win relationship for our businesses. It is imperative that productivity gains in agriculture are not eroded due to realignment of costs in other sectors, nor should productivity gains in other sectors be deleterious to our agricultural industries.

It is important that this joint investment be underpinned with coordinated national, state and local government policy. This policy should create a framework that rewards energy efficiency, supports research and development and ensures the industries have the tools and infrastructure to underpin this growth.

A key feature of the 2xEP Agriculture Roadmap development has been the engagement with national, state and local bodies. The working group comprised representatives from peak industry bodies across Australia, who are actively working with agricultural enterprises to address the profound problems associated with energy productivity in the sector. A key challenge is the complexity of the agricultural value chain and the diversity of business models involved. Agricultural firms range from small family farms to vertically integrated transnationals, operating sophisticated supply chain and marketing infrastructure. A whole value chain approach is required for agriculture to achieve the 2xEP 2030 target.

The energy productivity metric within agriculture is sensitive to both commodity and energy prices which, in the case of agriculture, are sensitive to factors beyond the control of agricultural enterprises such as currency exchange rates and the seasonal conditions. Consequently, simply maintaining levels of energy productivity during periods of adverse weather or low 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. Industry experts have identified a lack of level 2 and level 3 energy audits, audits which could provide guidance to energy efficiency improvements. Level 1 audits are relatively simple as the industry has diesel consumption information through the diesel fuel tax credit scheme and only a small number of electricity provider's service rural and regional areas. In the main, however, current audit-driven approaches to energy analysis are inefficient and ineffective.

The agriculture reference panel has identified the need for industry controlled integrated energy data collection, management and benchmarking solutions that give producers access to high density data around farm vehicle and pump performance.

As part of this, the sector is seeking integrated provision of real time electricity consumption data from retailers for benchmarking and optimisation modelling purposes, and means by which heavy vehicle vendors can provide integrated access to vehicle performance data streams.

In this regard, NSW Farmers is working with CSIRO and CISCO to explore the potential of data automation and telemetry to aggregate energy performance data. Such data in anonymised form would be a key input to both achieving and monitoring performance against energy productivity targets.

2. Competitiveness challenges for agriculture and justification for 2xEP

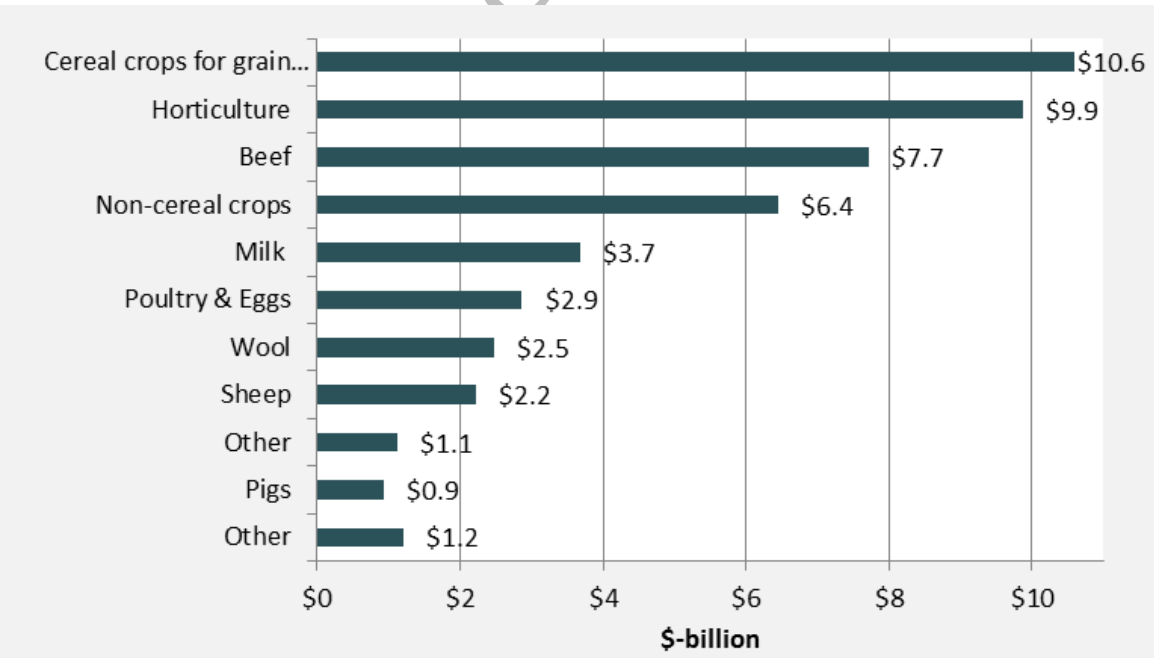
Significance of the sector in the Australian economy and energy market

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 are 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 to 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 and grazing cattle and sheep. 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-cereal[2] crops and milk account for approximately 80% of the value of agricultural commodities produced (Australian Bureau of Statistics, 2014c).

Figure 1: Gross value of agricultural commodities produced, Australia (2012–13)



Competitiveness, productivity and energy use in the Australian agriculture sector

[2] This includes cotton lint, peanuts, canola, sugar cane and other pulses and oilseeds.

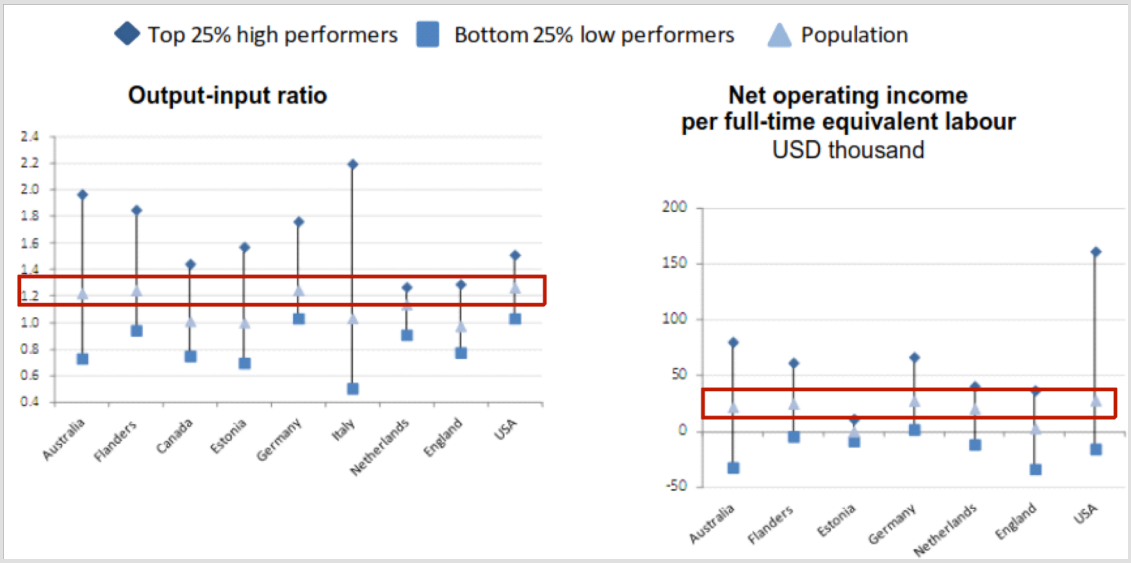
Over the last 200 years, Australian farmers have been adaptive, resilient and inventive with production methods. Production has become more sophisticated, which has enabled the achievement of substantial productivity growth over the past 50 years. Notably, major grain crops have been increasing in yield 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 1 below – the top 25% of Australian farms ranked second (Kimura & Le Thi, 2013) in the OECD of 34 countries.

Box 1: 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 OEDC 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.

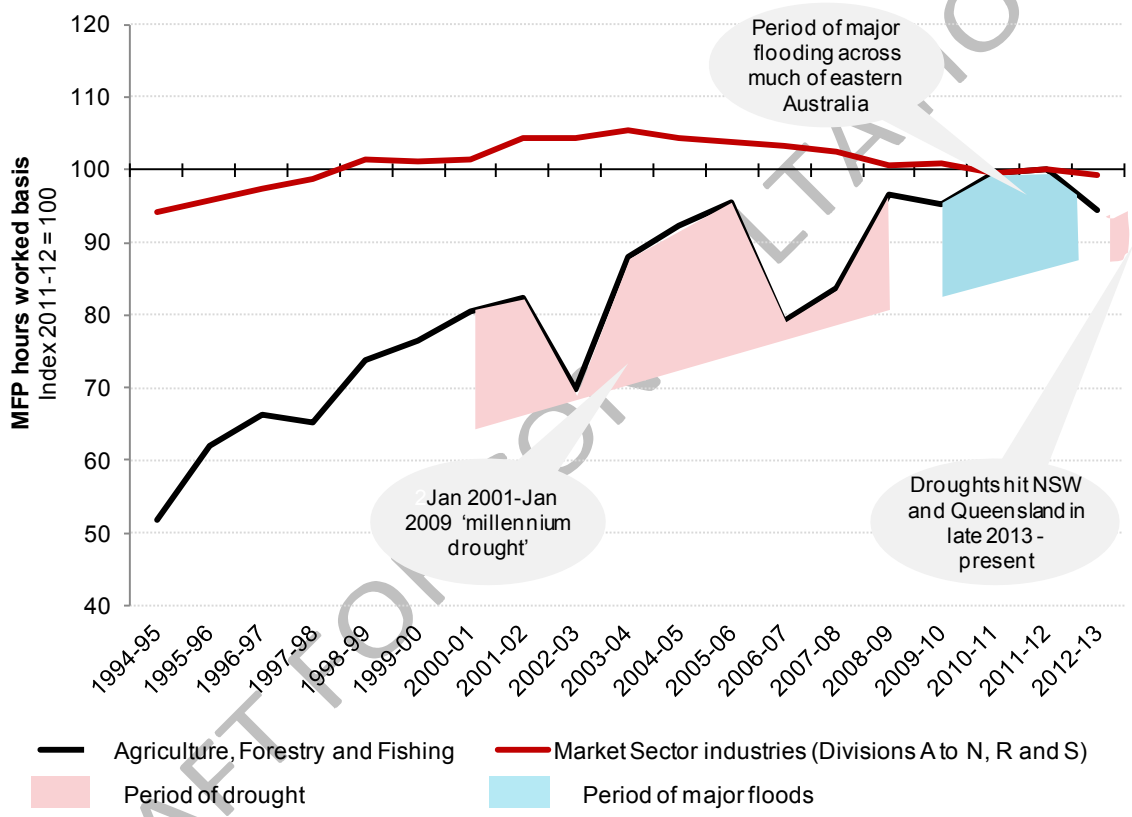


Today, Australia boasts the highest adoption rate of conservation agriculture principles worldwide. The principles of diverse rotations, reduced- or no-till systems and the maintenance of surface cover make good sense in extensive, mechanised, rain-fed cropping systems on erosion-prone, structurally 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,[3] and nearly doubling its MFP since 1994–95 as illustrated in Figure 2, 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 2: MFP trend of the Australian agricultural, forestry and fisheries industry



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).

[3] This includes Divisions A: Agriculture, Forestry and Fishing, B: Mining, C: Manufacturing, D: Electricity, Gas, Water and Waste Services, E: Construction, F: Wholesale Trade, G: Retail Trade, H: Accommodation and Food Services, I: Transport, Postal and Warehousing, J: Information, Media and Telecommunications, K: Financial and Insurance Services, L: Rental, Hiring and Real Estate Services, M: Professional, Scientific and Technical Services, N: Administrative and Support Services, R: Arts and Recreation Services and S: Other Services.

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. A downward adjustment in the value of the Australian dollar will likely lead to an increase in the price of imported production inputs for agricultural producers, including diesel and LPG. Substitution of energy sources is, 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 through food manufacturers), which are not within the scope of this report.

Consequently, the key strategies to ensure resilience and optimise operating income[4] irrespective of periods of low commodity prices, droughts or a high Australian dollar are managing production costs and maximising output per unit of land.

