Final report

Trial of Electric Two-Wheel Motorbikes on grazing properties

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Abstract

Electric Two-Wheel Motorbikes were trialled to compare safety, weight, and fossil fuel use relative to quad bikes as a mode of personal transport and mustering on farm.

The trial was conducted as there have been over 240 quad bike related deaths in Australia (Safe Work Australia), additionally, a number of popular manufacturers of quad bikes will be withdrawing quad bikes from the Australian market by October 2021 due to Australian government mandatory roll over protection laws. Electric two-wheeled bikes may expand the selection of machines for mustering and checking stock, as they are lighter and more manoeuvrable. Electric bikes charged with renewable power, align with the Australian Red Meat Industry's Carbon Neutral 2030 Initiative.

There were over 15 electric bikes found to be suitable for personal transport options that could potentially benefit the grazing industry. A representative sample was secured with five models ranging from a 2 kilowatt (kW) pedal-assist pushbike to a 9 kW full-size dirt bike.

The bikes were well received farmers as the preferred option for personal transport and mustering due to ease of operation, safety, low-noise, low operational cost of ownership, light weight, minimal maintenance, no gears or clutch and the ability to transvers terrain not passable by other motorized modes of transport.

Executive summary

Background

The trial was conducted to compare safety, weight, and fossil fuel use relative to quad bikes as a mode of personal transport and mustering on farm.

There have been over 240 quad bike related deaths in Australia (SWA, 2020) and over 600 hospitalised injuries on average per year. The cost of quad bike and side-by-side vehicles in terms of deaths and injuries in Australia is estimated to be $200 million annually (ACCC, 2018).

Electric two-wheel motorbikes needed to be tested on farm to ascertain their suitability and evaluate the claims of being more easy to ride than conventional two wheeled motorbikes, with no clutch or gears, lighter weight, more controllable, trackable power, no noise, heat, carcinogenic fuel, oil or fumes and have a lower lifetime cost of ownership.

Objectives

- Research current and emerging electric two-wheeled off-road bikes for their suitability as personal transport for farm use.
- Secure at least 3 electric two-wheel motorbike models that may suit farm work.
- Trial the electric, two-wheeled motorbikes, on at least 5 grazing properties.
- Compare livestock behaviour to electric vs petrol powered bikes, using video footage for mustering and livestock inspection.
- Compare the electric bikes to petrol bikes in performance, maintenance, and cost, compiling a table of specifications/statistics and costs. Include cost/benefit analysis, considering economic impact (cost of buying and running bikes vs improved mustering, running costs etc.), environmental impact (reduced GHG emissions etc.), and social impact (improved safety etc.).

Methodology

The methodology was to test a possible 20 bikes and the primary criteria for selecting electric bikes were: Weighing less than 130kg (to conform with traditional two-wheeled Ag-bike weights); Have off-road orientated suspension and handling, able to be ridden over dirt, gravel, grass, and small obstacles, consistent with general traversing and mustering of grazing properties; Wide range of sizes and designs to gauge suitability.

Results/key findings

Farmers involved in testing the electric bikes were surprised by the refinement of the electric motors and the integration into different two-wheeled variations, from a pedal assist, to full size dirt bike. Most riders preferred the full-sized electric bike, as it felt like their traditional bikes with the added advantage of quiet operation, no gears or clutch, light nimble handling, and no engine maintenance. The majority of farmers in the test panel identified a need for storage on the bikes and a preference for a larger seat. The battery range was sufficient for 4 hours of slow mustering or around 50km of faster riding. One full charge costing around 50c. Sheep showed little variation in reaction if mustered by an electric or petrol bike. Cattle accustomed to petrol powered bikes, were

initially spooked by the electric bikes with the absence of engine noise. Once accustomed however, cattle settled well with electric bikes working around them.

