Sarah Clack:

We are going to have a quick overview of the Agriculture Energy Investment Plan as a whole from Anthea, and then we are going to have Adriana speaking about the on-farm energy opportunities that's been identified through the analysis of the AEIP assessments. We're going to have Julie speaking about the economic insights from farmers' energy journeys from the case studies that she's been doing. We've got Greg Morris here to speak about dairy energy at the Ellinbank SmartFarm and the work that they've been doing there with demonstrations and research. We've got Ian Goodwin speaking about the orchard agrivoltaics at the Tatura SmartFarm and Bruce Gill speaking about pasture agrivoltaics in solar farms and the work they've been doing there.

Sarah Clack:

We do have some time set aside for questions at the end, and we're going to hold all questions until the end just to make sure that we are keeping track and keeping to time and not blowing out too far because I want to get everybody away by our advertised 1:30. And we'll also have Anthea speaking a little bit about what's next.

Sarah Clack:

All right, so I'll pass over to Anthea to speak about the Agriculture Energy Investment Plan.

Anthea Derrington:

Thanks, Sarah. With the Agriculture Energy Investment Plan, it came about in 2016-17 when we noticed that energy prices had been steadily increasing and they were not expected to decline. So we did a survey in conjunction with the Victorian Farmers Federation. It was a survey where we got 215 responses. And we asked what was preventing farmers doing more to address the energy price increases. And no surprises there, one of the main things was the cost of doing anything and the uncertain return on investment as well. There was also uncertainty about what technology to choose to put on farm, and also farmers wanted to learn from other people, so to see someone else already doing it and particularly to learn from other farmers.

Anthea Derrington:

So as a result of that, in 2017, the Victorian government released the Agriculture Energy Investment Plan, and that's what we're talking about today. It was realised by the government that there was a real need to be able to work with the agriculture sector to really embed the ability for farm businesses to withstand the higher energy prices and to be able to withstand those into the future as well.

Anthea Derrington:

The purpose of the Agriculture Energy Investment Plan is to support Victorian farmers to improve on-farm energy efficiency and incorporate renewable energy into farming systems. It was also very much intended as a transition program and to be able to build that resilience to withstand future energy prices. What is interesting is we knew there would be some co-benefits, but there have been a lot of co-benefits. We've got some of them there in relation to reducing greenhouse gas emissions, improving efficiency of irrigation, and a whole heap of other benefits. And you'll hear about those as we go through the presentations.

Anthea Derrington:

What is the Agriculture Energy Investment Plan? There were five components. In 2017 when the plan was released, it was a $30 million plan. You can notice there's another $30 million on the screen because it was so successful and it was oversubscribed, and the government into 2020 provided another $30 million more. The main components, there were five of them, were free on-farm energy assessments. Those energy assessments were available for all farmers who had energy bills more than $8,000 per annum across diesel, electricity, and gas. And they came in two tiers. So for people who had bills between $8,000 and $25,000, there was a type 1 assessment. And for those who had bills greater than $25,000, there were a type 2 assessment.

Anthea Derrington:

In addition, once a farmer had an on-farm energy assessment, they were able to apply for a grant. And those grants were in a couple of tiers and there was a tier 1 grant that was up to $50,000 and a tier 2 grant which was for grants for equipment between $50,000 and $250,000. The grants required at least 50% contribution from farmers. There was also at times a special dairy component to support the dairy industry with things that we knew from the assessments dairy farmers would gain benefit from, and there was also a fast track rebate.

Anthea Derrington:

In addition to those two components, there is the demonstration components, and Greg will talk to you about those. There's some education and skills components, and I'll mention those at the end. And there's some excellent research which you will hear some of those today.

Sarah Clack:

Next, we've got Adriana speaking about the on-farm energy opportunities that were identified through the AEIP assessments. Adriana is currently working in government policy, but she's got a background in research extension and commercial business management. I'll hand over to Adriana to speak about our AEIP assessments and the opportunities that were identified.

Adriana Robaina:

Thanks, Sarah. As Anthea mentioned, there was a number of components to this program, and the one I'm going to talk about is the free on-farm assessments and the follow-up grants. And there's a lot of information we gathered for that, but I'm going to focus on who are the farmers that participated, what were the type of opportunities that the energy experts identified for them, and which of those opportunities the farmers were most interested in adopting. This piece of work is a collaboration between myself, also Crystal Rebello and Kelly Rossborough from our policy team, as well as energy experts from Sustainability Victoria, Rodney Pugh and John van Rooden.

Adriana Robaina:

We had two rounds of assessments and grants with what we call Round 1 started in 2018. And in that round, there were 794 on-farm assessments completed. We delved into 680 of those reports. We read them in detail and took out key information to analyse. In that round, those assessments progressed to 339 grants, and we analysed 328 of them. They represented 320 grant holders because there were a few cases where farmers put in for more than one grant. They would sometimes apply for one grant and then go back to implement another action later on and apply for a second grant. So yeah, we kept track of every action that belonged to each individual farm. Next slide, please.

Adriana Robaina:

In Round 1, the first pie chart there represents the sectors, what sectors the farmers came from. That green, the 48%, was the majority, represents dairy farmers. And the second-highest group was shown in that light orange were horticulture growers. So they dominated the participation in this round. And then there was around 5 to 6% from representing each of the other sectors such as meat and wool, other livestock includes pigs and poultry, and cropping and mixed farming. Other production included aquaculture and other types of processing such as the manufacturing of oil from seeds.

Adriana Robaina:

While dairy and horticulture were the major participants, the second pie chart there from Round 1, we found that when we looked at their total energy costs as a group, horticulture had the highest followed by dairy. And then when we looked at average per business, we can see that horticulture had on average high energy costs as did the other livestock industries, which is pigs and poultry. With their intensive farming systems, that was not surprising. We also got the breakdown in this chart. The green shows how much reliance was on electricity versus diesel in the reddish colour. Not surprisingly, cropping. Viticulture, we classified into horticulture at this stage. We do have further breakdown and I can provide more information later about viticulture in particular. So these are our overall grouping or categories, and then we did have sub-sectors and smaller categories under that.