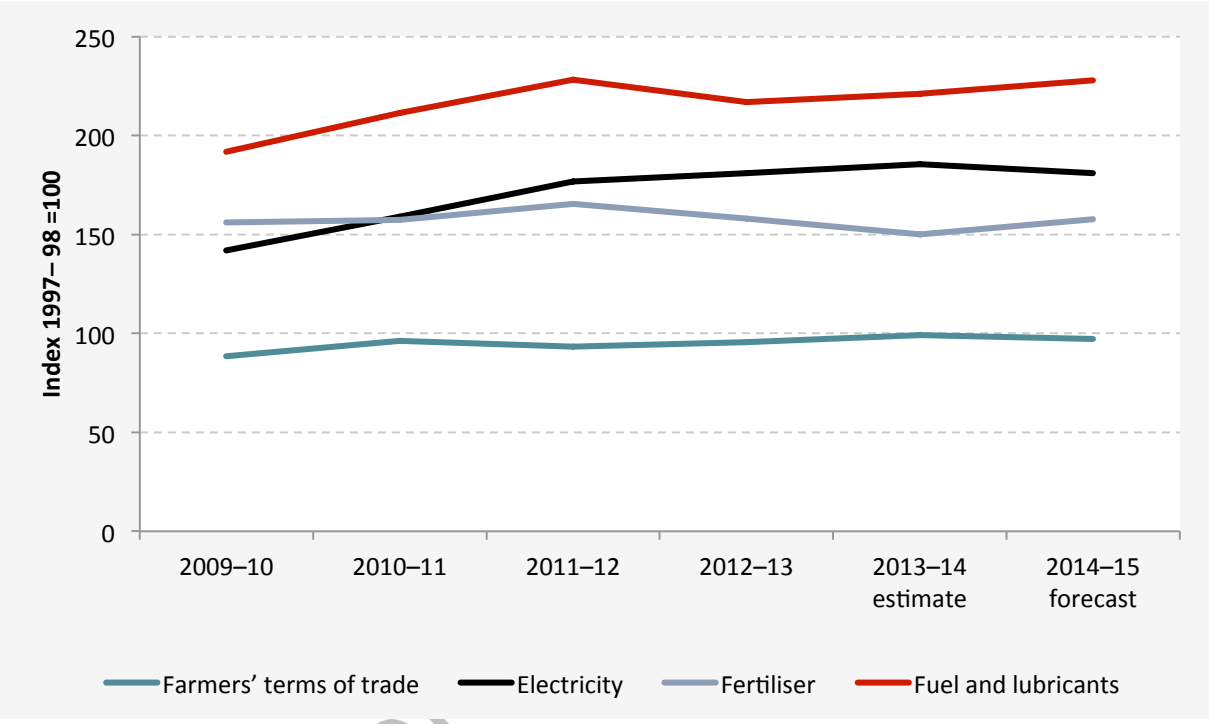
Energy is already a significant cost to many agricultural producers, often being the second or third highest operating cost after labour and seed/fertiliser. For most dairy and broadacre sub-sectors tracked through the ABARES Farm Survey (which includes less controllable costs such as seed) aggregate energy cost ranges between 7% and 10% of total cash cost (ABARES, 2014b, Valle, 2014). This is in line with more detailed studies of grain producers, which estimate that energy cost constitutes between 8% and 10% of total cash cost (Australian Farm Institute, 2011a; 2011b). Energy cost for vegetable growers is also estimated at 10% of total cash cost (Valle, 2014).

Cost for individual farmers can be higher, however, with variation resulting from age of equipment, farm practice and season, where higher energy spend may be warranted to exploit favourable climatic and pricing conditions. Farmers across all sectors surveyed by NSW Farmers reported that energy cost can account for 6–30%[5] of the cost of production, with heavy vehicles and irrigation pumping generally being the main energy sinks for extensive farmers and heating, ventilation and air-conditioning (HVAC) being the main energy sink for intensive producers (NSW Farmers Association, 2014).

[4] Including GVA, although statistically a different concept to operating income.
[5] NSW Farmers notes that caution is needed when interpreting the upper range since some farmers undervalue or exclude the value of their own labour when reporting input costs.

The prices of energy inputs, as well as fertiliser,[6] have been increasing at a faster rate than the growth in the prices farmers receive 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, on the other hand, has more than doubled in real terms over this period, with the electricity index reflecting an 80% real price increase over this period (ABARES, 2014a).[7]

Figure 3: 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%, 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.

Many farmers, however, treat energy as a fixed, rather than variable, cost and are often unaware of their ability to negotiate more favourable energy contracts, better manage demand, implement energy efficient practices and improve the relative energy efficiency of their equipment (NSW Farmers Association, 2014). Energy efficiency is rarely considered when vendors are marketing heavy farm machinery such as tractors and harvesters (NSW Farmers Association, 2014c).

[6] Much of the cost of fertiliser is linked to natural gas usage.

[7] 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.

Key challenges

A number of key challenges exist in the achievement of the 2xEP, these challenges are the same challenges that exist for all agriculture sector development programs. Given the small average workforce and the complexity of the systems managed, most farmers are time poor. A major challenge for the 2xEP program is gain the attention of government, industry stakeholders and farmers themselves.

As discussed farmers manage complex systems, systems that integrate land, climate, people, finance, and markets on farm with the many external elements impacting on the farming system. This system becomes even more complex when we take into account the strong emotional link many farmers have with their land. In summary the key challenges for our agricultural industries to achieve the 2xEP are:

- **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 (e.g. irrigation may be required in some years, but not in 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.
- **Primary energy use and final energy cost:** Data is available for all Australian farms for level 1 energy audit, through the individual farmer's fuel tax credit and their individual electricity providers.

Additional challenges include the potential barriers (Section 6):

- Industry and government leadership
- On farm leadership
- Perceived risks
- Imperfect information
- Hidden costs
- Access to capital

3. How energy productivity is increased

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 efficiency, which generally focuses on using less energy to deliver the same service is, however, an important part of the first of the four key strategies outlined below.

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 approach used in the 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

$$Energy\ Productivity\ = \frac{Real\ GDP\ (2010Aus\$)}{Primary\ Energy\ Consumption\ \ (GJ)}$$

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 4 below.

Figure 4: Key determinants of energy productivity

While it is understood that 2xEP may have a less direct influence on some elements included in the figure above, 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 energy conservation and 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. This can build upon existing programs under state and national programs for agriculture.

- **Strategy area 2:** Systems optimisation – e.g. focusing on energy-related aspects of farm production and distribution infrastructure design, production processes and the extended value chain, including capacity optimisation strategies. 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. focussing 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 or yield and value-add to products. Moving along the industry value chain may result in greater energy use, but will improve energy productivity if the increased value of outputs outweighs the increase in the inputs costs.

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 energy consumption, but also improved energy productivity.

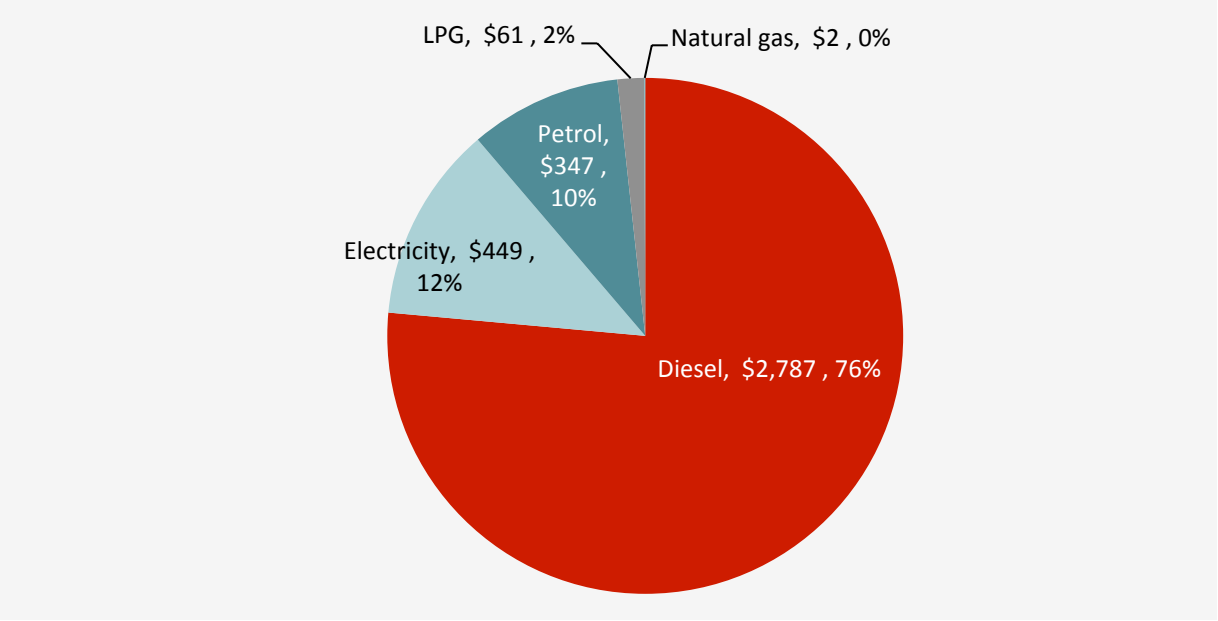
4. Energy productivity metrics

Energy use in Australian 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 dry land farmers have access to a reticulated gas network and grid-supplied electricity, the volume used per site may be relatively low, resulting in agricultural producers frequently paying for electricity and gas at rates that more closely resemble residential than industrial tariffs. However, for irrigators and other large electricity users, network charges account for more than 60% of the total bill (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 5 (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). An increase in worldwide production has led to a fall in fuel prices since this 2014, a situation that can change at any time with agreements from the major suppliers.

Figure 5: Agriculture energy spend in 2011–12 by fuel type ($-million)



A reduction in the diesel rebate (see shaded Box 2 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 2: Fuel taxation in the agriculture sector

The agriculture sector is entitled to a diesel rebate of $0.32 per litre for off-road use. A review of the rebate has been proposed several times, including in the run up to the 2014 Federal Budget. The Minerals Council of Australia, National Farmers' Federation and National Irrigators' Council have lobbied strongly for retention of the rebate on the basis that removal would lead to "double taxation" (Deloitte Access Economics, 2014).

Gas price movements are less material to the sector as a whole, but they could be material for individual operations. Western Australian gas prices increased rapidly over the last decade, before easing back somewhat recently. Large users on the Australian east coast now face the real possibility of 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.

From an energy productivity perspective the provision of capital works is a significant cost within agriculture both from a capital and systems perspective. The optimisation provided by both the electrification of on farm activities and the replacement of technically obsolete equipment is significant. However with long term farm return of assets at 1% this remains difficult (Australian Bureau of Statistics, 2012). Challenges include the:

- High cost of farm machinery replacement;
- Lack of information provided by vendors about energy performance and a lack of after sales support around set up and maintenance
- Large capital expenditure associated with new electricity connections;
- High network charges which are causing irrigators to abandon existing connections
- Significant and regular power supply interruptions and voltage irregularities which damage equipment, cause loss of stock
- Increasing cost of power and unpredictability of price rises (i.e. structural changes).

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).[8] 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.

[8] The 2xEP Foundations Paper (Stadler, Jutsen, Pears & Smith, 2014) canvasses these issues more extensively. http://www.2xep.org.au/2xep-foundations-the-opportunity.html

5. Barriers to achieving 2xEP

Many producers of agricultural goods are price takers, with limited options for value adding or product differentiation. The key strategies for optimising operating income are to minimise production costs and maximise yield. Energy is a significant cost to many agricultural producers particularly for broadacre grain and cotton and sugar. The convergence of high input costs, the [until recently] 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.

Table 1: Barriers to doubling energy productivity

Barrier	Overview
Energy industry and government leadership	• Lack of a systems approach to policy development leading to a win-loss strategic approach rather than a win-win strategic approach. For example, missed opportunities for energy productivity collaborations across production, transport, processing. • Savings made within electricity efficiency in agriculture are consumed by inefficiencies in the electricity market. This disconnect can drive down the adoption of technologies within agriculture. • Lack of incentives for midscale distributed renewable energy and off grid and hybrid electricity supply solutions.
Ability to address the major barriers	• The most significant energy productivity risks are out of farmers' control. For example, network charges; climate; commodity prices.
Access to finance	• The longer pay back periods often associated with investment in energy innovation hamper access to finance. • Farm capital replacement cycles are typically very long. • Market uncertainty leads to hesitancy to invest.
Imperfect information	• Insufficient information accessible to farming businesses about how to improve energy productivity (eg on-farm data and comparisons across alternative production systems and energy solutions). • Businesses lack information to identify and quantify non-energy savings benefits from energy productivity projects.
Hidden costs	• Poor information used for making energy-related investments, sometimes as a result of consultants/vendors over-selling the benefits and underselling the full implementation costs, leading to loss of confidence in the measure. • Due to the nature of innovation and the speed of change

	there is a lack of 3rd party review of the potential of new technologies. This is compounded within agriculture due to the tyranny of distance.
Access to capital	• Insufficient capital for investment – generally due to competition from what are considered more 'core' production efficiency such as though fertiliser or labour efficiencies – sometimes as a result of poor appreciation of the benefits of many energy investments in rate determining processes to improve output.

Source(s): Adapted from Copenhagen Centre on Energy Efficiency (2016), ACIL Tasman (2013) and ClimateWorks (2013a) (Eyre, 2016).

Note that some of these barriers represent market failures. Others simply represent features of the market and resource limitations that make energy productivity investment more difficult. In either case, well-judged policy support and business consideration directed at the barriers can potentially ease them.

