



FINAL REPORT 2017

For Public Release

Part 1 - Summary Details

Please use your TAB key to complete Parts 1 & 2.

CRDC Project Number: CFE0 1603

Project Title: Economic assessment of implementing potential mitigation sequestration options

Project Commencement Date: 01.05.2016 **Project Completion Date:** 31.03.2017

CRDC Research Program: 2 Industry

Part 2 – Contact Details

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Signature of Research Provider Representative:

Date Submitted:

5 – 4 – 2017

Part 3 – Final Report

Background

1. Outline the background to the project.

Project CFEO1603 was commissioned to gain an understanding of the opportunities, benefits and risks involved in emission reductions for broad acre irrigated and dryland cropping.

The eleven-month project was designed to contribute towards the completion of Objective 6 of the *Carbon Farming in the Australian Cotton Industry* project funded by the Carbon Farming Futures E&O Program via a grant to CRDC. Objective 6 was “Clarify to cotton industry participants the opportunities, benefits and trade-offs of participating in the ERF and/or implementing potential/sequestration options”.

Reducing emissions on farm has been hampered by a lack of technical capacity in the integration of science, practical farm management, policy context and economics. This project has filled a gap by creating economic outputs that consider all aspects of emission reduction decision making for the cotton farming system and extended the key findings to industry, government and the scientific community.

Objectives

2. List the project objectives and the extent to which these have been achieved, with reference to the Milestones and Performance indicators.

Key objectives of the project included;

- ***Determine and cost the opportunities, benefits and risks involved in implementing mitigation and sequestration practices. Specifically, alternative energy investments for mitigation and improved input efficiencies.***

The background, political context and solar energy’s potential application to the Australian cotton industry was outlined in the publication ‘*Solar Energy: Policy setting and applications to cotton production*’ available on the CottonInfo website (Milestone 1).

This objective was addressed with four analyses (Milestone 1.1-1.4). The opportunities and benefits were costed, risks discussed and emission implications reported for each analysis.

Milestone 1.1 analysed the feasibility of installing solar on grid connected irrigated bore pumps and was reported for two case study farms in ‘*Grid Connected Solar: Irrigation case studies*’.

Analysis for Milestone 1.2 compared two renewable investment alternatives to reduce electricity demand tariffs and emissions. The benefits and costs of the alternatives are reported in ‘*Energy and irrigation: feasibility study*’, Case study results for grower (Unpublished).

For Milestone 1.3 a case study investigating the feasibility of a solar/Genset microgrid is discussed in the journal paper ‘*Investment analysis of solar energy in a hybrid diesel irrigation pumping system in NSW, Australia*’. The first installation of its kind, the paper discusses at length the benefits, risks and practical implications of this mitigation strategy that also improves input efficiencies.

Milestone 1.4 analysed farm management strategies to reduce emissions. The case study and economic and environmental aspects of each strategy are discussed in the paper ‘*An irrigated cotton farm emissions case study in NSW, Australia*’, submitted to the Journal of Cleaner Production.

- ***Integrate research on new and emerging technologies for input efficiency, emissions reductions into trusted cotton industry extension, BMP's and adviser training.***

Findings of each analysis have been extended to industry and will continue to be extended as they are published.

The two published reports from Milestone 1.1 underpin the recent updates of the energy content in myBMP and the Cotton Production Manual (CPM).

The new research was also extended through article's titled 'The sums add up for solar powered irrigation' and 'Using solar power to drive bore pumps is now economically feasible', published in the Australian Cotton Grower magazine and The Northern Daily Leader respectively.

A 3-minute thesis was presented in the Energy session at the 18th Australian Cotton Conference outlining the key variables of a solar investment giving listeners an understanding of how the viability and emission reductions with solar investments can change in various situations.

The energy page on the cottonInfo website was updated to include the reports and key findings from Milestone 1.1. Links will be added for the journal papers from Milestone 1.3 and 1.4 once they are published.

The extension of this project will be continued into the next project with the findings from the later Milestones (1.3 & 1.4) ear marked for inclusion into further myBMP and CPM updates.