Benefits to industry

A move to electric two-wheeled bikes would:

- Greatly improve the selection of transport modes for the job.
- Slash the cost of personal transport and mustering.
- Cut CO_2 emissions when charged with solar or wind power.
- Give managers the ability to limit speed and power on bikes.
- Reduce accident injuries from death by quad bike, to bruises and grazed elbow and knees.
- The image of farmers on electric bikes is appealing to the public, improving licence to farm.

Future research and recommendations

- Testing the next generation of electric two-wheeled bikes, to be released by 2022.
- Continue long term testing and reporting into the lifespan and maintenance costs.
- Develop a solar charging station that can be placed at remote yard locations
- Expand testing into 4x4 pick-up trucks due for release in 2021 to 2023
- Link to www.electricoffroadbikes.com.au where results are published.

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1. Background

The trial was conducted to compare safety, weight, and fossil fuel use relative to quad bikes as a mode of personal transport and mustering on farm.

There have been over 240 quad bike related deaths in Australia (SWA, 2020) and over 600 hospitalised injuries on average per year. The cost of quad bike and side-by-side vehicles in terms of deaths and injuries in Australia is estimated to be $200 million annually (ACCC, 2020).

Hospitalised, recreational riders in the US, who had been riding ATVs were 50% more likely to die, and 50% more likely to need treatment in intensive care, compared to the two-wheeled motorcycle riders (Bowman, 2010).

Electric two-wheel motorbikes needed to be tested on farm to ascertain their suitability and evaluate the claims of being more easy to ride than conventional two wheeled motorbikes, with no clutch or gears, lighter weight, more controllable, trackable power, no noise, heat, carcinogenic fuel, oil or fumes and have a lower lifetime cost of ownership.

Electric two-wheel motorbikes needed to be tested on farm to ascertain their suitability and evaluate the claims of being more easy to ride than conventional two wheeled motorbikes, with no clutch or gears, lighter weight, more controllable, trackable power, no noise, heat, carcinogenic fuel, oil or fumes and have a lower lifetime cost of ownership.

2. Objectives

- Research current and emerging electric two-wheeled off-road bikes for their suitability as personal transport for farm use.
- Work with electric bike manufacturers and dealers to secure at least 3 models that may suit farm work.
- Trial the electric, two-wheeled motorbikes, on at least 5 grazing properties, with participants to complete questionnaires.
- Compare Livestock behaviour to electric vs petrol powered bikes, using video footage for mustering and livestock inspection.
- Compare the electric bikes to petrol bikes in performance, maintenance, and cost, compiling a table of specifications/statistics and costs. Include cost/benefit analysis, considering economic impact (cost of buying and running bikes vs improved mustering, running costs etc.), environmental impact (reduced GHG emissions etc.), and social impact (improved safety etc.).

3. Methodology

3.1 Bikes to be assessed

Appendix 8.1 tabulates 20 possible bikes to be assessed, condensed from global manufacturers.

Of the 20 bikes the tested, models include, Volitation ST2000DH, Sur Ron Light Bee X, Ubco 2X2, Electric Motion E Trek, Electric Motion E Scape and as a petrol comparison the Beta XTrainer.

3.2 Assessment Criteria for selecting bikes

The primary criteria for selecting electric bikes was:

- Weighing less than 130kg (to conform with traditional two-wheeled Ag-bike weights),
- Have off-road orientated suspension and handling, able to be ridden over dirt, gravel, grass, and small obstacles, consistent with general traversing and mustering of grazing properties.
- Wide range of sizes and designs to gauge suitability.
- Research method for undertaking the demonstration and comparison

3.2.1 Technical Parameters

- Overall dimensions including wheelbase, seat height, weight, suspension, clearance.
- Performance including power, endurance, acceleration, weight carrying. (Comparison to a petrol powered two-wheeled motorbike.)
- Battery parameters: power stability, charge time, charge current kW.
- Video of livestock behaviours between electric and petrol bikes.

3.2.2 On-farm trial and questionnaire

Farm owners/staff on five grazing properties had the opportunity to ride all the different bikes on their host property for a day, though a variety of tasks as appropriate to their operation.