6. Measures proposed to achieve 2xEP in agriculture

An appropriate and practical 2030 energy productivity target for agriculture will focus investment by the sector and individual farm businesses on economically efficient opportunities. A2E proposes to consult with a diverse range of stakeholders about what this target should be, the optimal pathways to follow for different sub-sectors within agriculture, as well as how improvement in the energy productivity of the agriculture sector could be tracked.

Consultation will canvass collaborative action that 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. The roles for government, industry stakeholders and the farmers were outlined earlier in this report. It is essential for coordination to ensure these roles are facilitated by A2EP.

The principles of the roadmap:

- Enterprises that increase their yield are rewarded with proportional revenue and profitability gains;
- Enterprises that reduce their energy and water consumption are rewarded with proportional cost savings;
- Energy suppliers and machinery vendors must provide access to to high density performance and consumption data to enable efficiency benchmarking and adaptive management.
- Energy and water productivity go hand-in-hand;
- Suitable information and expertise should be on hand to assist farmers in making decisions on energy and water productivity;
- Strategic demonstration pilots for energy solutions are funded to provide proof of viability to farmers in agronomic terms. These must be specific to the huge variety of farmers systems and geographies.
- The other benefits to be recognised include labour savings and health and safety benefits;
- Regulations and market rules need to keep pace with technical and commercial innovation;
- Innovation and commercialisation of energy and water efficiency technologies is supported and rewarded.
- Future investment in both network electricity and renewable energy in regional Australia is made in close consultation with the sector to ensure a strategic approach that maximise collaboration and net productivity benefits.
- Integrated least cost planning approaches are implemented for energy supply to regional Australia to maximise the benefits that can be achieved from demand management and off grid solutions.

A successful outcome from the 2xEP Roadmap process will be a realistic but challenging energy productivity target and a plan developed by the sector, supported by a broad spectrum of industry stakeholders to lead changes in the sector and in individual businesses to achieve the target. It is envisaged that outcomes of the 2xEP Roadmap may include:

- Definition of pathways to significantly enhance energy productivity, with reference to the different sub-sectors and scales of operations.
- Identification of energy-related opportunities to collaborate upstream and downstream in the food and fibre value chain and within regional economies to enhance Australia's leadership position in agriculture.
- Efficient communication mechanisms to accelerate awareness and understanding of emerging energy solutions, such as the recently launched AgInnovators.org.au website and its related social media network.
- Strategies for identifying and overcoming barriers to adoption of new, more efficient technologies and practices.
- Strategic support for demonstrating and proving the business case for advanced solutions.
- Recommendations proposed to federal, state and territory governments for policy changes to facilitate these activities.

Such outcomes are to be achieved through a collaborative process, involving agricultural enterprises, their value chain partners, industry associations, the research community, and the many government agencies involved in different aspects of policy-making and implementation.

7. Policy and program recommendations

The recommendations proposed are:

- **Initiatives for the agriculture sector and governments jointly**

  1. Conduct a thorough review of 'farm to plate' energy productivity opportunities along the entire supply chain;
  2. Build on-farm capacity to deliver energy productivity improvements with an emphasis on farm-use and supply chain diesel;
  3. Develop sustainable value chain precincts incorporating renewable energy, advanced manufacturing and logistics;
  4. Develop a national energy and water productivity program that aligns water policy with energy policy and enables adoption of water efficient irrigation technology;
  5. Deliver practical and relevant agriculture-specific energy productivity information including benchmarking data across production systems and energy solutions;
  6. Deploy on-farm digital technology to optimise energy use and generate data needed to inform energy efficiency improvement;
  7. Accelerate investment in energy productivity technologies, including through an effective, nationally consistent energy efficiency certificate trading scheme
  8. Establish a voluntary commitment and recognition program for businesses in the sector – the '2xEP Challenge';

- **Initiatives for governments and policy-makers**

  9. Reduce risk of early adoption of new technologies and practices for improving energy productivity through enhanced research, development and demonstration;
  10. Extend energy performance standards for on-farm equipment and require vendors to provide access to data streams generated by the equipment they sell;
  11. Develop efficient and effective energy markets that serve the interests of consumers, price fairly, facilitate innovation and reward investment;

- **Initiatives for the agriculture sector**

  12. Build on the existing role of agriculture industry associations in delivering integrated energy innovation information, demonstration and extension services.

High level benefit/costs analysis

A2EP has conducted a high level qualitative assessment of the costs and benefits for each of the proposed initiatives to help determine whether a project should be pursued. The analysis also includes reference to other assessments previously conducted where relevant and applicable. A more robust approach is required for assessing the initiatives prior to implementation.

Summary of potential benefits

Boosting productivity and competitiveness	Likely to result in improved output and a reduction in energy intensity as well as reduced costs and improved competitiveness
Improving company value and brand	High performance companies are more profitable, attract investment and customers, attract and retain staff
Reduced government outlays	Once implemented a reduced number of government staff required to administer the initiative. Additional savings are also achieved through a reduction in infrastructure and on-costs.
Reduced company resources	Reduced company resources required to access support and assistance as a result of streamlined and consistent processes
Red tape reduction (by industry)	Consistent and streamlined processes resulting in reduced regulatory burden
Improved investment certainty	Potential for increased investment as a result of increased certainty about the policy and regulatory environment and in the performance of plant and equipment
Contributing towards Australia's emissions reduction	Assisting Australia meet its emissions reduction goals through improved energy productivity
Reducing the cost of energy	Potential to reduce the amount of company expenditure on energy
Protecting energy security	Reducing reliance on imported liquid fuels as well as coal-based generation and networked electricity infrastructure

Summary of potential costs

Additional government outlays	Additional staff may be required to develop, administer or deliver the initiative taking into account additional salaries, infrastructure (i.e. office space and equipment) and on-costs.
Increased company resources	Increased company resources required to access support and assistance
Increased energy prices	Potential to increase energy prices. For example a nationally consistent white certificate scheme might increase retail energy prices in jurisdictions that currently don't have schemes.
Increased red tape	The potential for increased government involvement leading to delays in development and implementation
Government funding/support	Financial costs associated with providing either direct or indirect funding, incentives and support

Category: Government initiatives	
1. Conduct a review of 'farm to plate' energy productivity opportunities	
Overview	Conduct a thorough review of 'farm to plate' energy productivity opportunities along the entire supply chain. 2xEP recommends the Commonwealth fund a study to identify the barriers and opportunities for energy productivity improvements in the food supply chain. The study from 'farm to plate' would also cover energy productivity opportunities relevant to water, material use, resource efficiency, recycling, waste management (including industrial ecology opportunities and waste to energy), transport, as well as refrigeration (which is 5.5% of the energy Australia produces and offers high savings potential).
Current barrier to doubling energy productivity	• Imperfect information • Split incentives • Hidden costs
How the approach will address the current barriers	▪ The study would help overcome information barriers by identifying the risks and opportunities in the supply chain and assist companies make informed investment decisions. The study would also help identify regional and centralised solutions to issues (as opposed to only site based options).
Factors to consider	• Access to information and potential confidentiality issues • Opportunities to validate technologies e.g. low global warming potential (GWP) refrigerant based technologies • Optimisation opportunities across the food supply chain • Utilising reverse logistics to transport waste • Segregating waste streams to maximise use and avoid landfill • Collection and re-use of waste plastic packaging • Benchmarking site practices against best practice

Cost/benefit	• Benefits for this initiative include:
	  ○ Boosting productivity and competitiveness by creating linkages between sector roadmaps.
	• Costs for this initiative include:
	  ○ Additional government outlays in infrastructure is required to fund this initiative; and
	  ○ Government funding/support is required to fund this initiative.

Relationship with NEPP (COAG, 2015)	• The NEPP has a gap in dealing with supply chain opportunities
Linkage to other relevant programs	• Links with 8.1 to 8.10 within the 2xEP Agriculture roadmap

Category: Joint industry/government initiatives	
2. Build on-farm capacity to deliver energy productivity improvements	
Overview	Build on-farm capacity to deliver energy productivity improvements with an emphasis on farm-use and supply chain diesel. Urgent action is needed to increase the efficiency of diesel use in heavy farm vehicles and bulk water pumping, given 80% of the energy used in agriculture is diesel. There are currently a number of under-funded state based programs aimed at energy efficiency. In a time of big data and improving telecommunications there is a lack of on-farm information systems and a lack of systems that can underpin government, industry stakeholder and farmer program development along with superior on-farm decision making. In short to medium term there are no practical alternatives to diesel for powering tractors, harvesters and irrigation systems[9]. There are however numerous opportunities for farmers to improve energy efficiency by targeting the 'low hanging fruit', with such efficiencies producing the greatest on farm savings in the early stages of program development. With regard to pumping, irrigators in many areas do not have access to grid-supplied electricity and, due to the seasonal nature of their loads, solar technology is typically not financially viable without subsidies. Increased electrification is a priority for most sectors of agriculture and fundamental to general productivity as well as energy productivity. It should be noted however that in areas where irrigators do have access to grid-supplied electricity, high prices are encouraging farm consumers to revert to diesel systems or to invest in off-grid supply. Electricity is the optimal energy source for smart systems, automated vehicles, robotics and advanced manufacturing plants. Over the longer term and as the industry innovates, we predict significant increases in demand for grid-supplied electricity from the agriculture sector. However this will only be the case if consistent, predictable and reasonable pricing (via a suite of specialised food and fibre tariffs) informs investment decisions. To drive diesel efficiency, we are calling for: • national fuel efficiency standards for heavy vehicles, • an extension program around pump and vehicle purchase, set up, maintenance and operation, and • a certificate market to incentivise investment in more efficient diesel powered machinery. A modern energy system needs to address the barriers to electrification of farm functions through: • quickly adapting the National Electricity Market to new commercial

[9] In coming years we hope to see significant breakthroughs in electric, autonomous farm vehicles

	and technical energy solutions • reducing the cost of network electricity for irrigators and other intensive sectors • driving demand management collaboration in regional networks • driving strategic deployment of renewable generation where it is most needed to provide energy at least cost to industry and society • rewarding farmers who improve efficiency with proportional cost savings, reducing fixed charges as a proportion of the bill and deters investment in efficiency
Current barrier to doubling energy productivity	• Industry and government leadership • On farm leadership • Perceived risks • Imperfect information • Hidden costs • Access to capital

How the approach will address the current barriers	• The key to building on-farm capacity and addressing the barriers for diesel and electricity efficiency lies in the government, industry stakeholders and farmers each playing their part to improve efficiency. In turn these alliances rely on:
	  ○ information that optimises program planning
	  ○ delivery of the business case for on-farm options
	  ○ delivery of state and local programs to assist farmer adoption
	  ○ links to pilot site within 8.1 to demonstrate the opportunities.

Factors to consider	• Energy efficiency is just one of the opportunities for farmers to consider to improve on-farm efficiency.

Cost/benefit	• ABS collects only total energy use in Australia for agriculture, detailed information in relation to on farm energy use is required to create a detailed cost benefit analysis for all initiatives;
	• Benefits for this initiative include:
	  ○ Boosting productivity and competitiveness through on farm energy reduction; and
	  ○ Contributing towards Australia's emissions reduction through by increasing energy productivity.
	• Costs for this initiative include:
	  ○ Additional government outlays for infrastructure are required to manage this initiative
	  ○ Government funding/support is required to fund this initiative.
	  ○ Increased company resources required to implement practices

Relationship with NEPP (COAG 2015)	- NEPP measure 6: Help business self-manage energy costs - NEPP measure 11: Reduce barriers to financing - NEPP measure 19: Emerging technologies in the electricity system - NEPP measure 22: Develop an Energy Use Data Model for better planning

	- NEPP measure 25: Build service provider capacity - NEPP measure 26: New market mechanisms for demand response - NEPP measure 27: Promote competitive retail markets in electricity and gas
Notes re application or implementation of NEPP measures	22) Develop an Energy Use Data Model for better planning. CSIRO is developing the EUDM to provide meaningful and accessible data about energy use in Australia. This information will assist in better forecasting and policy development to potentially support the development of more efficient infrastructure in rural areas. 24) Improve the exchange of market data. The lack of competition in energy supply to rural and regional areas is a potential barrier to the development of more efficient and cost effective energy markets and innovative products for farmers. 25) Build service provider capacity. Improved capacity in the energy sector would have significant benefits for farm businesses and rural communities. 26) New market mechanisms for demand response. Increased access to new market arrangements and innovative demand-side services could enable farmers to engage with new, energy efficient technologies in their productive businesses.
Linkage to other relevant programs	• Sustainability Advantage, Energy Saver Program (NSW) • Smarter Resources, Smarter Business (VIC) • EcoBiz (QLD) • National Centre for Engineering in Agriculture and its links to University of Nebraska Tractor Lab and John Deere • Canegrowers • GrainGrowers • Cotton Australia