- ***Contribute to the extension campaign to provide information and raise awareness on the emissions footprint and least cost emission reduction scenarios or broad-acre irrigated and dryland cropping.***

This objective was addressed with Milestone 1.1 – 1.4. The outputs for each Milestone outlined and discussed the emission implications of every investment option and management strategy analysed.

Outputs have been produced that will reach an extended audience including the cotton industry, broader agricultural community, scientific community and Government departments. The broad reach of the extension ensures that awareness is raised of the emissions footprint and various cost effective strategies for broad acre irrigated and dryland cropping.

Methods

3. Detail the methodology and justify the methodology used. Include any discoveries in methods that may benefit other related research.

The project conducted four case study analyses to consider the opportunities, benefits and risks involved in implementing mitigation and sequestration practices. The project focused on alternative energy investments for mitigation and improved input efficiencies.

In each study an overview including a literature review was presented to give context for the analysis and an understanding of the research question.

A case study approach was used to understand the application of alternative energy to real cotton farming businesses. The four case study farms included;

- "Kensal Green", Gunnedah (Scott Morgan) (Milestone 1.1)
- Krubi Farms, Wee Waa (Steve & David Boyle) (Milestone 1.1, 1.2)
- "Mirrabooka", Narromine (Andrew Gill) (Milestone 1.3)

- Auscott, Narrabri (Milestone 1.4)

Emission mitigation strategies analysed include;

- Installation of grid connected solar energy
- The utilisation of solar powered vehicles to increase the utilisation of solar energy
- Installation of a microgrid comprising solar energy and a diesel powered generator
- Installation of a microgrid comprising of solar energy, battery storage and two diesel powered generators
- Rotational strategy of 100 per cent cotton – pulse rotation
- Utilisation of enhanced efficiency fertilisers (EEFs) on cotton
- Planting a tree lot
- A combined scenario of pulse rotation, EEFs on cotton and a tree lot

Two key economic methods utilised in the analysis of the solar and hybrid microgrid investments were discounted cash flow and partial budgeting. These methods investigated the stream of benefits and costs over the life of the investment, resulting in an expected return per dollar invested, expressed as internal rate of return (IRR). Whole farm gross margin budgeting was used to compare the emission reduction strategies in Milestone 1.4 with results discussed in terms of whole farm gross margin and marginal cost per unit of CO₂e abated.

Several proven software tools and models were utilised within the analyses. Solar design and output information were created in the bankable modelling software HelioScope (used Milestone 1.1, 1.2 & 1.3). The microgrid investments in Milestone 1.2 and 1.3 were analysed using HomerEnergy a sophisticated software tool for modelling cost effective microgrid scenarios. The environmental impact in terms of emissions was reported for each analysis. Emissions were modelled using the FarmGas Calculator Scenario Tool (ST) developed by the Australian Farm Institute (Australian Farm Institute, 2016) (Milestone 1.4).

Where there was uncertainty within an analysis assumption, additional analysis was conducted. The sensitivity analysis indicated the change in economic results and emissions, should any of the key variables change. This rigour allows the reader to understand how the model works and the key factors that contribute to the economic feasibility of an investment or management change. By having this understanding the readers are able to consider and apply the theory to their own situation.

Results

4. Detail and discuss the results for each objective including the statistical analysis of results.

Current government renewable energy policy, increased energy costs, advances in solar technology and falling cost of solar installations have all aligned to create a good opportunity for cotton growers to employ renewable energy pumping systems that will reduce both on farm costs and carbon emissions.

The project attributes that are key to the feasibility of a grid connected solar investment are the net cost of the installation and the benefits generated by the utilisation of the solar energy.

The net cost of the solar installation is dependent on the installation cost of the system and the payment of Government incentives such as Renewable Energy Certificates (RECs). The considerable reduction in the cost of solar installations has meant that the RECs subsidise a significant proportion of the installation costs. Within the case studies this subsidisation ranges from 28 per cent of a whole new pump site (Milestone 1.3) to 49 per cent of a solar installation on an existing pump site (Milestone 1.1). Rebates from RECs is reducing down each year (2015-2030) until another policy is put in place. On a 100kw system, the rebate is reduced by approx. \$5,400 each year.