Adriana Robaina:

This one shows what was recommended and what was adopted. The light green bars is the number of times these actions were recommended, and the dark green shows how many times they were adopted by the grant holders. This is looking at the grant holders only. Solar photovoltaics less than 50 kilowatts was the most popular opportunity and also the one that was adopted the most, and this is overall for all participants. The second most popular action was upgrading to more efficient equipment. That included upgrading milk vats, upgrading refrigeration in cool rooms. It was replacing equipment they had with a more efficient version. And variable speed drives rounded up the top three. As I said, this is overall. When we looked at individual sectors, there were some sector specific differences.

Adriana Robaina:

Here, solar was so popular that we actually broke it down into four groupings. I've got the solar PV for 100+ kilowatts, solar at 50 to 99 kilowatts, solar other is mostly using solar for water pumps, and solar less than 50 kilowatts. We've got the number of times they were recommended by the grant holders and the number of times they were adopted. If we look at the adoption rate, they ranged from 54 to 68%. I have to say it's not surprising that there's a pattern between what the frequency that something was recommended versus the frequency it was adopted because one of the conditions of the grants was that farmers could only adopt what was provided in their list of recommendations. Next slide, please.

Adriana Robaina:

And these are few of the other categories that were not so popular and we see lower adoption rates. Insulation, adoption rate around 25%. Heat pumps, adoption rate 20%. And renewables that did not include solar, other types of renewables such as wind turbines, the adoption that there was around 13% for this Round 1 period.

Adriana Robaina:

The assessors in their assessments, the farmers were provided with a simple payback. And when I say simple payback, it's simply the cost of the capital of the equipment divided by the estimate of what the annual savings are. It's pretty, it's a rough paper calculation, back of envelope type calculation. It doesn't take into account any interest that might be involved. It doesn't take into account ongoing maintenance costs, but it is just a bit of a guide. And there's a simple payback we see on average for each sector for the recommendations they were given.

Adriana Robaina:

And then we look at the simple payback. The first column shows payback based on the savings in energy only, and the second column shows what does the payback look like when we consider the co-benefits. You can see for cropping and mixed farming, which is livestock and crops, there was on average over 15 years in payback. But we looked at the co-benefits, that came down significantly to six to seven years. The reason for that was a lot of the cropping and mixed farms that were involved in this round of assessments did have irrigation. A lot of the energy upgrades that were being considered were involving irrigation, and therefore there were other benefits in terms of productivity, water savings, and so on. There were also some other recommendations that involved savings in labour or chemicals used for example.

Adriana Robaina:

Where there were major co-benefits, it was for insulation and system reconfiguration, which is a pretty technical classification, but that largely involved irrigation upgrades. Moderate co-benefits also found for upgrading to more efficient equipment or upgrading to different technology. And as I've mentioned, we saw a lot of examples of co-benefits being associated with productivity gains and water savings in irrigation. Other co-benefits that were identified included improving product quality, reducing maintenance costs, reducing chemical costs, and reducing labour.

Adriana Robaina:

We looked at, we calculated from the actions that the farmers adopted in Round 1 not just in terms of the savings that they could achieve on-farm but also what does it represent in terms of reducing greenhouse gas emissions for the industry overall. And in the dark green, we see the reduction achieved by the actions already adopted. The light green represents the potential to reduce emissions further through the opportunities that are still available. And the red line, which is quite small, very narrow amount there, but they represent opportunities that weren't captured in the grant. There was a lot of small items, low-cost repairs, maintenance that have a contribution to saving both energy and emissions. But because they're not a low-cost, we often heard from the farmers that they did it themselves. They didn't need to write up a grant application or include it in their grant application. So the changes that we can't capture through the grant process ourselves, but we suspect that farmers are adopting them from what they've told us.

Adriana Robaina:

Round 2, as I've mentioned, started in 2020. We've started just analysing the data. We've got quite a bit of way to go yet. But one of the first things we've noticed already is a different mix in farmers participating, much more cropping and livestock farmers involved in this round. Still good participation from dairy and horticulture, but much more of a mix. So Round 2 is the chart on the right here. I also have to say that... Sorry, go back. We did notice that there are some farmers from Round 1 who came back in Round 2 who had assessments done in Round 1 and then requested, applied for a grant in Round 2.

Adriana Robaina:

What we've shown in adoption is so far is where they got to at the end of Round 1, but we've realised that some farmers came back later so there's still ongoing adoption occurring. There's still, yes. So from those assessments, there's still actions being followed up and we'll capture more of that in Round 2. And so there's an extension of the adoption still occurring through the process.

Sarah Clack:

Thank you, Adriana. Our next speaker is Julie Harman. Julie's got a history and experience around energy markets and regulation, having worked for ABARES in Canberra and at the state energy regulator in Western Australia. Julie is currently one of our farm business economists and is part of our Energy Smart Farming team, and she's been undertaking economic analysis for case studies on the adoption of farm energy technologies. She's going to share some of those insights with us.

Julie Harman:

Good morning, everyone, and thank you, Adriana. That was a great point to let for me to lean into that. Yes, the journeys that we are seeing, which I'll speak about, which are those stepping stones from farmers who had limited information to start with who are now uptaking more energy technology either being self-funded or applying in Round 2 to put in more energy assessment. It really is a journey, and they're all on different parts of that journey.

Julie Harman:

The case study is a complementary to the other products that you're going to hear about today and also to the other webinars and podcasts and videos that are available on the Energy Smart Farming website. We have currently been undertaking a number of new case studies, which again are looking at participants that had an energy audit and received a grant in Round 1. And they will be available on the Energy Smart Farming website at the end of June.

Julie Harman:

We really wanted to highlight both the practical opportunities about providing more information to farmers besides the ones that had audits or haven't had audits. And we wanted to showcase a mix of energy technologies and insights across different industries. So we have covered all those key industries that Adriana has spoken about. And in the key technologies, it's the heating, it's the cooling, it's the pumps, the solar pumps, and other technology.