Category: Joint industry/government initiatives	
3. Develop sustainable value chain precincts	
Overview	Develop sustainable value chain precincts incorporating renewable energy, advanced manufacturing and logistics. While the majority of energy use in agriculture is currently in the broad acre sectors, we expect to see massive growth in the intensive agriculture sectors, with attendant increases in energy demand. Much of this growth will occur in urban and peri-urban environments, which places agriculture on a collision course with residential land use. The conventional model of scattered chicken sheds and greenhouses simply does not work for urban planners due to the amenity problems. We argue that this problem can be made a driver for intensive agriculture precincts that co-locate production facilities with recycling and renewable energy facilities. Noxious waste from poultry production can be turned into a bioenergy resource; vertical greenhouses incorporating solar energy can be entirely energy self-sufficient. Doubling energy productivity in agriculture entails re-visioning the sector as a data driven, knowledge industry deploying advanced sustainability technologies. A program to establish a network of high tech 'food and fibre precincts' in regional and peri-urban centres would be a practical way to focus the strands of innovation and converging technologies necessary to bring this about. Key concepts include: • Design and planning solutions for food production in urban environments including vertical agriculture; • The civil and data infrastructure and needed to enable efficient industrial ecology; • Facilities for renewable energy generation and recycling of urban storm water and organic waste, linked to the NSW Government's $465 million Waste and Resource Recovery Initiative; • A 'boiler house' for future manufacturing in the food and nutraceutical sectors and digital solutions across precision farming, automation, logistics and marketing; • A focal point for government sustainability and innovation programs, enhancing opportunities for linkage and cross fertilisation; • Research and educational facilities to support training and technology transfer; • A 'show room' for Australian food products and supply chain solutions designed to facilitate Asian market development and linked to Austrade and Industry NSW initiatives; • Facilities necessary for the preparation of fresh produce, both grown on the site and freighted from other areas of the state, for export by

	airfreight. This will include the necessary registered establishments and on-site capabilities to ensure produce meets export protocols, such as irradiation facilities; and • Significant social and economic benefits to Western Sydney accruing from direct employment and multipliers from tourism and educational visitation. The landscape would be a mix of high technology, agriculture and nature, with wildlife habitat integrated throughout the site. The built environment would include intensive horticulture facilities, advanced food processing factories, laboratories, warehouses, waste recycling plants, office and learning facilities, all constructed to highest energy efficiency and design standards. New technologies such as vertical agriculture, roof agriculture and integrated solar installations would contribute to the visual interest and establish the 'industrial ecology' narrative.
Current barrier to doubling energy productivity	• Industry and government leadership
How the approach will address the current barriers	• By providing innovation hubs for value chains to engage with each other we allow those who provide the innovation to engage with those who require the innovation. These hubs showcase all innovations and provide the business cases to allow value chain partners to inquire, understand and evaluate the opportunities.
Factors to consider	• Funding for these hubs are across industry with funding required from multiple streams. This includes government funding also can include funding from the technology providers who can efficiently showcase innovation to a broad market quickly.

Cost/benefit	• Benefits for this initiative include:
	  ○ Boosting productivity and competitiveness through showcasing energy productivity options to food value chains;
	  ○ Improved investment certainty – as an industry / government partnership this initiative can showcase the performance of plant and equipment; and
	  ○ Contributing towards Australia's emissions reduction by showcasing industry best practice.
	• Costs for this initiative include:
	  ○ Additional government outlays in infrastructure is required to fund this initiative; and
	  ○ Government funding/support is required to fund this initiative.

Relationship with NEPP (COAG, 2015)	- NEPP measure 8: Research business benchmarks and success factors - NEPP measure 11: Reduce barriers to financing - NEPP measure 13: Support innovation and commercialisation

	- NEPP measure 17: Promote leading practice - NEPP measure 18: Collaborate internationally
Notes re application or implementation of NEPP measures	8) Research business benchmarks and success factors. Benchmarking research to demonstrate the financial and competitive performance improvements that can be gained in agricultural industry sectors would increase farmer confidence in new technologies or systems that deliver energy productivity gains. 13) Support innovation and commercialisation. There is currently an under-investment in innovation and commercialisation of new energy productivity technologies with application in the agriculture and related value chain sectors. Government and industry investment in this area would have far-reaching benefits for farming businesses. 17) Promote leading practice. It has be a practice adopted by government and Industry stakeholders to utilise pilot farms in key areas. 18) Collaborate internationally. Collaboration between international governments and organisations on energy productivity can achieve better outcomes more quickly and reduce regulation through greater alignment. Opportunities exist for international collaboration and technology transfer, particularly in the intensive horticulture and livestock industries.
Linkage to other relevant programs	• Sustainability Advantage, Energy Saver Program (NSW) • Smarter Resources, Smarter Business (VIC) • ecoBiz (QLD)

Category: Joint industry/government initiatives	
4. Deliver a national energy and water productivity program	
Overview	Develop a national energy and water productivity program that aligns water policy with energy policy and enables adoption of water efficient irrigation technology. The water/energy nexus is well documented globally. Optimal water efficiency in irrigation can only be achieved by considering the water and power savings within the one equation on farm. There is no one size fits all for this complex question to support on farm decisions. State and federal governments have invested significantly in water buy-back and water efficiency programs without addressing the energy part of the water equation. A national irrigation energy productivity program is needed to develop and incentivise adoption of irrigation systems that optimise both energy and water usage. In addition to increasing energy and broader agricultural productivity, the program would help reduce pressure on national bulk water resources, and in so doing may reduce water allocation conflict in the Murray Darling Basin and other irrigation catchments. This national program including demonstration pilots, extension and outreach, and training for service providers, linked to a capital fund that farmers access for new infrastructure could significantly improve energy productivity. In a variation from existing programs, funding criteria would embrace the portfolio of measures required to optimise energy productivity and sustainability and would not be restricted to renewables. Funded works would include digital control systems, pump and layout optimisation and hybrid energy solutions (e.g. network energy supplemented by solar). The program would also cover planning for irrigation districts to identify demand management, load shifting and distributed generation opportunities.
Current barrier to doubling energy productivity	• Industry and government leadership • On farm leadership • Perceived risks • Access to capital
How the approach will address the current barriers	• It is proposed that the program be managed through National Irrigators who will provide the coordination of the various program components. National Irrigators have existing long term on-farm relationships, relationships that can improve adoption. A key to the proposal is the utilisation of Commonwealth co-investment, investment that will significantly enhance program success.

Factors to consider	• The capacity building program would comprise:
	  ○ Technical and business case support
	  ○ R&D pilots
	  ○ Professional training
	  ○ Extension and engagement through farm sector bodies

	○ A digital hub for technical resources. ○ The crucial component is the coordination of the program elements as a whole of farm approach for farmers.
Cost/benefit	• Benefits for this initiative include: ○ Boosting productivity and competitiveness through showcasing energy productivity options in irrigation efficiency while improving water use efficiency; ○ Improved investment certainty – as an industry / government partnership this initiative can showcase the performance of irrigation systems; and ○ Contributing towards Australia's emissions reduction by enhancing energy productivity while improving water use efficiency. • Costs for this initiative include: ○ Additional government outlays in infrastructure is required to fund this initiative; ○ Increased company resources to realise on farm value and ○ Government funding/support is required to fund this initiative.
Relationship with NEPP (COAG 2015)	- NEPP measure 6: Help business self-manage energy costs - NEPP measure 7: Recognise business leadership and support voluntary action in business - NEPP measure 8: Research business benchmarks and success factors - NEPP measure 11: Reduce barriers to financing - NEPP measure 25: Build service provider capacity
Notes re application or implementation of NEPP measures	7) Recognise business leadership and support voluntary action in business. Farmer led voluntary action can boost adoption at a local, state and national level leading to economic productivity, competitiveness and employment opportunities. Government will work cooperatively with the farming community on options to support energy productivity improvements. 8) Research business benchmarks and success factors. Benchmarking research to demonstrate the financial and competitive performance improvements that can be gained in agricultural industry sectors would increase farmer confidence in new technologies or systems that deliver energy productivity gains. 25) Build service provider capacity. Improved capacity in the energy sector would have significant benefits for farm businesses and rural communities
Linkage to other relevant programs	• Sustainability Advantage, Energy Saver Program (NSW) • Smarter Resources, Smarter Business (VIC) • EcoBiz (QLD) • Canegrowers • Cotton Australia

Category: Joint industry/government initiatives	
5. Deliver agriculture-specific energy productivity information and data	
Overview	Deliver practical and relevant agriculture-specific energy productivity information including benchmarking data across production systems and energy solutions. The Commonwealth and states already provide significant and valuable information, including through the eex.gov.au site (Energy Efficiency Exchange) and programs like Energy Efficiency Information Grants. 2xEP recommends that this information should be expanded and improved, particularly in the context of energy productivity. Repackaging information, upgrading EEX by adding and refining content, increasing access to case studies in video and text format, providing information and case examples of financing and innovative commercial models, and using a range of media to more effectively deliver these to market, would be valuable. The delivery of this information through improved outreach activities is critical as experience says the information does not deliver itself and personal contact with companies to deliver content which is relevant to them is important to extract the maximum value from this investment. Where applicable, the revised information (and new materials where gaps exist) should be: • Industry specific • Practical information on best practices • Include verified information on cutting edge technologies. The materials need to be practical and ensure that they cater for a range of audiences including people with technical as well as non-technical backgrounds/roles (i.e. engineers as well as commercial/procurement roles and for trades people as well as professionals). Energy productivity information and capacity building could be enhanced through integration with the Entrepreneurs Program and the Industry Growth Centres and other existing sectoral programs/channels. Trusted service providers and industry bodies have an important role to play in utilisation and promotion of the service and specific content. This program needs to be linked to the outreach programs – see recommendation 2. This measure should also include funding support for an annual conference, such as the 'Summer Study on Energy Productivity', to disseminate world best practice information.
Current barrier to doubling energy productivity	• Business leadership • Imperfect information
How the approach will address the current barriers	• Consolidates and enhances previous resource materials • Provides an opportunity to implement big data • Provides an opportunity to underpin program development with high

	quality information
Factors to consider	• Intellectual property of existing materials • Potential issues with modifying digital content i.e. videos

Cost/benefit	• Benefits for this initiative include:
	  ○ Boosting productivity and competitiveness by providing the information required to build the business case for change; and
	  ○ Contributing towards Australia's emissions reduction by enhancing energy productivity providing the information for change to government, industry organisations, training organisations, universities and farmers.
	• Costs for this initiative include:
	  ○ Additional government outlays in infrastructure funding;
	  ○ Increased company resources to realise on farm value; and
	  ○ Government funding/support is required to fund this initiative.

Relationship with NEPP (COAG 2015)	- NEPP measure 6: Help business self-manage energy costs - NEPP measure 8: Research business benchmarks and success factors - NEPP measure 17: Promote leading practice - NEPP measure 22: Develop an Energy Use Data Model for better planning - NEPP measure 30: Deliver a new Equipment Energy Efficiency (E3) prioritisation plan
Notes re application or implementation of NEPP measures	8) Research business benchmarks and success factors. Benchmarking research to demonstrate the financial and competitive performance improvements that can be gained in agricultural industry sectors would increase farmer confidence in new technologies or systems that deliver energy productivity gains. 17) Promote leading practice. It has be a practice adopted by Government and Industry stakeholders to utilise pilot farms in key areas. 22) Develop an Energy Use Data Model for better planning. CSIRO is developing the EUDM to provide meaningful and accessible data about energy use in Australia. This information will assist in better forecasting and policy development to potentially support the development of more efficient infrastructure in rural areas. 30) Deliver a new Equipment Energy Efficiency (E3) prioritisation plan. The current E3 plan is contributing over $1 billion in avoided energy costs to the Australian economy annually and reducing carbon emissions by about 11.6 million tonnes per annum. The agriculture sector and related value chain businesses stand to benefit from any improvements in equipment energy efficiency generated through the E3 programme, provided compliance costs are minimised.
Linkage to other relevant programs	EEIG (now concluded), Sustainability Advantage, Energy Saver Program EcoBiz, Smarter Resources, Smarter Business

Category: Joint industry/government initiatives	
6. Deploy on-farm digital technology	
Overview	Deploy on-farm digital technology to optimise energy use and generate data needed to inform energy efficiency improvement. As is the case for every sector of the economy, digital technology is presenting new opportunities for agriculture, the opportunity to increase efficiency and energy productivity. Farmers typically experience very poor reliability and power quality, with attendant productivity losses and damage to equipment such as VSDs and digital control systems. The increasing use of sensitive and expensive automation and sensor technology demands that performance is lifted in this regard. This is a potentially an area for collaboration between distributors and farmers. For example, sharing the costs of a Tesla battery that includes smart power factor correction and voltage regulation and contributes to peak load reduction. There is presently an almost total lack of data available to industry regarding energy consumption in agriculture for strategic and benchmarking purposes. The group calls for funding to establish a national database for energy consumption in agriculture that is accessible to farmers and researchers working in their interests. Access to real-time energy and water data would allow farmers greater visibility of energy consumption and the ability to act to manage energy consumption to reduce costs or free up network capacity in times of constraint. Having access to that data will also allow: 1) Industries to understand and quantify the factors that drive farm productivity 2) The theoretical limits to energy and water productivity and how these are affected by external factors (i.e. if a farmer limits output by planting less or irrigating less due to low commodity price, high power price, or climate risks) 3) Benchmarking of yields and resulting energy and water productivity 4) Detailed monitoring to verify savings from trials. Sensor technology and big data solutions make it technically feasible to automate collection of real time data from farm machinery such as tractors, pumps and mills. Major machinery vendors already do this but their customers have no direct access to the data. Presently there is no requirement or mechanism for vendors of tractors and other heavy machinery to make the data streams generated by machines available to the owners. This is something that could be addressed as part of the new nation fuel efficiency standards policy.
Current barrier to	• Imperfect information – timeliness of the information

doubling energy productivity	
How the approach will address the current barrier (s)	• The provision of information that is both timely and targeted at the on-farm system will enhance on farm adoption • This information, when linked to the business case for the individual technologies, will also allow for an increase in energy productivity and on-farm profitability
Factors to consider	• There is no one size fits all approach to agriculture but a range of options allows for a suite of options to be identified for an individual farming system

Cost/benefit	• Benefits for this initiative include:
	  ○ Boosting productivity and competitiveness by providing the efficient information systems to enhance change; and
	  ○ Contributing towards Australia's emissions reduction by enhancing energy productivity providing the information systems to assist government, industry organisations, training organisations, universities and farmers to understand on farm energy productivity.
	• Costs for this initiative include:
	  ○ Additional government outlays in infrastructure is required to fund this initiative; and
	  ○ Government funding/support is required to fund this initiative.