Benefits generated by the use of the solar energy include feed in tariffs (FITs) and avoided costs of; energy (such as grid electricity or fuels), labour and emissions. The avoided electricity costs are those costs that would have been incurred without the solar installation. In the case studies analysed these are the variable cost of electricity and/or the cost of fuel. The higher the proportion of solar electricity that is used to pump water, the higher the avoided costs and the higher the project returns.

The internal rate of return (IRR) for the scenarios ranged from 2 per cent to 21 per cent (both Milestone 1.3). This large difference in returns comes down to the amount of pumping using the solar energy source. The higher the proportion of water pumped using the cheapest energy (solar) the higher the returns.

In Milestone 1.4, management strategies for emission abatement were analysed. Each abatement option came at a varied cost from \$519/t CO₂e to a benefit of \$1566/t CO₂e. The strategies with an increase in area grown to the high value chickpea crop improved the whole farm gross margin. These results are highly sensitive to the value of the chickpea price, which was analysed in the sensitivity testing. At a 30 per cent premium to urea, the EEFs are the most costly emission abatement strategy at \$519/t CO₂e. The EEF premium is also discussed in sensitivity testing. The EEF strategy is also the easiest to implement with minimal disruption to the existing farm operations.

Emissions

The installation of solar technology on farm is an environmental consideration. By substituting fossil fuels such as diesel or traditional grid supplied energy with renewable energy, emissions are avoided. This can be substantial and is a clear environmental benefit. In all scenarios analysed across the project, avoided emissions over the 25-year life of the project for energy investments, ranged from 546t to 2,838t (Milestone 1.3). With CO₂e valued at \$10/t, this equates to an environmental benefit of \$5460 and \$28,380 respectively. Scenario analysis shows that emissions reductions will increase or decrease with changes to project inputs.

In terms of operational emission reduction strategies, the study in Milestone 1.4 indicated that estimated on-farm emissions for a large broad-acre cropping enterprise can be reduced by changing land use, cropping enterprises and fertiliser programs. A combination of these strategies, if successful, can lead to substantial reductions in whole-farm emissions and emissions intensity per cotton bale by as much as 33 per cent.

Altering cotton crop rotations to increase the area of pulses has shown a reduction in GHG and an increased profit with the chickpea price at historic high levels. Opportunities will exist to reduce emissions and increase profits; however, as a long-term emissions abatement strategy (which assumes historic average pricing), including a pulse rotation is likely to be costly with a low impact on emissions.

One of the scenarios (in Milestone 1.1) indicated improved project returns and increased avoided emissions with energy being used to charge electric vehicles. The scenario was analysed as an indication of the results when some of the solar energy can be utilised for a purpose in addition to irrigation. Depending on the location of a solar installation, charging electric vehicles may not be a practical solution. It should be noted that the addition of batteries (whilst not considered within this study due to the technology not being commercially feasible at the time of the analysis), would change the patterns in which the solar energy produced was used, thus changing the feasibility of the investments dramatically.

Farm investments and/or management strategies are generally made trying to achieve several objectives simultaneously. A solar installation may achieve the objectives of; lowering emissions, reducing cost and reducing exposure to electricity price fluctuations. In Milestone 1.2 and 1.3, the installation of the Genset in addition to the solar maximises pumping capacity during the critical summer growing months when water is demanded, however the Genset comes at both an economic and environmental cost. In both case studies, the Genset is the costliest method of pumping and produces the highest emissions. Ensuring water is available to meet water demanded by a crop is a key priority because the yield and thus income of the cotton crop was a major contributor to whole farm income in all case studies assessed.

Sensitivity analyses

Key variables within each analyses were adjusted to understand the relationship and sensitivity of the results to particular inputs. Conducting this analysis for a static model when inputs may change during the investment period reduces the uncertainty of the results and potentially allows them to be considered for other scenarios.

Outcomes

5. Describe how the project's outputs will contribute to the planned outcomes identified in the project application. Describe the planned outcomes achieved to date.