Julie Harman:

Very obvious, so we have done extensive research on the grants that were undertaken across the team, and it's very obvious as the others have said this morning that the adoption is all part of other benefits in whole farm planning. And that strongly comes across in the grant applications as well, that there is really a great deal of co-benefits that farmers have put thought into their energy plans, and they're thinking about business, environmental sustainability, and the choices that they make are as much driven by those as they are the components of the energy savings that they will acquire from adopting the new technology.

Julie Harman:

In talking to farmers, and we have spoken to many farmers across the last year, keeping pace with that dynamic nature of technology advances and information, too little or too much. So the audit was a great stepping stone for many of them to acquire that first set of information which has put them on that journey. Subsequent to that, many of them are looking at that next step in their sequence of investment to drive other savings, whether they be water savings or whether they be energy savings. With the newer technologies, if we're talking about perhaps battery, that's mentioned quite often that they've put solar in. And if they want to optimise the energy that they can use in the right situation for their business, then it's whether they go to that next step to get that optimisation if they don't undertake another energy audit.

Julie Harman:

In addition to the energy audits, that's what the drivers are for these case studies. And as we've been talking to farmers, there is a limited use at the moment of online calculators, but that is another tool into the future as we bring out more calculators that they can also access to look at the returns on the technology.

Julie Harman:

Adriana spoke briefly about simple payback. We also will be doing what we call the economic payback. And so we are looking there at what's your true cost of your capital, what would you return if you put in another investment. So basically we're allowing for interest rates and risk, but one of the ones we have captured also is looking at their future plans. So a number of the case studies, they are in expansion. Whereas simple payback is a point in time. So year 1, you're basically looking at what your benefits are and then you just use those same benefits for each year. In the modelling that we're doing for the economic payback, we're taking account of fact that as their operation grows, as they'll be using more electricity either in grain storage or another activities, that the benefits are calculated for what that is in a point in time.

Julie Harman:

Sequential investments is very important, and some of the audits that you'll read are very detailed on putting sequencing. So where you step to if you undertake a high-cost adoption of technology, where are your benefits after that? So if you're in a dairy and you make choices on a chiller which comes with heat recovery, what are the choices that you make after that? And one of the things we also are capturing are avoided costs because if you choose to go off-grid and a number of people have received grants or are in the process of going off-grid, it is what are the benefits for them of not having to connect to the grid that is also built into the economic payback you receive for going to solar and battery.

Julie Harman:

As I said, these are stepping stones, and the feedback from farmers that it was a terrific step. Some of them hadn't thought of taking an energy audit before, and one of the great outcomes was those low-cost adoption things that they could do to start with. And then within their business plan, they could focus on where do I want to spend my capital?

Julie Harman:

Also, in addition to the co-benefits, well, they are the co-benefits but some of them are complex to value in speaking to them. The case studies are particularly about highlighting those other opportunities. So product quality and risk came across very strongly. Some of these enterprises have had brownouts and issues with electricity, and they have to maintain food safety or they have to maintain a nursery. So it's very important to them to look at what's going to minimise the risk there. Extremely large operational benefits across the organisation, and that particularly comes across in the labour savings, that many of them were maintaining older equipment which required daily checking, multiple checking, was leading to water or wastage or other energy wastage. And so the grant gave them the opportunity to dramatically change their operational systems.

Julie Harman:

And people in OHS as well. So obviously, you can't put a dollar where you can, but we haven't on OHS because that depends on the risk of an event occurring. But many of these products, big machinery in cropping, whether you are doing labour and it's safer for them to be working in an orchard. And obviously when there's water and there's pumping, there are animal welfare issues so they get security of mind, and that can occur with very low tech, low tech being low value tech. And that goes into the water sensors which have been basically immediate payback for farmers or within one or two years.

Julie Harman:

What does the technology deliver for them or what do the outcomes tell us? That doing extensive research on the audits that were provided, obviously the audits focused on the technology in a ranking and also looking at individual technologies. What we saw that the realised energy savings are in line with what was within the audit, not withstanding that if there was an expansion of production in the period that we were analysing since they've installed it, that the expectations would be that you would often get higher energy savings. When I say longer payback energy savers can be smart choices, that is about capturing all the co-benefits. So it's very obvious from doing the work, the case studies, and they are highlighted that the opportunities are in co-benefits in addition to those energy savers.

Julie Harman:

So many, if it was a critical part of your operation to install a longer life asset, that may be cool room, insulation, that may be a chiller, that may be a greenhouse insulation, that these were integral to not only saving energy but driving your production savings forward. I did briefly want to mention energy tech and ag tech because the two go hand in hand. Farmers are thinking about how those two can work together. So you had the opportunity to also adopt sensors under the energy case studies as you do under the ag tech grants as well, the IOT grants as well. So that is working very well together.

Julie Harman:

What can the technology deliver? Very strong that reading through the case studies that farmers take information from the audits and from other farmers as expected. So do the numbers for your own individual situation because there are multiplicative benefits, and where you go forward for your business is driven by what your goals are for your farm plans. Understand your resource, use and costs. Really important particularly in if you're not got a constant load over the day, so if you're a dairy and you've got peak spots, but also if you've got pumping, that's a large benefit too. This is about electricity, to monitor your hot spots and where you can get into load shifting. And what you see after people have installed solar is that they'll then look to tools to shift irrigation as well. Smart tech, that's absolutely essential for providing the information so you can analyse and go forward with what you would like to install next.

Julie Harman:

As I've said, advice by an independent expert is very important, and always, always assess your co-benefits along with your direct energy benefits. And that came across both from the energy audits where they had asked some for more detailed information and also in their applications, that the grant applicants are very strong on considering co-benefits. There may not have been a dollar value on those, but they had included in the applications and it was certainly a key driver in them adopting the energy technology.

Julie Harman:

So thank you very much today. I just wanted to highlight that in the next slide that the case studies will be available on the Energy Smart Farming website.