Relationship with NEPP (COAG, 2015)	- NEPP measure 3: Make choice easier - NEPP measure 6: Help business self-manage energy costs - NEPP measure 8: Research business benchmarks and success factors - NEPP measure 17: Promote leading practice - NEPP measure 22: Develop an Energy Use Data Model for better planning
Notes re application or implementation of NEPP measures	8) Research business benchmarks and success factors. Benchmarking research to demonstrate the financial and competitive performance improvements that can be gained in agricultural industry sectors would increase farmer confidence in new technologies or systems that deliver energy productivity gains. 17) Promote leading practice. It has be a practice adopted by government and industry stakeholders to utilise pilot farms in key areas. 22) Develop an Energy Use Data Model for better planning. CSIRO is developing the EUDM to provide meaningful and accessible data about energy use in Australia. This information will assist in better forecasting and policy development to potentially support the development of more efficient infrastructure in rural areas.
Linkage to other relevant programs (including state	Sustainability Advantage, Energy Saver Program (NSW), Smarter Resources, Smarter Business (VIC), EcoBiz (QLD), Canegrowers, GrainGrowers Cotton Australia

programs)	
Category: Joint industry/government initiatives	
7. Accelerate investment in energy productivity technologies	
Overview	Accelerate investment in energy productivity technologies, including through an effective, nationally consistent energy efficiency certificate trading scheme. Industry substantially under-invests in productivity (and particularly energy productivity) measures, and it is crucial to rapidly improve energy productivity to enhance incentives for these investments. Farm business seeks consistent encouragement and national frameworks with common rules. The fragmented nature of the energy efficiency 'white' certificate schemes has been a barrier to effective participation as well as making it challenging for companies with operations in multiple jurisdictions to access schemes that all have different rules. 2xEP recommends two types of initiatives to accelerate investment in energy productivity technologies, to make 'white' certificate schemes work more effectively and nationally to provide incentives for both electricity and gas energy productivity investments, and if this measure is not sufficient, to implement a tax incentive scheme. An effective Energy Efficiency Certificate Trading Scheme that is available nationally with common rules is required. Currently there are separate energy efficiency white certificate schemes operating in NSW (ESS), VIC (VEET), ACT and SA (REES). These schemes allow energy users to generate tradable certificates for verified energy saving activities, which they can sell to energy retailers with energy saving obligations. The schemes are currently inconsistent with varying rules and methodologies. While there have been recent efforts to achieve some consistency between some states, there are serious limits within some schemes preventing recognition of a range of meaningful energy reduction initiatives. 2xEP recommends the establishment of a nationally available white certificate scheme based on the following principles: • Individual states may still administer the programs and decide whether to join, but the rules and methodologies would be the same regardless of location. • The scheme would be available to anyone that contributes to the state schemes. • The scheme would be based on the NSW model, but further enhanced to ensure they deliver effective market transformation in all the market sectors they impact. • Exemption arrangements will be needed, based on those in NSW and Victoria, for energy intensive trade exposed industries and large energy users. States and territories currently without White Certificate Schemes of their own should favourably consider joining the nationally consistent model,

	following consultation with local energy users and cost benefit analysis. Secondly consider tax incentives to accelerate investment in energy-efficient plant and equipment to modernise manufacturing and deliver energy productivity benefits. Note that such measures should be at least partially self-funding over time as the resulting investments would drive additional savings that will ultimately appear as profits in company tax returns. The incentives considered would be in line with those available to businesses in competing countries. Australia has provided successful general investment incentives previously, including during the Global Financial Crisis. An additional tax reform could be to look at the GST status of certificates in tradable certificate schemes, which can be confusing and bureaucratic to navigate. There are also examples of programs in competing countries. The UK's Enhanced Capital Allowances enables businesses to write off 100% of the cost of new plant and equipment (including compressed air equipment, HVAC equipment, boilers, motors and drives and refrigeration equipment) against the businesses' taxable profits in the financial year the purchase was made rather than over an extended period. Similar incentives exist in other parts of Europe and many states in the USA (Copenhagen Centre on Energy Efficiency, 2016). Improve access to finance. It is recommended that the government fund a study to determine the best options for improving manufacturer access to off-balance sheet finance for energy productivity investments. While access to debt finance has improved, this has not addressed the key issue for business – accessing an additional capital source for energy productivity projects that does not have to compete for limited CAPEX with 'core' projects for producing more/different products. The project should also provide broader guidance to companies on accessing finance for energy productivity projects.
Current barrier to doubling energy productivity	• Perceived risks • Access to capital
How the approach will address the current barriers	• Will provide incentives for companies to invest in plant and equipment
Factors to consider	• White certificate schemes in VIC, NSW, SA and ACT • R&D tax incentive

Cost/benefit	• Benefits for this initiative include:
	  ○ Boosting productivity and competitiveness by providing the finance to enhance technological change; and
	  ○ Contributing towards Australia's emissions reduction by enhancing energy productivity financing options required for on

	farm change.
	• Costs for this initiative include:
	  ○ Additional government outlays in infrastructure is required to fund this initiative;
	  ○ Increased company resources to realise on farm value; and
	  ○ Government funding/support is required to fund this initiative.

Relationship with NEPP (COAG, 2015)	- NEPP measure 2: Market mechanisms to capture societal benefits (Emissions Reduction Fund (ERF), state energy efficiency (EE) schemes, Renewable Energy Target (RET)) - NEPP measure 11: Reduce barriers to financing
Notes re application or implementation of NEPP measures	11) Reduce barriers to financing: There remain a range of barriers that can limit efficient private sector investment in energy productivity improvements. A range of measures are addressing these issues, including existing projects under the Clean Energy Finance Corporation and work streams under the G20.
Linkage to other relevant programs	1. White certificate schemes in VIC, NSW, SA and ACT 2. R&D tax incentive 3. Instant tax write-off for small business

Category: Joint industry/government initiatives	
8. Establish a voluntary commitment and recognition program – the '2xEP Challenge'	
Overview	2xEP recommends: Establish a voluntary program that supports leadership and commitment to improving energy productivity in agriculture and its supply chains. The concept of the program: • Leadership program to light the way for other farming businesses • MoU between farm representative bodies and Challenge administrators • Commitment leads to recognition and support • Aligns with other voluntary programs including international programs e.g. energy productivity100 and state and territory energy efficiency programs • Participating farmers will be assisted to report annually against their milestones, though commercially sensitive information will not be published • Will be aligned with agriculture sector led energy data and benchmarking programs • Entirely voluntary program • Initially the proposed program will target influential farmers, farmers that will be the program pilots for the program rollout to the wider farming community.
Current barrier to doubling energy productivity	• Electricity network regulation and tariffs • Lack of integrated least cost planning around bulk energy provision at ends of networks • Unwillingness of energy retailers and network service providers to design and offer specialised food and fibre tariffs • Unwillingness of energy retailers and machinery vendors to provide operational energy-use data • Lack of coordination across energy, water, and agricultural, transport, and regional development policy and t programs
How the approach will address the current barriers	• By providing an overarching framework targets and feedback to guide energy innovation across the food and fibre value chain.
Factors to consider	• Investment largely from government • Government funding commitment to develop and implement program elements particularly relating to recognition, capacity building, and case study development and promotion is also essential for success • Industry stakeholder support is critical • Active involvement of the representative farm sector in program desgn and implementation is critical to ensuring alignment with industry needs • Farmer and corporate uptake and farm business acceptance depends on the program design addressing the real world problems faced by the sector.

Cost/benefit	• ABS collects only total energy use in Australia, detailed information in relation to on farm energy use is required to create a detailed cost benefit analysis for this initiative; • Boosting productivity and competitiveness[10] – at this point information is not available to determine a cost/benefit analysis, comparable state programs have led to 19% savings on energy for program participants; and • Additional government outlays are required to drive energy productivity through this program.
Relationship with NEPP (COAG 2015)	- NEPP measure 6: Help business self-manage energy costs - NEPP measure 7: Recognise business leadership and support voluntary action in business - NEPP measure 17: Promote leading practice
Notes re application or implementation of NEPP measures	7) Recognise farm business leadership and support voluntary action on farm: farmer led voluntary action can boost adoption at a local, state and national level leading to economic productivity, competitiveness and employment opportunities. Government will work cooperatively with the agricultural industry on options to support energy productivity improvements. 17) Promote leading practice through the grower pilot programs. It has be a practice adopted by government and industry stakeholders to utilise pilot farms in key areas. With better data derived from 8.2, pilot farms can be better targeted. The NEPP focus is on identifying options. This recommendation is for implementation of the 2xEP Challenge Program subject to a successful pilot in 2016/17.
Linkage to other relevant programs	• Sustainability Advantage, Energy Saver Program (NSW) • Smarter Resources, Smarter Business (VIC) • EcoBiz (QLD)

[10] EcoBiz Queensland

Category: Government initiatives	
9. Reduce risk of early adoption of new technologies and practices	
Overview	Reduce risk of early adoption of new technologies and practices for improving energy productivity through enhanced research, development and demonstration. This measure incentivises agricultural equipment manufacturers to more rapidly adopt international best practice technologies that drive enhanced energy productivity. This approach provides strong linkages to the National Innovation and Science Agenda. 2xEP recommends the following initiatives to support innovation and the demonstration of energy productivity technologies. Provide a 50% incentive for investments in novel technologies and best practices to increase energy productivity, including the use of waste fuels, on-site cogeneration and emerging renewable technologies. This measure supports provision of 50% funding to assist the development of projects that have implementation risk because they have novel elements or are being implemented in Australia for the first time in this application. Funding would also be provided for technology transfer from the project. Note that participating companies will be required to make their projects accessible for industry visitation and to publish and promote a high quality case study providing commercial information demonstrating the benefits and problems experienced with the project. The grants would be for a maximum 50% of the installed capital cost of the project. There should be consideration for making large grants at least partially recoverable if the project achieves a minimum targeted ROI (for example, reducing a project ROI to 2 or 3 years). This would help to grow the funding pool over time. Note that this scheme is similar to the successful NERDDC scheme, which operated in the 1990s. The government should consider a study into the next generation of energy productivity technologies. The study would look at: • Define key emerging technologies and alternative business models that could drive significant step changes in energy productivity • Develop learning cost curves for these technologies to define expected trends in energy productivity benefits and costs for these technologies 2xEP – Manufacturing sector roadmap V1.o April 2016 - 32 - • Identify barriers to commercialisation, technology transfer, adoption, and ultimate market transformation • Define policies and programs required to accelerate the transfer of these technologies to market • Work with each of the sector working groups to define the specific

	innovation needs and opportunities in sector process technology • Communicate outcomes to inform decision-makers. The study would target markets and be refreshed on a regular basis i.e. every two years. The outcomes of the study would also help refine and improve any additional support required by the manufacturing sector.
Current barrier to doubling energy productivity	• Business leadership • Perceived risks • Access to capital
How the approach will address the current barrier (s)	• Will provide incentives for companies to invest in plant and equipment
Factors to consider	• Government's innovation agenda • 2017 review of Carbon mitigation measures to meet C reduction targets
Cost/benefit	• Benefits for this initiative include: ○ Boosting productivity and competitiveness by providing the finance to ensure technological change; and ○ Contributing towards Australia's emissions reduction by enhancing energy productivity providing the infrastructure required for on farm change. • Costs for this initiative include: ○ Additional government outlays in infrastructure is required to fund this initiative; ○ Increased company resources to realise on farm value; and ○ Government funding/support is required to fund this initiative.
Relationship with NEPP (COAG, 2015)	- NEPP measure 11: Reduce barriers to financing - NEPP measure 13: Support innovation and commercialisation - NEPP measure 17: Promote leading practice
Notes re application or implementation of NEPP measures	17) Promote leading practice: There is potential to drive energy productivity innovation through the promotion and recognition of leaders. The Commonwealth will continue current international work in this area. The Commonwealth will also seek wider options to drive innovation linked to Measures 2 and 7.
Linkage to other relevant programs	• Link to Commonwealth and state and government innovation agendas and programs