Outcome 1: Economic analysis developed that is tailored to cotton farming

All five analysis and outputs have been tailored specifically to the Australian cotton industry, significantly contributing to the industry's resources on energy. Those farmers interested in investing in solar installations now have sound, tailored economic information available to them that they can consider. The thorough discussion and sensitivity analysis gives the reader a clear understanding of how an energy investment or emission reducing management strategy may be implemented as well as the potential change to gross margins.

Outcome 2: Economic analysis of reduced emissions and improved input efficiencies undertaken for case study cotton farming scenarios

A case study approach was used for all four of the project Milestones. Emission reducing energy investments were discussed in Milestones 1.1, 1.2 and 1.3. And emission reducing management strategies were analysed in Milestone 1.4. By applying actual and hypothetical scenarios to a case study farm, readers can understand the application in the context of real cotton farming businesses.

The four case study farms varied in management structure, size, access to water and energy requirements. To broaden the relativity of the results, sensitivity analyses were conducted on the key inputs in ensure the reader could clearly understand how the scenarios may be applied to a farm with different resources or requirements.

The results for each case study have been clearly outlined and discussed in the outputs listed in Section 2 and 9.

6. Please describe any:-

a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.);

n/a

b) other information developed from research (eg discoveries in methodology, equipment design, etc.); and

n/a

c) required changes to the Intellectual Property register.

Nil. All methodologies and key findings were published.

Conclusion

7. Provide an assessment of the likely impact of the results and conclusions of the research project for the cotton industry. What are the take home messages?

Investing in renewable energy pumping systems can be a feasible investment to reduce emissions for broadacre irrigation farms. The feasibility of an investment in solar or a microgrid will be highest when; solar energy produced can be utilised throughout the year and electricity or fuel costs are high. Until batteries are commercially available, or electric vehicles are a practical solution, realistic estimates of long term pump use and anticipated energy prices are the key factors for those considering a solar or microgrid installation.

In terms of operational management to reduce broad acre irrigation emissions, from year to year different strategies may be more attractive depending on commodity pricing, disease status and environmental conditions. These variable farming conditions need flexible and adaptive approaches by farm management. The combined scenario (Milestone 1.4) which incorporates three modelled emission abatement strategies pulse rotations, EEFs and a tree-lot indicates how in practice, farm managers could use a combination of strategies to achieve emission reduction goals.

Opportunities exist for farm owners and managers to make investment or operational decisions that can improve gross margins and reduce farm emissions.

Extension Opportunities

8. Detail a plan for the activities or other steps that may be taken:

(a) to further develop or to exploit the project technology.

n/a

(b) for the future presentation and dissemination of the project outcomes.

The journal paper outlining the case study and results for Milestone 1.3 is currently in the review process and is yet to be submitted. Titled '*Investment analysis of solar energy in a hybrid diesel irrigation pumping system in NSW, Australia*'. The paper discusses at length the benefits, risks and practical implications of investing in a microgrid which also improves input efficiencies.

The paper (attached) is currently being reviewed by the third author Bob Farquharson (Senior lecturer (Economics professor at the University of Melbourne). Upon finalisation of the paper, it will be circulated for review to; Allan Williams (CRDC), Felicity Muller (Cotton Australia) and Sid Masilamani (Energy Made Clean).

The final approved paper will be submitted to the international 'Journal of Cleaner Production'.

The paper '*An irrigated cotton farm emissions case study in NSW, Australia*', was recently submitted to the international Journal of Agricultural Systems. The authors are committed to seeing both these papers through to publication as soon as the process allows.

Once both papers are published, an overview of the key findings and links to the papers will be included on the cottonInfo website as well as distributed to the cottonInfo team.

Janine Powell and Jon Welsh are entering into a contract to that includes continuing energy research and extension for the cotton industry from July 2017. This work includes updates for the energy content of the CPM which will incorporate key research findings including those in the above mentioned papers.

(c) for future research.

A three year workplan has been agreed for Janine Powell and Jon Welsh by CRDC commencing July 2017 with a component for Energy research and extension.