Sarah Clack:

Next, we've got Greg Morris. Greg, he coordinates the commercial dairy farm operations at Ellinbank and works with the researchers to incorporate the scientific research that occurs there at Ellinbank. And so as part of Greg's role, he's involved in implementing and validating novel technologies such as our energy technologies that we've got at Ellinbank to improve the farm performance at a practical level. I'll hand over to Greg to speak about the energy technologies demonstrations and research that are happening at Ellinbank.

Greg Morris:

I'm based at the Ellinbank SmartFarm. Basically, this is where we're going to look at some of the things that we've implemented at Ellinbank and the idea behind that thing. Basically, the farms needed to undertake research and innovation for the agricultural sector, and a big part of that has been looking to demonstrate, develop, and showcase this ag tech. It's not only around the alternative energies things but a whole range of different tech that applies to the dairy industry, I suppose.

Greg Morris:

Personally within this project, I wanted to be able to implement this at a farm scale, I wanted to be able to demonstrate its suitability, wanted to look at the problem-solving issues with implementing this tech, and then finally refine and optimise this for farmers and for our farm in itself. So I've just got this little quote down here that was from one of the older neighbour farmers down there, dairy farmers. And when I spoke to them about this project and this programme, he said, "Well, it's better that you try all this stuff for us farmers," than they waste their money, which was quite relevant, I think.

Greg Morris:

Just a quick overview of the farm to, I suppose, indicate its relevance to the industry. Basically, the farm's here to provide a research-ready resource and that we operate well and truly on a commercial level. The farm is about 217 hectares in size, and about 175 of that is available to the animals for grazing. And we do have some support area as well, across the road. We milk about 450 spring calving cows, and they're producing around that 7,500 litres or 550 to 600 kilos of milk solids annually. We have 250 odd replacement stock there just at off farm, so they don't have to look after them, which is nice. And as mentioned, it's a pasture-based system, and about 60% of the diet is that pasture component. And then we look at feeding, but generally depending on price of course, around 1.8 tonne of grain per cow per year.

Greg Morris:

One of the interesting parts that was brought to my attention probably 18 months ago, two years ago was the idea that we were going to become the first carbon-neutral dairy farm, and then that's in the world. So there's a plan put together, and I suppose this is really just showing the different areas that we are focusing our research on. And it links right into the efficiencies or the work or research we've been doing on the farm. But yeah, we're just right now focused on reducing the carbon output and being energy-neutral.

Greg Morris:

Apart from the energy audit, which I think is the next slide I get to, we went through and did our dairy greenhouse calculator and really just focused on what the farm was contributing greenhouse gas wise. So we looked at our net farm emissions. We looked at what the major contributors of the greenhouse gases were and then tried to identify these areas where we could make these reductions. This pie chart just really shows where those major areas are that we could focus on.

Greg Morris:

The dairy electricity audit, we'd done this I think it was some time ago, 2017, and that again identified the different places where we could hopefully make things more efficient. We've got some stuff around there about our total consumption, what our total greenhouse gas equivalents were. And from the audits, we had our recommendations. So with that, we actually did start to implement some of those recommendations some time ago before this project started, and that's what we will go through in a second. But another quote during the time of this energy audit was, "Greg, just whack up 400 kilowatts of solar and you'll be carbon-neutral in no time." But that wasn't really what the project was about and not what we wanted to do here. We wanted to try and demonstrate or trial different options for alternative energies.

Greg Morris:

The first one we went through and put in, and this was probably the major one for the farm, was the solar system. The system's 99.2 kilowatts. Yes, a random number, but basically we had to try and keep it under the 100 because then the subsidies and so forth you need to apply for annually as over 100, yet you're classified as a power or energy supplier. So there's some graphs on each of these slides that show how the systems work, but I won't go into them too much. So basically from this, we found that the system supplying about 45 or between 15% and 45% of our dairy energy requirements, 15% being obviously through the winter periods and 45% in the summer.

Greg Morris:

The system does draw on the main supply for the battery to charge it during an off-peak areas or times. Excess energy is sold back to the grid. We've looked at our energy savings and what the estimates were and what we've been monitoring. They line up very, very well, and we're looking at these values here. Again, the greenhouse gas equivalent reductions worked out very well to what their initial estimates were, so the payback period on this system is about 10 years. The one thing that we are looking at doing is trying to refine what we can do with our batteries, trying to monitor or alter those periods of discharge for when we're trying to either cool milk or heat water.

Greg Morris:

Another part of the program, we installed a solar and battery system for our farm water supply. And again I think this was relevant not only to dairy farm but across a lot of different ag industries. Our stock water supplies is a gravity-fed system and there's a hill that we basically need to pump water up to. So we thought it would be a great idea to be able to supply this with solar so that it doesn't run the pump directly. It just supplies the grid itself to run that pump.

Greg Morris:

We found that the system is a 10-kilowatt system. We took the opportunity to trial a zinc bromine battery as opposed to the lithium one, and the efficiency of that has been working quite well. So it supplies about 20 to 40% of the energy requirements. And again that depends on how much water we are needing to transfer up the hill. The other things we found is that with this system, we can get about three hours of pumping when we're offline, which seems to be enough to keep those tanks topped up through the periods or through the night. And the payback period of that, which again was an estimate, is about 3.6 years.

Greg Morris:

One of the interesting ones that we've put in was both a vertical and horizontal wind turbine. Each of them, again, they're a demonstration system but it was being able to compare and monitor, one, I suppose the installation of these but also their efficiency. So each one is 5 kilowatt. They supply power back to the grid and into the battery. And the interesting part is the payback period of 34 years. And again what the estimates were and what we're finding are pretty much spot on. We did have some challenges with installing these. We went through and wanted to install them in the windiest part of the farm, but unfortunately there, our vertical turbine we put in here actually only lasted about four days and we've had some excessive storms come through and it destroyed it. So we're actually at the moment waiting for it to be replaced with a more robust version.

Greg Morris:

Again, the next one we looked at was the pumped hydro. Again, it definitely needs to be a demonstration. As you can see on the bottom here, the payback period for this system would be 183 years. So look, the way I see it is that if we are using a gravity-fed stock water system around a farm and we could implement this type of technology where the capital costs weren't so excessive, they might be worth doing. And that's what this system is about.