Once riders had experienced the bikes, they complete a questionnaire covering.

- Suitability for the task,
- Ease of operation,
- Power,
- Suspension, manoeuvrability, comparison to petrol bikes,
- Livestock response,
- Adaptability for the business and cost per km
- Overall suitability.

The questionnaire asks riders to provide a rating and comment.

There were also open questions allowing test riders to describe the best fit for each different type of electric bike.

The bikes were compared to a petrol-powered bike with lifetime cost of ownership and operation cost analysis, environmental impact of emissions, safety, livestock response and social impacts.

3.2.3 Long term testing

The primary researcher conducted over 2,000km of long term tests on their own property throughout the test period, cycling the batteries, endurance testing and generally putting the bikes through their paces over a longer period with general farm duties on a working grazing property.

This testing was used in addition to the five farm trials to more fully evaluate and report on the bikes.

3.2.4 On farm demonstration

Due to government enforced travel restrictions caused by the COVID-19 pandemic, the full reach of test sites from Roma to Dubbo was restricted to Armidale to Dubbo.

Five sites were selected to represent commercial grazing operations that used quad bikes or two wheeled bikes for personal transport and mustering.

3.2.5 Health and safety plan for demonstration

Full details in Appendix 8.2

- All riders will be inducted to the trial, outlining our commitment to safety.
    - This will include a familiarisation with the equipment and test track.
- Riders will all have a demonstrated ability and riding history
- All riders will be required to wear
    - an accredited helmet,
    - full length work clothes,
    - gloves,
    - full covered work boots and
    - goggles.
- All riders will be assessed for rider skill/competency on a flat course with marker cones on the smallest bike, working up to the largest.
- Riders assessed not competent will not complete the trial.
- All riders will be required to follow the safe operating procedures and conditions specific to that workplace/property as set out by the manager.
- Riders will be asked to sign the form showing they understand the requirements.

Kondinin Group has indemnity and public liability insurance, bikes are insured by the researcher.

3.3 Summary of bikes tested

3.3.1 Gas Gas E12

Designed for children, this 1.5kw electric bike is fitted with 12-inch wheels. This bike was not offered to adults in the trial but was included to demonstrate a viable alternative for kids, with the aim of keeping them off quad bikes.

The Gas Gas E12 has variable power modes, no clutch or gears and is extremely easy to ride or learn to ride on. Kids can become mobile members of a family farm with this bike.

3.3.2 Volition ST2000DH

The Volition is an electric-motor-assisted-pushbike with front and rear suspension, latest mixer wheel sizes (larger front wheel instead of the equal wheel sizes of conventional pushbikes). 29-Inch front and 27.5-inch rear, down-hill rated tyres.

The motor offers 2kw assistance with variable power modes. Most manufactures offering pedal-assist bikes have a 0.25kw motor to be road legal as a pushbike, offering little assistance on farm.

This bike was the most complicated to ride of all the bikes tested, as it had traditional pushbike gears, power modes, and seat post dropper controls to use. Pushbike riders may be familiar with these controls, but it was challenging for others.

Having a 2kW motor on a 29kg bike provided ample power, the large diameter tyres rolled over obstacles easily, however not being as strong as motorbike tyres, punctured more readily. The pedal assist was tricky to become accustomed to and made timing obstacle riding more difficult. The bike was great in bare paddocks however the chain derailleur tangled with grass at the end of the growing season. The pedal assist completed all prescribed tests except the hill climb and log-jump.

This bike would be well suited for those looking to incorporate exercise whilst carrying out mustering and personal transport around the farm.

3.3.3 Ubco 2X2

This bike was designed by a New Zealand dairy farmer. The only bike designed for agricultural applications in the trial and is considered a utility bike. The frame is basic with great storage solutions and the suspension can handle up to 150kg total load however, this made the bike suspension quite stiff.