Category: Government initiatives	
10. Extend energy performance standards for on-farm equipment	
Overview	Extend energy performance standards for on-farm equipment and require vendors to provide access to data streams generated by the equipment they sell. Policies are required to ensure that equipment available for retrofit and upgrading cycles supports improved energy efficiency performance. 2xEP recommends: Energy performance monitoring capability to be installed on all energy-intensive equipment, pumps, tractors, sprayers and harvesters. All new energy intensive equipment sold should be required by regulation to include energy performance monitoring capability (energy use vs utility output) as standard. Currently it is difficult for companies to determine the energy efficiency of equipment prior to purchase as well as its energy performance once installed. This requirement should be developed in close consultation with suppliers and users and in cooperation with initiatives to implement and regularise Internet of Things (IoT) technologies in Australia. To minimise regulatory costs, the standards applied to embedded performance monitoring devices should be aligned with international standards such as the EU Measuring Instruments Directive (2004/22/EC). International linkages are possible through National Centre for Engineering in Agriculture and its linkage to University of Nebraska Tractor Lab and John Deere. The Commonwealth to expand the Equipment Energy Efficiency (E3) program to include a greater range of farm equipment, improving the required efficiency standards of existing equipment. To minimise costs, standards should be developed, agreed and applied in close consultation with suppliers and users, and should be in line with trusted international frameworks. Currently some lighting, three phase cage induction motors (with output power from 0.73 kW up to, but not including, 185 kW, with rated voltages up to 1100 V, alternating current (AC)), commercial chillers and non-domestic fans are covered by the E3 Program. The program should be expanded to include other industry equipment whose minimum performance is regulated by competitors, such as (but not limited to) air compressors, boilers, blowers and pumps. Non-conforming product is a serious issue in many sectors with respect to many kinds of standards, and it is important to ensure that compliance is considered fully when developing energy standards. Enforcement responsibilities should be clear and vested in capable agencies that are well-resourced by government, including suitable research infrastructure to test equipment. Either set of standards will take time to have an effect on national energy productivity, since they only affect the choice of new equipment. Capital expenditure reflects both individual farm investment

	cycles and 2xEP, as the farming sector's equipment investment levels are low, investigation of incentives for new investment is important. Testing energy savings claims. It is recommended that the government fund a program for testing the performance of new energy saving equipment entering the market against promotional claims. This is seen as important to protect consumers and the credibility of the energy management industry, in the light of many new products being introduced in recent years carrying dubious savings claims. We propose that this be initiated with a feasibility study to design and cost this program.
Current barrier to doubling energy productivity	• Imperfect information • Split incentives • Hidden costs
How the approach will address the current barriers	• Will provide greater guidance to business when upgrading new equipment • Drive improved knowledge and skill in relation to energy productivity amongst service and equipment providers
Factors to consider	• Administrative process for registering products

Cost/benefit	• Benefits for this initiative include:
	  ○ Improved investment certainty by enhancing confidence in the performance of energy efficient equipment.
	• Costs for this initiative include:
	  ○ Additional government outlays in infrastructure is required to fund this initiative; and
	  ○ Government funding/support is required to fund this initiative.

Relationship with NEPP (COAG, 2015)	- NEPP measure 3: Make choice easier - NEPP measure 30: Deliver a new Equipment Energy Efficiency (E3) prioritisation plan
Notes re application or implementation of NEPP measures	(30) Deliver a new Equipment Energy Efficiency (E3) prioritisation plan: Through the Equipment Energy Efficiency (E3) programme, governments increase the energy efficiency of equipment through mandatory energy efficiency regulations. The recent independent review of the programme highlights that it is contributing over $1 billion in avoided energy costs to the Australian economy annually, while avoiding carbon emissions by an estimated 11.6 million tonnes per annum. The agriculture sector and related value chain businesses stand to benefit from any improvements in equipment energy efficiency generated through the E3 programme, provided compliance costs are minimised.
Linkage to other relevant programs	• Equipment Energy Efficiency (E3) programme: http://www.energyrating.gov.au/news/prioritised-work-program-e3 • Standards Australia

Category: Government initiatives	
11. Develop efficient and effective energy markets	
Overview	Develop efficient and effective energy markets that serve the interests of consumers, price fairly, facilitate innovation and reward investment in improved energy efficiency and energy productivity. Increased electrification is a priority for most sectors of agriculture and fundamental to general productivity as well as energy productivity. Electricity is the optimal energy source for smart systems, automated vehicles, robotics and advanced manufacturing plants. In the longer term, we predict significant increases in agricultural electricity demand as the industry innovates. The electricity networks need to adapt quickly to enable the full potential of new technologies and commercial models for energy use and supply. A modern energy system needs to address the barriers to electrification of farm functions: • Quickly adapt the National Electricity Market to new commercial and technical energy solutions • Allow financial and technological innovation to encourage demand management collaboration in regional networks • drive strategic deployment of renewable generation where it is most needed to provide energy at least system[11] cost to industry and society • reward farmers for improved efficiency with proportional cost savings, reducing fixed charges as a proportion of the bill which deter investment in efficiency A network that allows businesses a range of options to buy and sell power will encourage businesses to collaborate to develop own and maintain energy assets and use the grid
Current barrier to doubling energy productivity	• Inflexible Market Rules • Split incentives • Hidden costs
How the approach will address the current barriers	• Provide a market mechanism for companies to invest in energy efficiency/energy productivity
Factors to consider	• Role of the Australian Energy Regulator and existing network rules • New business models for Electricity Market and grid operator.
Cost/benefit	• Benefits for this initiative include: ○ Boosting productivity and competitiveness by providing the finance to facilitate change in markets.

[11] Least System Cost in this context refers to the lesser lifetime cost where

	• Costs for this initiative include: ○ Government funding/support is required to fund this initiative.
Relationship with NEPP (COAG, 2015)	- NEPP measure 6: Help business self-manage energy costs - NEPP measure 19: Emerging technologies in the electricity system - NEPP measure 26: New market mechanisms for demand response
Notes re application or implementation of NEPP measures	26) New market mechanisms for demand response: New market arrangements could allow new innovative demand-side services to engage in the wholesale market and support embedded networks. The Australian Energy Market Commission is currently considering rule changes for a number of such mechanisms proposed under the Power of Choice review.
Linkage to other relevant programs	• AEMC Power of choice

Category: Industry initiative	
12. Build on the existing role of agriculture industry associations	
Overview	Build on the existing role of agriculture industry associations in delivering integrated energy innovation information, demonstration and extension services. 2xEP recommends 'industry' investigates the role of sector associations in providing information to businesses working in and with the agriculture sector to improve energy productivity. There is significant potential to build on successful current and past programs to enable momentum and continuity with a view to implementing a coordinated national program that engages farm sector bodies in a 'community-of-practice' delivery model. For example: • Raise decision-makers' awareness of the benefits of improved energy productivity and its co-benefits, such as more productive deployment of labour and materials and lower maintenance costs. These benefits can contribute to improving overall productivity, competitiveness and profitability. Where energy productivity initiatives are assessed to be cost-effective, decision makers are encouraged to sanction implementation of these initiatives. • Provide information regarding appropriate energy productivity-related performance indicators for staff and associates, cognisant of existing contractual obligations and agreements. Note, an integrated view of energy productivity is required to incentivise decision making in each part of the process that contributes to the enhancement of energy productivity of the process or plant as a whole.
Current barriers to doubling energy productivity	• Availability of relevant information • Benefits of energy projects pursued in isolation are perceived as lacking materiality • Management practices and internal barriers
How the approach will address the current barriers	• Increase collaboration and understanding within the sector of the direct and indirect benefits of improved energy productivity, and the associated positive impacts on competitiveness, productivity and value. • Provide practical assistance in implementing changes to bring about energy productivity improvements.
Factors to consider	• Risk of lower productivity compared to competitors if energy productivity issues are not addressed: link energy productivity to overall productivity and competitiveness. • Success of international organisations in bringing together members to better understand sector-wide performance and improve energy performance. • Diversity of businesses within farm and related sectors and challenges in providing information relevant to all. • Resourcing challenges within association staff given the range of

	responsibilities and initiatives coordinated across the sector. • The business case for energy productivity is not always clear using typical financial tools. For example, NPV analysis discounts future energy cost reductions relative to up-front investment in energy productivity projects. It may be helpful to include alternative methods of valuation when assessing energy projects e.g. real options analysis. Taking a long-term 'value at risk' perspective of energy cost may be useful.
Cost/benefit	Potential **costs** of this measure • Increased industry association resources – staff in sector associations may require energy productivity training and additional human resources may be required to provide information the sector. The cost to sector associations of implementing this initiative may be significant. Potential **benefits** of this measure • General benefits of improving energy productivity, as listed in the introduction to section 7. • Leveraging established networks to share knowledge will likely accelerate the development of a cohesive approach to energy productivity for the sector.
Relationship with NEPP (COAG 2015)	- NEPP measure 7: Recognise business leadership and support voluntary action in business
Linkage to other relevant programs	Energy Savers Plus is an initiative of the Queensland Government delivered by the Queensland Farmers' Federation. The objective of the program is to assist farmers reduce energy costs by supporting the accelerated adoption of improvements in on-farm energy use. http://www.qff.org.au/policy-projects/our-projects/energysavers/ Energy Efficiency Information Grants Program (EEIG): was part of a suite of measures announced in July 2011. The Program assisted industry associations and non-profits to provide information to small and medium enterprises (SMEs) and community organisations, allowing them to make informed decisions about energy efficiency and operational costs. A broad range of sectors were covered by the Program, including agriculture, food processing in particular and manufacturing in general. For an example of the material produced through the program, see Apple & Pear Australia Ltd. (2013). "Watts in your Business" baseline survey responses. North Melbourne: Author. Retrieved from http://apal.org.au/wp-content/uploads/2013/07/Watts-In-Your-Business-Baseline-survey-report-Sept-2013.pdf

8. 2xEP Steering committee and working group members

2xEP Steering Committee

The 2xEP Steering Committee was inaugurated in July of 2015 and is tasked with guiding the program through development and completion. The Committee meets quarterly to review progress, refine strategy, and provide leadership. Most Steering Group members are involved in one or more of the sector working groups.

Kenneth Baldwin, Director, Energy Change Institute, Australian National University
Graham Bryant, Deputy Chair, Energy Users Association of Australia
Tony Cooper, Chief Executive Officer, Energetics
Bo Christensen, Manager Sustainability, Linfox
David Eyre, General Manager, Research & Development, NSW Farmers
Chris Greig, Fellow, Australian Academy of Technology, Sciences and Engineering
Tim Hicks, Senior Manager, Economic Policy, Australian Chamber of Commerce and Industry
Travis Hughes, Head of Energy Services, AGL Energy
Jonathan Jutsen, Deputy Chairman, Australian Alliance for Energy Productivity
Andrew Lamble, Co-Founder and Chief Operating Officer, Envizi
Adam Lovell, Executive Director, Water Supply Association of Australia
Sid Marris, Director – Industry Policy, Minerals Council of Australia
Luke Menzel, Chief Executive Officer, Energy Efficiency Council
Brian Morris, Vice President, Energy & Sustainability Services, Schneider Electric
Gordon Noble, Managing Director, Inflection Point Capital
Andrew Peterson, Chief Executive Officer, Sustainable Business Australia
Glenn Platt, Group Leader, Energy Technology, CSIRO
Tennant Reed, Principal National Adviser – Public Policy, AiGroup
Duncan Sheppard, Director Communications and Policy, Australian Logistics Council
Anna Skarbek, Executive Director, ClimateWorks Australia
Scott Taylor, Head of Living Utilities, Lend Lease
Kane Thornton, Chief Executive Officer, Clean Energy Council
Suzanne Toumbourou, Executive Officer, Australian Sustainable Built Environment Council
Laura Van Wie McGrory, Vice President, International Policy, US Alliance to Save Energy
Stephen White, Energy for Buildings Manager, CSIRO
Stuart White, Director, Institute for Sustainable Futures
Bruce Wilson, Syndicate Chair, CEO Institute, Transport specialist
Oliver Yates, Chief Executive Officer, Clean Energy Finance Corporation

2xEP is supported by 10 working groups; for each key end use sector of the economy plus finance, innovation, metrics and communications.