Greg Morris:

So some quick stats on this. Basically, we have the two tanks. The diagram explains it quite well. The solar feeds a 3 kilowatt pump. And when not pumping, it also supplies the grid. It takes about eight hours during the day for the solar to pump that water to recharge the top tank. And then once the top tank's full, basically a valve switches and the water run back down the hill it takes about six hours to go back down to the bottom tank and it's looking at producing about 10 kilowatt of power in that cycle.

Greg Morris:

Again, this has been an interesting one. We had some... The hot water services needed replacing, so we took the opportunity to install a heat pump system. Basically, we are wanting to heat these two tanks of 1,500 litres and needed to get that water to 85 degrees basically for our dairy washing hygienist system. Had some calculations in there on what it is using power water, and they're quite significant between the heat pump and electricity requirements. The payback period I think is quite good at 10 years. But the thing was that it did take a lot of integration. So again, I've got a little quote here. Basically when you're walking around the field days and the bloke say, "Well, just hook it up here, mate, and it pretty much comes out for free." Well, within this system, that wasn't really the case. It did take some, quite a number of modifications to suit our system and when we required that water.

Greg Morris:

The other one that's been very interesting has been the adoption of all-terrain electric vehicles. We shifted from quad bikes about five or six years ago and have gone through and looked at all manufacturers and variations of ATVs and had the opportunity to trial and implement the electric all-terrain vehicles. So there's some benefits to this. The noise has been great. They are easy to operate. The charging time, so probably note that it takes about eight hours to charge and three hours of driving. But three hours of driving, that's constant driving at full pace or full rate.

Greg Morris:

And again, we've got a few costs here. So I think the interesting ones are these annual repair costs. Now, these costs were taken off actual invoices that we've had for a number of years. And I think the main point here is this total cost after the three years and quite a significant change when you take the trading value into account between a diesel and an electric. And this quote here, I think that was actually me because I didn't ever think I'd say but I would take an electric vehicle. They're quite comparable.

Greg Morris:

The Ellinbank SmartFarm moving forward, and this is across the board and I suppose with all our alternative energies, but we want to still test and monitor all the components that we've adopted or installed on farm. I'd like to be able to refine the parameters to improve their performance, continue to identify and adopt novel energy technologies, but not only technology but ideas. We are looking at implementing and trying an anaerobic digester for a pasture-based system. So I think that's going to be an interesting thing moving forward. We're going to need to continue our enteric methane reductions through our research, continue to improve our milk performance production efficiencies, and still the main point is to assist, educate, and help inform farmers. And thank you very much. Yeah, that's it.

Sarah Clack:

Next up, we have got Ian Goodwin. Ian is a research leader in crop physiology in Agriculture Victoria based up here at Tatura at the SmartFarm. Ian's got nearly 40 years worth of experience in horticultural research and innovation with a focus on intensive production systems, crop water requirements, and climate challenges. And that has led Ian to being involved in the Tatura Solar Energy Projects and the agrivoltaics in the orchard. I will hand over to Ian.

Ian Goodwin:

Good afternoon, everyone. Just obviously this is going to be a pretty short presentation, and I'll try to be just providing an update of where we're at with a bit of background at the start.

Ian Goodwin:

The intended outcomes of overall of the Tatura Solar Energy Projects is to firstly support horticultural businesses to improve energy efficiency. And then the second dot point there is to support opportunities for agrivoltaics, which is obviously where I fit in with respect to the work we're doing in the pear orchard with solar panels. There's four objectives overall for the Tatura Solar Energy Projects. And as I said, the first one there I'll talk about what we're doing in terms of investigating solar energy generation and sun protection. And then Bruce Gill will subsequently talk about the work that he's been doing with agrivoltaics in large-scale solar farms.

Ian Goodwin:

This is just a bit of background. Fruit crops, they suffer from sun damage. As you can see from that middle photo, that's a pear that's obviously sunburned. And the incident of sunburn damage, particularly in apples and pears, has increased dramatically in the last five or six years as we've had more and more extreme events during the summer months. Although last summer, we did have one of the mildest, mind you it was average but compared with the previous seasons, it was a mild summer. And the slide on the right there is really to show that despite fruit crops suffering from sun damage, any fruit that is coloured requires sun for it to colour up. So that pear in the foreground in that photo was shaded for nearly the whole season with just a small umbrella over the top of it, small foil umbrella, and absolutely no colour developed in the fruit as opposed to the fruit in the background in that slide, in that photo where it's obviously developed colour. So there's a trade-off between making sure that we don't get excessive radiation but still requiring radiation for colour developments.

Ian Goodwin:

So 12 months ago, we completed the establishment of our experiment at the Tatura SmartFarm, and it is in a pear orchard, an experimental pear orchard. And it's a blush cultivar of pear that's marketed under the trading name of Lanya. What we did is we've set up, it's a replicated experiment where we've got two solar panel configuration treatments and of course comparing those with a control. So you can see from this slide that one of the particular treatments has got solar panels at 45 degree that is facing to the west, and then there's a solar panel treatment that's where the panels are basically flat. They're slightly configured a little bit differently, those two solar panels where the ones to the west are positioned so that they shade the trees in the mid-afternoon, whereas the flat panels are directly above the canopy so that they're shading the majority of the foliage and fruit at midday.

Ian Goodwin:

This slide is really to just show that of course we're generating electricity from the experiment that then is used to demonstrate the concept of being able to store that energy, operate an irrigation pump. In our particular case, it's the pump that irrigates the entire experimental pear orchard, and of course any of that excess power is going into the grid. So it's to demonstrate that small scale type energy system.

Ian Goodwin:

Here are some of the results. This is just the energy that production from the flat versus the 45 degree west-facing solar panels. The flat ones, they had slightly higher levels of energy production for most of the year and maybe in winter time, which is probably just really quite insignificant because of the amount. The 45-degree west panels are generating a little bit more energy.