9. A. List the publications arising from the research project and/or a publication plan.

(NB: Where possible, please provide a copy of any publication/s)

Powell, J.W. and J.M Welsh (2016). Grid connected solar: Irrigation case studies. Available at; http://www.cottoninfo.com.au/sites/default/files/documents/Cotton%20Energy_GRID%20CONNECTED%20SOLAR.pdf.

Powell, J.W. and J.M Welsh (2016). Solar energy: policy setting and applications to cotton production. Available at; http://www.cottoninfo.com.au/sites/default/files/documents/Cotton%20Energy_SOLAR%20ENERGY.pdf.

Powell, J.W. (2016). 'Grid connected solar case study – Upper Namoi: Key variables & results', 3-minute thesis, 18th Australian Cotton Conference, Gold Coast

Bowman, R. (2016) 'The sums add up for solar powered irrigation', The Australian Cotton Grower, Oct-Nov, pp22-25

6th October, 2016. 'Using solar power to drive bore pumps is now economically feasible', Northern Daily Leader, Available at; <http://www.northerndailyleader.com.au/story/4211030/solar-power-to-drive-bore-pumps/>

Welsh, J.M. and J.W Powell (2016). 'Energy and irrigation: feasibility study', Case study results for grower (Unpublished)

Powell, J.W, Welsh, J.M and R.J Eckard (2017). 'An irrigated cotton farm emissions case study in NSW, Australia', Journal of Agricultural Systems, (submitted)

Powell, J.W, Welsh, J.M and R.J Farquharson (2017). 'Investment analysis of solar energy in a hybrid diesel irrigation pumping system in NSW, Australia', intended for submission to Journal of Cleaner Production

B. Have you developed any online resources and what is the website address?

No

Part 4 – Final Report Executive Summary

Provide a one page Summary of your research that is not commercial in confidence, and that can be published on the World Wide Web. Explain the main outcomes of the research and provide contact details for more information. It is important that the Executive Summary highlights concisely the key outputs from the project and, when they are adopted, what this will mean to the cotton industry.

Opportunities exist for farm owners and managers to make investment decisions or operational changes that can improve gross margins and reduce farm emissions.

The scenarios analysed within the project that indicated both improved farm gross margins and lowered emission include;

- Installation of grid connected solar energy
- The utilisation of solar powered vehicles to increase the utilisation of solar energy
- Installation of a microgrid comprising solar energy and a diesel powered generator

- Rotational strategy of 100 per cent cotton – pulse rotation
- A combined scenario of pulse rotation, EEFs on cotton and a tree lot

Investing in on farm renewable energy pumping systems can be a feasible investment to reduce emissions for broadacre irrigation farms. The feasibility of an investment in solar or a microgrid will be highest when; solar energy produced can be utilised throughout the year and electricity or fuel costs are high. Until batteries are commercially available, or electric vehicles are a practical solution, realistic estimates of long term pump use and anticipated energy prices are the key factors for those considering a solar or microgrid installation.

In terms of operational management to reduce broad acre irrigation emissions, from year to year different strategies may be more attractive depending on commodity pricing, disease status and environmental conditions. These variable farming conditions need flexible and adaptive approaches by farm management. Altering cotton crop rotations to increase the area of pulses has shown a reduction in GHG and an increased profit with the chickpea price at historic high levels. Whilst opportunities will exist to reduce emissions and increase profits at times, as a long-term emissions abatement strategy (which assumes historic average pricing), including a pulse rotation is likely to be costly with a low impact on emissions. The combined scenario which incorporates three modelled emission abatement strategies indicates how in practice, farm managers could have a more flexible approach using a combination of strategies to achieve emission reduction goals.

While opportunities do exist to increase gross margins and reduce emissions, every farm is unique in terms of resources and priorities. In each analysis, as the key variables change so do the economic results and emission abatement realised. The relationship each variable has on the economic feasibility of the investment or management change is clearly outlined so the readers can consider and apply the theory to their own farms and unique set of circumstances.

Adoption of feasible emission reduction practices or investments made in renewable energy pumping systems will result in lower inputs per bale of cotton, increased gross margins and lower emissions.