Agriculture Sector Working Group

David Eyre, General Manager, Research & Development, NSW Farmers
Tony Mahar, Deputy Chief Executive Officer, National Farmers Federation
Robert Nicholson, Principal Energy Services, KMH Environmental
Phil Shorten, Associate, Energetics
Tom Chesson, Chief Executive Officer, National Irrigators Council
Dale Holliss, Company Secretary, Bundaberg Regional Irrigators Group
Gerry Flores, Energy Innovation Manager, NSW Farmers
Dale Park, President, WA Farmers
Andrew Chamberlin, Project Manager - Energy, Queensland Farmers' Federation
Michael Claessens, General Manager, Agrifood Skills Australia
Tony Westmore, General Manager, Australian Alliance for Energy Productivity

9. References

AgInnovators. (n.d.). AgInnovators web portal. Retrieved from http://aginnovators.org.au

AgInnovators. (2014). Technology: Precision agriculture. St Leonards, NSW: Author. Retrieved from http://aginnovators.org.au/initiatives/technology/themes/precision-agriculture

Allianceto Save Energy. (2013b). Doubling US energy productivity by 2030. Washington, DC: Author

Anderson, K. (2014). Australia's competitiveness in contributing to global food security. Farm Policy Journal, 11(3), 19–33.

Apple & Pear Australia Ltd. (2013). "Watts in your Business" baseline survey responses. North Melbourne: Author. Retrieved from http://apal.org.au/wp-content/uploads/2013/07/Watts-In-Your-Business-Baseline-survey-report-Sept-2013.pdf

Apple & Pear Australia Ltd. (2014a). "Watts in Your Business " technical report. North Melbourne: Author. Retrieved from http://apal.org.au/wp-content/uploads/2013/07/Watts-In-Your-Business-Technical-Report-FINAL.pdf

Apple & Pear Australia Ltd. (2014b). Case story 4 : Power factor correction. North Melbourne: Author. Retrieved from http://apal.org.au/wp-content/uploads/2013/07/CS4-EEIG-Batlow.pdf

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). 2013. *AGSURF Data* [Online]. Available: http://apps.daff.gov.au/AGSURF/ [Accessed 30 April 2013].

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). (2014a). Agricultural commodities: September quarter 2014 (Statistics Data Table). Canberra, Author. Retrieved from http://www.agriculture.gov.au/abares/publications/display?url=http://143.188.17.20/anrdl/DAFFService/display.php?fid=pb_agcomd9abcc20140916_11a.xml

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). (2014b). Surveys: Summary of AAGIS and DDIS data tables (broadacre and dairy). Canberra: Author. Retrieved from http://www.agriculture.gov.au/abares/surveys

Australian Bureau of Statistics. (2007). Information paper: Experimental estimates of industry multifactor productivity Australia (Catalogue No. 5260). Belconnen, ACT: Author.Australian Bureau of Statistics. (2013a). Australian system of national accounts 2012–13 (Catalogue No. 5260.0.55.002). Belconnen, ACT: Author.

Australian Bureau of Statistics 2012. Australian Social Trends December 2012 - Australian farming and farmers.

Australian Bureau of Statistics. (2013b). Energy accounts 2011–12 (Catalogue No. 4606). Belconnen, ACT: Author. Retrieved from http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4604.02011-12?OpenDocument

Australian Bureau of Statistics. (2013c). Estimates of industry multifactor productivity (Catalogue No. 5260). Belconnen, ACT: Author.

Australian Bureau of Statistics. (2013d). Value of principal agricultural commodities produced, Australia (Preliminary 2012–13) (Catalogue No. 7501). Belconnen, ACT: Author.

Australian Bureau of Statistics. (2014a). Australian industry: 2102–13 (Catalogue No. 8155). Belconnen, ACT: Author.

Australian Bureau of Statistics. (2014b). Australian System of National Accounts, Agricultural income (current prices) (Catalogue No. 5204). Belconnen, ACT: Author.

Australian Bureau of Statistics. (2014c). Value of Australian commodities produced: 2012–13 (Catalogue No. 7503). Belconnen, ACT: Author.

Australian Farm Institute. (2011a). The impact of a carbon price on Australian farm businesses: Grain production. Surry Hills, NSW: Author.

Australian Farm Institute. (2011b). The impact of a carbon price on Australian farm businesses: Rice farming. Surry Hills, NSW: Author.

Australian Government. (2013). Australian farming and agriculture – grazing and cropping. Retrieved from http://www.australia.gov.au/about-australia/australian-story/austn-farming-and-agriculture

Australian Institute of Petroleum. (2013). Maintaining supply security and reliability for liquid fuels in Australia. Canberra: Author. Retrieved from http://www.aip.com.au/pdf/Maintaining_Supply_Security_and_Reliability_for_Liquid_Fuels_in_Australia.pdf

Australian Institute of Petroleum. (2014). 2014 AIP annual TGP data. Canberra: Author. Retrieved from http://www.aip.com.au/pricing/tgp.htm

Australian Pork. (2014). Industry focus: Renewable energy (biogas). Barton, ACT: Author. Retrieved from http://australianpork.com.au/industry-focus/environment/renewable-energy-biogas

Australian Trade Commission. (2013). Brand Australia global food strategy research: Desk review and primary highlights [Webinar]. Australian Government. Retrieved from https://www.austrade.gov.au/ArticleDocuments/1418/Brand-Australia-Food-Webinar-2013-Presentation.pdf.aspx

AUSVEG & Horticulture Australia. (2013). Costs of production for Australian vegetable growers. Camberwell, Vic: AUSVEG.

Barbour, L. (2014). Fears US may try to water down Australian farm chemical rules under TPP. Ultimo, NSW: ABC Rural. Retrieved from http://www.abc.net.au/news/2014-11-10/concerns-us-trying-to-water-down-australian-chemical-rules-tpp/5879108

Blackburn, J. (2014). Australia's liquid fuel security Part 2: A report for NRMA Motoring Services. North Strathfield, NSW: NRMA. Retrieved from http://www.mynrma.com.au/images/About-PDF/Fuel-Security-Report-Pt2.pdf

British Columbia Ministry of Agriculture and Lands. (2005). Farm storage and handling of petroleum products, (Farm Mechanization Factsheet No. 210.510-1). Abbotsford, BC: Author.

Bureau of Resources and Energy Economics. (2014). 2014 Australian energy statistics. Canberra: Author. Retrieved from http://www.bree.gov.au/publications/australian-energy-statistics/2014-australian-energy-statistics-data

Cabrera, E., Cabrera, E., Cobacho, R., & Soriano, J. (2014). Towards an Energy Labelling of Pressurized Water Networks. Procedia Engineering, 70, 209–217. doi:10.1016/j.proeng.2014.02.024

Claughton, D. (2014). New web portal to help agribusiness access global markets like China. Ultimo, NSW: ABC Rural. Retrieved from http://www.abc.net.au/news/2014-11-20/ag-innovators-launched/5905166

Clean Energy Finance Corporation. (n.d.). World-leading solar thermal technology creates sustainable agriculture. Sydney: Author. Retrieved from http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/tomato-farm-a-solar-innovator.aspx

Clean Energy Finance Corporation (CEFC). (2014a). CEFC and agriculture and agribusiness (Fact Sheet). Sydney: Author. Retrieved from http://www.cleanenergyfinancecorp.com.au/media/76321/cefc-factsheet_agriculture-and-agribusiness_lr.pdf

Clean Energy Finance Corporation(CEFC). (2014b). Chicken manure and organic waste provide power and heat. Sydney: Author. Retrieved from http://www.cleanenergyfinancecorp.com.au/our-investments/case-studies/egg-producer-turns-waste-into-energy.aspx

ClimateWorks. (2013). Tracking progress towards a low carbon economy - Industry. Melbourne: Author. Retrieved from http://www.climateworksaustralia.org/project/current/tracking-progress-towards-low-carbon-economy

Commonwealth of Australia. (2014). Agricultural competitiveness green paper. Canberra: Author. Retrieved from https://agriculturalcompetitiveness.dpmc.gov.au/sites/default/files/green_paper.pdf

Council of Australian Governments (COAG). (2010). Improving the energy efficiency of industrial equipment. Barton, ACT: COAG Equipment Energy Efficiency Committee.

Dairy Australia. (2014). Smarter energy use program phase 1 evaluation – Draft report. Southbank, Vic: Author. Retrieved from http://frds.dairyaustralia.com.au/wp-content/uploads/2014/04/Smarter-Energy-Use-Phase-1-Evaluation-report-FINAL.pdf

Department of Agriculture. (2014). Agriculture and food: Research and innovation. Canberra: Author. Retrieved from http://www.daff.gov.au/agriculture-food/innovation

Department of Foreign Affairs and Trade. (2014). Australia-China free trade agreement, Key outcomes: Agriculture and processed foods. Barton, ACT: Author. Retrieved from http://dfat.gov.au/fta/chafta/fact-sheets/key-outcomes.html

Department of Industry. (2014). Energy white paper: Green paper 2014 to inform preparation of a white paper. Canberra: Author. Retrieved from http://ewp.industry.gov.auDepartment of Industry. (2014b). Impacts of the E3 program: Projected energy, cost and emission savings. Canberra: Author. Retrieved from http://www.energyrating.gov.au/wp-content/uploads

Department of the Environment. (2014). On-farm irrigation efficiency program. Canberra: Author. Retrieved from http://www.environment.gov.au/water/rural-water/srwui/on-farm-irrigation-efficiency-program

Dwyer, G. (2014, June). Identifying and managing energy cost in irrigation. Presentation at the 'Water for Life, Future for All' 2014 Irrigation Australia Conference, Gold Coast, Qld. Retrieved from http://irrigation.org.au/wp-content/uploads/2014/06/Greg-Dwyer.pdf

Ellis, D. (2012). Fuel efficiency: Reducing your bill and helping the environment. Rennes: Efficient 20 – Intelligent Energy Europe. Retrieved from http://uk.efficient20.eu/files/2012/11/Fuel-efficiency-guide.pdf

Energetics. (2014). Submission to the Energy White Paper 2014. North Sydney: Author. Retrieved from http://ewp.industry.gov.au/sites/prod3.ewp.industry.gov.au/files/Energy Issues White Paper 2014 submission.pdf

European Commission (2013). Europe 2020 indicators – Climate change and energy. Retrieved from http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Europe_2020_indicators_-_climate_change_and_energy

Eyre, D. (2016, February 24). *New thinking needed about regional electricity supp*. Retrieved May 27, 2016, from Aginnovators: http://www.aginnovators.org.au/blog/new-thinking-needed-about-regional-electricity-supply

Eyre, D., Alexandra, J., Richards, R., & Swann, S. (2014). Optimising energy efficiency in irrigated agriculture: RD&E priorities and program design. St Leonards, NSW: NSW Farmers.

Deloitte Access Economics. (2014). The economics of fuel taxation in the mining sector. Report prepared for the Minerals Council of Australia. Barton, ACT: Author. Retrieved from http://www.minerals.org.au/file_upload/

files/reports/DAE-MCA_Fuel_Tax_Credit_-_1_July_2014_sent_to_client.pdf

Flores, G., Hoffmann, D., Lister, A., & Shorten, P. (2014). Switching off the grid and switching to solar for an artisan trust bore near Moree delivers big returns (NSW Farmers Case Study – Garrah, Moree). St Leonards, NSW: NSW Farmers.

Flores, G., Hoffmann, D., Rostron, L., Lister, A., & Shorten, P. (2014). Simple energy savings measures deliver suprisingly large cost savings (NSW Farmers Case Study: Birrah, Moree). St Leonards, NSW: NSW Farmers.

Flores, G., Hoffmann, D., Rostron, L., & Shorten, P. (2014a). Diesel effieciency measures deliver large cost savings (NSW Farmers Case Study: Tahlee Farm, Gunnedah). St Leonards, NSW: NSW Farmers.

Flores, G., Hoffmann, D., Rostron, L., & Shorten, P. (2014b). Insights provided by fuel and electricity monitoring drive energy plans for sheep farm near Griffith (NSW Farmers Case Study: Steam Plains). St Leonards, NSW: NSW Farmers.

Flores, G., Hoffmann, D., Rostron, L., & Shorten, P. (2014c). Reduce the speed, reduce the cost – VSDs on pumping systems lead irrigation efficiency measures (NSW Farmers Case Study: Kensal Green and Gruen Park, Gunnedah). St Leonards, NSW: NSW Farmers.