Ian Goodwin:

Some of the physiological type results. We were lucky enough to get a student from University of Melbourne to do some work last winter where he was measuring the bud and corresponding air temperature. So in that photo there, what the student did is he stuck a very fine wire thermocouple into the flower bud so that he could measure the temperature of that bud during the winter months. And from that data that he collected, he calculated the amount of chill that that bud was receiving because of course fruit trees require winter chill so that they actually do flower and set a crop. And what he found was that under the solar panels, there was an increase in chill accumulation.

Ian Goodwin:

And he looked more closely at the data that was being generated as per that graph there, and it showed that firstly under the solar panels, the nighttime temperature wasn't dropping as low and then during the daytime, the temperature was not getting as high. And of course with respect to chilling, there's an optimum range where you'll get chill accumulation in the developing bud. So basically that was an extended period during the day of being able to accumulate chill.

Ian Goodwin:

He continued on doing those measurements during the flowering period. You can see the actual thermocouple that was stuck in the bud, most of them fell out when the buds started to produce a flower. So this is just purely the air temperature data next to that flower, and you can see that, as I said a minute ago, during that flowering period, the red squares are our control and the other two coloured points are our different solar panel treatments. And there's about a half a degree difference with the control being lower temperature, which the reason why I'm presenting this is because there's potential control or prevention of frost damage. Obviously last year, you can see that there's not too many negative temperatures there during that flowering period in spring, but in some years we do get negative temperatures which can have a severe impact on fruit set and initial fruit development.

Ian Goodwin:

We also did some measurements of fruit surface temperature because fruit surface temperature is the determinant of whether the fruit gets sunburned. And so we stuck again. We used the fine wire thermocouples and we pricked the skin of the fruit and stuck them just under the skin, measured the temperature of that surface. And you can see from the graph there that on this particular day in the middle of summer, air temperature was somewhere around about that 30, 35 degree maximum, whereas the fruit surface temperature in the control which is the red line and in the 45-degree west-facing panel which is the blue line, you can see in the control the temperature of the fruit surface is getting up around 48 degree Celsius, which is really close to getting sunburn damage.

Ian Goodwin:

We've actually reported thresholds for sunburn damage in pears and it's about 48 degrees. And of course the 45-degree west-facing panels have shaded the fruit in the mid-afternoon where the temperature there drops right down the blue light. But then as the sun of course goes down, you're getting radiation hitting the fruit again later in the afternoon and it comes up again. But that's sufficient to avoid sun damage.

Ian Goodwin:

This is the last snapshot of some of the results we found last year where we actually of course measured the sunburn damage and we found that the control treatment had about 3% of the fruit that was harvested was sunburn damaged, whereas the two solar panel treatments had really insignificant amounts of sunburn damage. A bit of difference there between the 45-degree west and the flat one. But again, that's not significant different. The graph there is of hue angle, which is a measure of colour, red colour. The lower the number, the more red the fruit. And so you can see from that particular graph that the 45-degree west and the flat treatments had less red colour on the fruit, this is at harvest. Whereas the control had higher red colour. So if you like, that's a bit of a negative result from the experiment.

Ian Goodwin:

And of course we are thinking about how we could try to modify the configurations or even modify the type of panels that are being used into the future so that you do get sufficient light for red colour development. Of course the other argument too is that there are green fruit that are growing in the Golden Valley, Granny Smith or Williams or Packham Pears where you're trying to prevent any form of sun that could cause discoloration in the crop.

Ian Goodwin:

So yeah, the work's going to continue for another 18 months and hopefully we'll be able to continue to collect some pretty good results and come up with some new ideas and thoughts. So I'll leave it there. Thanks, Sarah.

Sarah Clack:

Next up, we have got Bruce. Bruce is a senior research scientist with Agriculture Victoria based at Tatura at the SmartFarm here. He's got over 35 years of experience in agriculture and environment fields, including hydrology of salinity and water supply, catchment management, and water resource management. More recently, Bruce has been working in the area of agrivoltaics which is part of his... He has a bit of a curiosity in renewable energy opportunities for farming systems. I'll pass over to Bruce to speak about the work that they've been doing with the agrivoltaics and pasture.

Bruce Gill:

Firstly, thanks, Ian, for giving a bit of the background to the... This is the second of the Tatura-based Agriculture Energy Investment Program research projects. I'd also like to thank Dr. Jane Rogers who's our pasture agronomist-botanist working on the pasture component of the project, ably assisted by technical officer Tony Cook. And we had very valuable technical support from Mike Morris who enabled our remote monitoring systems at the two commercial solar farms to operate and touch wood are still working today.

Bruce Gill:

So yeah, basically we are wanting to look at the forage production potential under solar panels. And the photo there shows one of the weather stations, automatic weather stations and various sensors associated in the mid-row in the middle of a large area of panels. And we're collecting continuous microclimate data, so the various weather parameters plus soil moisture and temperature at a couple of farms. We've also got similar stations placed outside of the panel fields for comparison.

Bruce Gill:

And the project also includes the field trials of six pasture species in some plots that are placed underneath from side to side of the panels. You can vaguely see the pegs in the ground there. And we've now run for about nine months since all the equipment was installed and switched on and the pasture plots were planted, one in May last year and the other one in August I think it was.

Bruce Gill:

As a result of having automatic sensors, it's great. We don't have to be there to record things. We don't have to download loggers. We get this continuous stream of lots and lots of data points. So about I think 2 1/2 thousand data points a day from 600 per day from 15-minute intervals. So this is a typical plot of the month of December temperature data, the brown line being the outside panel field sensor and the green in the panel field. And so when you zoom in, you can, a bit like some of the data Ian just showed, you can see there's a slight separation between what we're measuring within the panel field and what's occurring just out or outside of the panel field.

Bruce Gill:

And so these subtle influence, subtle variability is what we are looking at. One of the outputs we need is to gather information that we can then use for the pasture crop modelling programs that requires maximum temperature much like you can get from the Bureau of Meteorology from their SILO website. We've got now about nine months of that, or when I download May's data, we've got nine months of data for the two sites which Mary Jane will be using with the modelling. Likewise, next click, we've got lots of humidity data from the inside and outside the two sites. And once again, the subtle variation or slight change in the behaviour as a result of being inside the panel field.

Bruce Gill:

These are all factors that will influence the... Well, they may influence what the growing conditions and the outputs from the pasture trials are in the solar farms. Likewise, as you'd expect with the panels, and these are tracking stations, the panels lie north-south, on the wind rows there you can see that the wind tends to funnel up through the middle of the panels. If you can see the outside wind data, not only is it more angular or mainly from the southwest in November when that data is from, but you can see the yellow and reds at the end of that. The wind speeds are a bit higher outside compared to what's being measured inside at about the 2-metre height, 1.8-metre height in the field. So once again subtly different conditions within the panel field.

Bruce Gill:

I mentioned the pasture trials. At both facilities, these are northern Victorian solar farms, commercial solar farms, there's plenty, 20 long 9-metre by 1.5-metre plots. And these were sown in May and September last year and there was five plant species tested, listed there, including a native windmill grass. I almost had the name of it on the tip of my tongue. And at one of the sites, we planted lucerne instead of all annual ryegrass. And measurements have been made to date on those trials plant establishment and the percentage of ground cover and the dry matter production. And there's been several cuts being made now at both sites throughout the measurement period.

Bruce Gill:

And this is a graph just of the early plant establishment data from one of the farms. And you can see that the area between the panels and under the drip lines where the rain and the moisture was able to get, significant difference there. And there's usually seems to be a dry patch pretty much under the rain shadow of the panels, which is not unexpected. But as the plants and the season progressed, the results are now fairly consistent that the dry matter production and the plant density was significantly influenced by the position of the plot under in respect to the solar panels. And the plant production have been greatest under the drip lines compared with either the panels or between the panels, especially as the season dried out.

Bruce Gill:

And the photo there just shows you one of the more recent or February, I think it was, the photo shown, the kikuyu enjoying the shade under the panels there during the heat of summer when a lot of the other dry land pastures of course have dried out and the plants have either senesced or stopped producing. So some real data there about what the conditions for growing pasture have been like in amongst the panels.

Bruce Gill:

Some of the more graphical outputs from the measurements, field measurements, and the perennial rye grass showing quite good right ground cover in November and dropped off a bit. And then the green bars being the drip line where the extra moisture captured off the panels perhaps is encouraged and supported a bit more growth during the heat of summer from some of the few rainstorms, rain showers that have fallen on the sites. And one of the key issues for the solar farm managers is having plant species that will keep low to the ground. One of the key management issues is managing fire risk. So interest in some of the ground cover plants and particularly kikuyu or some of the other creeping grasses might be more suitable.

Bruce Gill:

Anyway, we've got some real data now upon which we can get some practical understanding and we're looking now at trying to make sense of all the data we've got and extract the key learnings from it. And one of those is that you can see and it stands to reason that the just slightly different growing conditions. And it's the same, similar to what we've found in the horticulture, that the panels don't exert a huge amount of influence but they are subtly different. And likewise, the wind data shows that the conditions under the panels perhaps a little bit more benign for sheep production systems.

Bruce Gill:

So we've now got the weather data we can use for the modelling, and one of the key outputs, we want to be able to have a more definitive guidance and agronomy advice in relation to the pasture and animal production within solar farms because ultimately the solar farms are a real need and they are in existence now across large parts of northern Victoria and New South Wales and inland areas in New South Wales where the sun energy resource is strong. So trying to find the best production system that can reduce the cost for the agrivoltaic production and also in the livestock production systems and then ultimately, reducing greenhouse gas emissions, improving water use efficiency. And there's also the regional opportunities that come from generating those dual use outcomes from agricultural land. So I'll leave it there, and thank you. You see some sheep enjoying the shade there.

Sarah Clack:

Thank you, Bruce. All right, so now we have some time for some questions. And so we've had a few questions come through already so we can start with those. But if you do have some questions, please feel free to put them into the question and answer box, please. So the first question is, did you get any impressions during the analysis as to whether there were many other farmers doing this type of energy efficiency work outside of the grant system? That would be for Julie or Adriana or maybe even Anthea?

Adriana Robaina:

Yes, we did, Sarah. There was a piece of work on behavioural research that was done by Monash researchers for us, and they did interview farmers both within the program and outside the program. And there were some similarities and differences, but yes, there were farmers outside the programs interested in energy and in making changes of their own.

Sarah Clack:

Fantastic. Thanks for that, Adriana. I've got a question here. Can you make available electricity interval data for the pumped hydro pump, the PV battery heat pump, et cetera? So that might be one there for Greg around the work that's happening at Ellinbank and making that data available.

Greg Morris:

Yeah. Well, Adriana or Anthea might be able to help with how we make that available, but basically yeah, it's all being monitored via either the particular apps that link into each system. And we do have some separate electrical monitoring looking at the peak power usage. But yeah, how we'd make that available to the public I suppose needs to be worked out. But it is all there, yeah.

Adriana Robaina:

We have a live dashboard of the demonstrations at Ellinbank on the Energy Smart Farming website, and the pumped hydro is the latest of the installations. So we're investigating how to download the data to how to monitor the data and add that to the dashboard as well.

Sarah Clack:

Thanks, Adriana and Greg. There's another question here for you Greg. What is the energy efficiency of pumped hydro verse electrical batteries as energy storage in terms of kilowatt-hours in compared to out...

Greg Morris:

Again, I think they're the sorts of things that we do need to get into and start being able to apply to either the case studies within the Energy Smart dashboard. But off the top of my head, I probably can't give you an answer. But again, it's something that needs to be sorted out because there is always those questions asked that'd be nice to be able to give a good, easy answer.

Sarah Clack:

Thanks, Greg. The next question we've got here for Bruce, is there any chance of stock damaging panels or electrical connections?