Girgenti, V., Peano, C., Baudino, C., & Tecco, N. (2014). From "farm to fork" strawberry system: current realities and potential innovative scenarios from life cycle assessment of non-renewable energy use and green house gas emissions. The Science of the Total Environment, 473-474, 48–53. doi:10.1016/j.scitotenv.2013.11.133

Gray, E. M., Oss-Emer, M., & Sheng, Y. (2014). Australian agricultural productivity growth: past reforms and future opportunities (ABARES Research Report 14.2). Canberra: Department of Agriculture. Retrieved from http://www.oecd.org/tad/events/Mr.%20Merrilees_Agricultural%20productivity%20growth%20reforms%20opportunities.pdf

Group of 20 (G20). (February, 2014). Communiqué: Meeting of finance ministers and central bank governors. Sydney: Author. Retrieved from https://www.g20.org/sites/default/files/g20_resources/library/Communique

%20Meeting%20of%20G20%20Finance%20Ministers%20and%20Central%20Bank%20Governors%20Sydney%2022-23%20February%202014_0.pdf

Gruen, D. (2012, November). The importance of productivity. Paper presented to the Productivity Commission-Australian Bureau of Statistics Productivity Perspectives Conference, Canberra.

Innes, B. (2014). Your guide to preparing for the ERF's first auction. North Sydney: Energetics. Retrieved from http://www.energetics.com.au/insights/latest-news/climate-change-matters/your-guide-to-participating-in-the-erf

Institute of Industrial Productivity. (2011). China (CN-2): Energy and carbon intensity targets of the 12th five year plan (Industrial Efficiency Policy Database). Retrieved from http://iepd.iipnetwork.org/policy/energy-and-carbon-intensity-targets-12th-five-year-plan

Jackson, T. M., Khan, S., & Hafeez, M. (2010). A comparative analysis of water application and energy consumption at the irrigated field level. Agricultural Water Management, 97(10), 1477–1485. doi:10.1016/j.agwat.2010.04.013

Keogh, M. (2014). Optimising Australian agriculture's comparative advantages. Farm Policy Journal, 11(3), 1–7.

Kimura, S., & Le Thi, C. (2013). Cross country analysis of farm economic performance (OECD Food, Agriculture and Fisheries Papers No. 60). Paris: OECD Publishing. Retrieved from http://dx.doi.org/10.1787/5k46ds9ljxkj-en

Kirkegaard, J. A., Conyers, M. K., Hunt, J. R., Kirkby, C. A., Watt, M., & Rebetzke, G. J. (2014). Sense and nonsense in conservation agriculture: Principles, pragmatism and productivity in Australian mixed farming systems. Agriculture, Ecosystems & Environment, 187, 133–145. doi:10.1016/j.agee.2013.08.011

KPMG. (2013). The agricultural and food value chain: Entering a new era of cooperation. Amstelveen: KPMG International: Global Life Sciences. Retrieved from http://www.kpmg.com/Global/en/IssuesAndInsights/

ArticlesPublications/Documents/agricultural-and-food-value-chain-v2.pdf

Liddy, M., Elvery, S., & Spraggon, B. (2014). Interactive: 100 years of drought in Australia. Ultimo, NSW: ABC News. Retrieved from http://www.abc.net.au/news/2014-02-26/100-years-of-drought/5282030

Lydon, J., Dyer, D., & Bradley, C. (2014). Compete to prosper: Improving Australia's global comeptitiveness. Sydney: McKinsey Australia. Retrieved from http://www.bca.com.au/docs/becc9d88-f873-48bf-b5fb-c5b3d0335aba/McKinsey_Compete_to_Prosper_Improving_Australias_Global_Competitiveness_FINAL_28.7.2014.pdf

Manson, S. (2014). Farmers take meat processing on-farm to meet a boutique consumer market. Ultimo, NSW: ABC Rural. Retrieved from http://www.abc.net.au/news/2014-12-03/farmers--processing-meat-on-farm-to-control-their-markets/5933720

Meta Economics Consulting Group. (2013). Electricity supply issues for farmers. Gundaroo, NSW. Retrieved from http://www.nswfarmers.org.au/__data/assets/pdf_file/0014/31190/Farmers-Electricity-Supply.pdf

Monsanto. (2014a). Integrated farming systems (IFS). St Louis, MO: Author. Retrieved from http://www.monsanto.com/products/pages/integrated-farming-systems.aspx

Monsanto. (2014b). Monsanto in Australia and New Zealand. St Louis, MO: Author. Retrieved from http://www.monsanto.com/global/au/whoweare/pages/monsanto-in-australia.aspx

National Farmers' Federation. (2014a). Industry Skills Fund submission. Barton, ACT: Author. Retrieved from http://www.nff.org.au/get/submissions/4645.pdf

National Farmers' Federation. (2014b). Submission in response to the Energy green paper. Barton, ACT: Author. Retrieved from http://www.canberraiq.com.au/downloads/2014-11-4-5.pdf

National Farmers' Federation. (2014c). Submission to the Agricultural Competitiveness Issues paper. Barton, ACT: Author. Retrieved from http://www.nff.org.au/get/submissions/4499.pdf

National Farmers Federation. 2016. *NFF Farm Facts 2012* [Online]. Available: http://www.nff.org.au/farm-facts.html [Accessed].

National Irrigators' Council. (2014). Submission to the Energy white paper: Green paper 2014 to inform preparation of a white paper. Barton, ACT: Author. Retrieved from http://www.ewp.industry.gov.au/sites/prod3.ewp.industry.gov.au/files/submissions/Energy White Paper//EWPGP023-693.pdf

Nebraska Tractor Test Laboratory. (2014). Test reports. Lincoln, NE: Nebraska Tractor Test Laboratory, University of Nebraska-Lincoln. Retrieved from http://tractortestlab.unl.edu/testreports

NSW Business Chamber and Sydney Business Chamber. (2014). Industry research collaboration: Discussion paper. North Sydney: Author. Retrieved from http://www.nswbusinesschamber.com.au/NSWBC/media/

Forms/Final-Report_-Thinking-Business-Industry-Research-Collaboration.pdf

NSW Farmers Association. (2013a). Adaptive driving – the skill factor in fuel efficiency. St Leonards, NSW: Author. Retrieved from http://www.nswfarmers.org.au/__data/assets/pdf_file/0008/35846/Efficient-Farm-Vehicles-Adaptive-driving-the-skill-factor-in-fuel-efficiency.pdf

NSW Farmers Association. (2013b). Diesel versus electric pumps. St Leonards, NSW: Author. Retrieved from http://www.nswfarmers.org.au/__data/assets/pdf_file/0007/35854/Energy-Irrigation-Diesel-versus-electric-pumps.pdf

NSW Farmers Association. (2013c). Purchasing a fuel-efficient tractor. St Leonards, NSW: Author. Retrieved from http://aginnovators.org.au/sites/default/files/Efficient%20Farm%20Vehicles%20-%20Purchasing%20a%20fuel%20efficient%20tractor.pdf

NSW Farmers Association. (2013d). Saving energy in irrigtion. St Leonards, NSW: Author. Retrieved from http://www.nswfarmers.org.au/__data/assets/pdf_file/0010/35857/Energy-Irrigation-Saving-energy-in-irrigation.pdf

NSW Farmers Association. (2013e). Solar PV pumping systems. St Leonards, NSW: Author. Retrieved from http://www.nswfarmers.org.au/__data/assets/pdf_file/0011/35858/Energy-Irrigation-Solar-PV-pumping-systems.pdf

NSW Farmers Association. (2013f). Variable speed drives on pumps. St Leonards, NSW: Author. Retrieved from http://www.nswfarmers.org.au/__data/assets/pdf_file/0003/35859/Energy-Irrigation-Variable-speed-drives-on-pumps.pdf

NSW Farmers Association. (2014). Research and development initiatives. St Leonards, NSW: Author. Retrieved from http://www.nswfarmers.org.au/r-and-d

NSW Irrigators' Council and Cotton Australia. (2013). A trial program to achieve better electricity prices (Progress Update 2). Sydney: Author. Retrieved from http://www.nswic.org.au/pdf/Briefings/131202 Progress Report 2.pdf

NSW Office of the Environment and Heritage. (2014). Small business energy efficiency program – Agriculture data set (Summary supplied to A2EP by NSW Farmers).

Productivity Commission. (2014). Submission to the Agricultural Competitiveness Taskforce. Melbourne: Author. Retrieved from http://www.pc.gov.au/__data/assets/pdf_file/0010/135883/agricultural-competitiveness-submission.pdf

Queensland Cane Growers Organisation Ltd. (n.d.). Energy efficiency in irrigation systems (Fact Sheet). Brisbane: Author. Retrieved from http://www.canegrowers.com.au/icms_docs/196337_Energy_efficiency_

in_irrigation_systems_factsheet.pdf

Rabobank. (n.d.). All in one-account. Sydney: Author. Retrieved from http://www.rabobank.com.au/rural/loans/pages/all-in-one-account.aspx

Regional Development Australia – Gippsland. (2014). Gippsland food plan. Traralgon, Vic: Author. Retrieved from http://www.rdv.vic.gov.au/__data/assets/pdf_file/0015/214431/Gippsland-Food-Plan.pdf

Reserve Bank of Australia. (2014a). Index of commodity prices. Sydney: Author. Retrieved from http://www.rba.gov.au/statistics/frequency/commodity-prices.html

Reserve Bank of Australia. (2014b). Submission to the Inquiry into the Reserve Bank Amendment (Australian Reconstruction and Development Board) Bill 2013. Sydney: Author. Retrieved from http://www.rba.gov.au/publications/submissions/inquiry-rba-amend-aus-rec-dev-brd-bill-2013/pdf/inquiry-rba-amend-aus-rec-dev-brd-bill-2013.pdf

Robertson, M. (2010, November). Agricultural productivity in Australia and New Zealand: Trends, constraints and opportunities. In H. Dove & R. A. Culvenor (Eds.), Food Security from Sustainable Agriculture: Proceedings of the 15th Australian Agronomy Conference 2010, 15–18 November, Lincoln, New Zealand (pp. 15–19). Retrieved from http://www.regional.org.au/au/asa/2010/plenary/climate-change/7402_robertsonmj.htm

Sarker, R. (2014). Half-a-century competitiveness of the wheat-sectors: A comparative analysis of Canada and Australia. Farm Policy Journal, 11(3), 35–47.

Schwab, K., Sala-i-Martin, X., & World Economic Forum. (2013). The global competitiveness report 2013–2014 (Full data edition). Geneva: World Economic Forum. Retrieved from http://www10.iadb.org/intal/intalcdi/PE/2013/12834.pdf

Stadler, A., Jutsen, J., Pears, A., & Smith, M. (2014). 2xEP: Australia's energy productivity opportunity, Draft Version 1.2. Sydney: Australian Alliance to Save Energy

Sundrop Farms. (2014). Sundrop system. London: Author. Retrieved from http://www.sundropfarms.com/sundrop-system

Sundrop Farms & Coles Supermarkets Australia. (2014). Ground-breaking deal to create 300 jobs at Port Augusta [Media Release]. London: Author. Retrieved from http://www.sundropfarms.com/wp-content/uploads/2014/12/Coles-Partners-with-Sundrop-Farms.pdf

University of New England. (2014). The SMART farm – UNE rural property “Kirby”. Armidale, NSW: Author. Retrieved from http://www.une.edu.au/about-une/academic-schools/school-of-science-and-technology/research/smart-farm

Valle, H. (2014). Australian vegetable growing farms: An economic survey 2012–13 and 2013–14. Canberra: ABARES. Retrieved from http://data.daff.gov.au/data/warehouse/9aab/9aabf/2014/avfesd9absf20141114/

AustVegGrwFrmEcoSurvey20141114_1.0.0.pdf

Victorian Farmers Federation. (2014). State election 2014: Energy efficiency grants put farmers on equal footing. Melbourne: Author. Retrieved from http://www.vff.org.au/vff/Documents/2014 Election Docs/Policy - Energy efficiency grants for farm businesses FINAL.pdf

Vivid Economics. (2013). Energy efficiency and economic growth: Report prepared for The Climate Institute. London: Author.

Western Dairy. (n.d.). Saving energy on WA dairy farms. Denmark, WA: Author. Retrieved from http://frds.dairyaustralia.com.au/wp-content/uploads/2013/05/WA-booklet.pdf

White, M. (2014a). Field robots set to make farming faster and simpler. St Leonards, NSW: AgInnovators. Retrieved from http://aginnovators.org.au/news/field-robots-set-make-farming-faster-and-simpler

White, M. (2014b). SMART farm: A taste of agriculture's future. St Leonards, NSW: AgInnovators. Retrieved from http://aginnovators.org.au/news/smart-farm-taste-agriculture%E2%80%99s-future

World Bank. (n.d.). World DataBank. Retrieved August 24, 2014, from http://databank.worldbank.org/data/home.aspx

Yusaf, T., Hamawand, I., Schmidt, E., Binnie, J., Rees, S., & Chakrabarty, S. (2014). Coals seam gas (CSG) in agriculture – A review: Technical and market analysis for Australia. Sustainable Energy Technologies and Assessments, 8, 149–158. doi:10.1016/j.seta.2014.08.005