Bruce Gill:

What we've learned anecdotally, I guess, from the companies is that no, the sheep are certainly the preferred animal because unlike goats, they won't climb. They're pretty benign living underneath the panels, mind you, that's only one of the farms actually has, I think there was 3,000 head of sheep on there last spring and then they lambed. So yeah, so as far as I know, there is a slight risk of entanglement of sheep in the drive shafts but that's just, there was only one minor incident that I'm aware of. It might've been more, but yeah, so you wouldn't want to put cattle in there because the panels aren't set high enough to prevent them being interacted with.

Sarah Clack:

Thanks, Bruce. There's a question here, and this would probably most likely for Greg. Was the battery charge discharged at Ellinbank controlled to optimise on-farm consumption?

Greg Morris:

We're in the process of making that possible so we needed to provide some connection between the inverter and the controller as well as the power supply. But basically, we can manually go through and adjust when that battery discharged. So basically, we were just trying to do that during those peak periods which was obviously through our milking, well it was really through the cooling process of keeping the vats cool that required the most power. So initially in a manual version, but looking at trying to have that automated to adjust as required.

Sarah Clack:

Thanks for that, Greg. And it'd be really interesting to see how well optimised we can get that battery and solar system there at Ellinbank. Someone's just written a report on demand management protocols for an international agency. What protocols, a battery pump, heat pump, et cetera, support assists online platform access, avoids vendor lock-in? And maybe this can be considered for future rounds. That might be a question that may not be able to be answered, but feel free if someone is able to answer that, but we'll take that one on notice for now. There's a question here for Greg again. That they've read that some plants like chicory and plantain and some clovers can help to reduce cows' methane emissions. Is there any research around this happening at Ellinbank as part of a mixed pasture diet?

Greg Morris:

I know there has been some work looking at the different plant species of those mixed swards regarding methane emissions previously. I know that there's nothing that I can think of coming up in the near future, but the one thing that we have put in place or introduced is some in-vitro work or lab studies that'd be able to give us some initial ideas of those different swards and the applicability to reducing methane. So I think there's some collaborative work coming up. I think the University of Tassie are doing some work on mixed swards and its suitability to dairy systems. So yeah, look, I think it's definitely something we're going to or should be looked into.

Sarah Clack:

Thanks for that, Greg. I know that one was a bit off-topic, but it's a really good question though. There's a question here for Julie. Were there any surprises in your economic analysis of the case study farms?

Julie Harman:

I guess surprises in the sense that the information set that we had was in their application, which was focused on energy savings as for the dollar values that came out of the audits. What was surprising is that when you started to quantify in the case studies, because that's what it's about, the other savings that they were that are really substantial. And of course reduced your payback period.

Julie Harman:

The other thing that I found is that they'd use those initial savings to reinvest in the business, and that could be some of the case studies bought the same technology again. So if it was a weed sprayer in your orchard or solar pumping, that it worked so well that they basically could purchase another one of those products. And besides I guess the operational benefits as well, just reducing idle time, improving your OHS, and it really did give farmers a great information set. And it also gave them some literacy around looking at their energy and how to quantify it. And a number of those have done their own assessments since and have chosen to reinvest or make changes in their operations. So you're really going to see great product quality and output benefits, which is great for the farm gate production.

Sarah Clack:

Thanks, Julie.

Julie Harman:

Thank you.

Sarah Clack:

Ian, did you find that the horizontal panels required more regular cleaning compared to the tilted panels?

Ian Goodwin:

No, we haven't as yet. But it is a pretty important question because in an orchard environment, you can imagine the amount of potential residues that might actually land on the panels because of course we'd still have to spray the orchard, et cetera. But also, so no, we haven't found any difference yet. But the flat ones, I've told a little bit of a furphy there because they're actually not completely horizontal. They actually have a slight angle to them, which we had to build into the system so that you would get that rain washing the panels occasionally. So they're at about a 5-degree slope.

Sarah Clack:

Thanks for that, Ian. There's a question here around where do we find out more about installation of solar panels and lithium battery for our dairy and pumping of underground water? What company sells and installs this equipment? And are there any grants currently available to assist with this project? So there is a range of resources on the Energy Smart Farming website, and we've got a resource page there that links to a number of different resources available that are relevant to farmers. And there is, for grants, there is currently a solar rebate for businesses available. Other than that, there's nothing else coming to mind unless another speaker has anything that comes to mind there.

Fantastic. All right, so we've only got a couple of minutes left and we've got Anthea to discuss around the next steps or what's coming up next. So I'll hand over to Anthea to give a rundown of that.

Anthea Derrington:

Thanks, Sarah. So there's been quite a few mentions of the Energy Smart Farming website, and Sarah has very kindly included the link there on the slide. And we strongly recommend that you have a look at that, tell a friend, ask your friend to tell a friend about what's on there. There's a range of new things coming up, as Julie said. There will be the case studies that she's provided. There'll be information from the material that Adriana provided. There'll be case studies about using the Victorian Energy Upgrades program, which does provide some quite significant financial benefits, it's not grants, but it does provide another avenue for being able to fund some of your programs.

Anthea Derrington:

The work that Bruce and Ian spoke about in terms of agrivoltaics is there in relation to the effect of solar panels on fruit. So you can find that article there already. The demonstrations that Greg mentioned are up there, including the dashboard. And the dashboard shows what's happening on a daily basis and monthly basis in relation to the pumping from the dam for stock water, what's happening in the dairy, our horizontal turbine, and also our solar and battery as well. So you can see exactly what's happening every day, which is very good. And there will be more research coming. Greg mentioned an anaerobic digester that will go out to Ellinbank, and there's another power of research that's still happening that will be there.

Anthea Derrington:

So also, I should mention. Our colleagues in New South Wales who we share the Energy Smart Farming platform with have a great range of articles on there about diesel and a whole range of other things as well. So please go and check that one out and tell your friends. Thanks, Sarah.

Sarah Clack:

Thanks. Thanks for that, Anthea. Yes, and definitely there's some amazing videos there, Exploring Beyond Diesel, that our colleagues at New South Wales DPI, in particular John O'Connor, have been involved in. So thank you all for being involved today and joining us today. Thank you to all of our speakers, not only for presenting today, but all the work that they have put in over the last couple of years on these projects.