The motors are in the hub of both front and rear wheels, eliminating the need for a drive chain. Each motor is 1kW giving a total of 2kW of power for a 60kg bike. Whilst it is responsive on flat ground, most farmers found it underpowered and the Ubco was unable to climb more than a 17-degree slope. If the front wheel spun, the rear 1kw engine was insufficiently powered to maintain momentum.

The Ubco completed all prescribed tests except the hill climb and log-jump. The computer would not allow any jumping or shock loading to the engines without reverting to limp-mode.

The Ubco would be a great runabout on flat country and is the quietest with the lowest maintenance requirement of all the bikes tested due to the absence of reduction gears or drive chains.

3.3.4 Sur Ron Light Bee

The Light Bee is one of a new market segment of electric freeride bikes, sharing some downhill pushbike components and motorbike components with a 5Kw engine and swappable battery.

There are some innovations on the Light Bee and at a price point, accessible to more people.

Riders recommended many modifications to this bike to make it more suitable as a farm bike including:

- Larger wheels and tyres to improve handling.
- The overall dimensions of the bike are small for a full-size adult rider. The handlebar height had to be increased and foot pegs moved back.
- The tyres are small and hard. Larger sidewall tyres were an improvement.
- The suspension has lots of vibration and sticton (Fork gripping along the stroke). New front forks were added.
- With the added weight of larger tyres, a big rear sprocket was also added to increase torque.
- Larger seat for extended riding comfort.

With the noted modifications the Light Bee is quite a nifty, capable bike with swappable battery at a more accessible price, to be the starting preference for riders looking to try electric transport.

3.3.5 Electric Motion EScape

The Escape is a French bike based on Electric Motions trials bikes, it has added battery capacity, faster gearing, and a small seat. Manufacturing quality is very high.

Riders appreciated the trials heritage of this bike for negotiating obstacles and the hill climbing ability is excellent, by far the best of all the tested bikes. The electric motor is 6kw with a range of power modes and has a boost, under strong acceleration making the bike more powerful than the numbers suggest. The steep fork angle, short swing arm and forward handlebars are great for a standing position for obstacles, but is not as well suited to long, fast riding. All riders would have liked a softer seat and some storage on this bike. With these modifications, the Escape would suit a wide range of farm situations and handle obstacles like logs and rocks better than all tested bikes.

3.3.6 Electric Motion ETrek

The Etrek was most riders' favoured bike, as it closely resembles traditional two-wheel bikes. It has the same wheel and tyre ratios, similar ergonomics and rider position to a traditional dirt bike and our comparison bike the Beta XTrainer. The motor is a 9kW electric with power modes. The controller on this Electric Motion bike was not as responsive as the EScape. This gave the ETrek a smoother deliver of the power despite a larger motor. The suspension is soft and the seat height

low, suiting farm work. A softer seat and some storage would make this bike perfect according to most test riders.

3.3.7 Beta XTrainer, petrol comparison bike.

The XTrainer was chosen as the lightest, most agile petrol bike available, as a comparison bike.

Riders were impressed by the suspension, ergonomics, handling, brakes, and power of this bike. Many decades of research and development is behind this Italian built, XTrainer, designed to be lighter and more agile than a traditional dirt bike with high torque at low rev's, delivering predictable linear power, without a powerband "hit" of traditional two stroke bikes. This linear power delivery was closer to an electric motor, which has the full torque available from zero revolutions.

Riders highly rated the XTrainer, however said in comparison to the electric bikes tested, it is noisy, smelly and has a high running cost. In comparison, the electric bikes were easier to ride without a clutch or gears. Starting off on hills, is more difficult with a traditional petrol bike.

If a conventional two-wheeled Ag-bike was used as the comparison bike, it would have been eclipsed by the Electric bikes on all performance points except seat size and carrying capacity. Riders could say that a better handling petrol bike would beat the electric bikes, which the XTrainer did, however the buying preference was for the ETrek with all the advantages of electric propulsion.

4. Results

4.1 Engineering differences between bikes

Appendix 8.1 contains the full list of electric bikes.

Table 1: Engineering differences between bikes

Engineering Specifications	Sur Ron Light Bee	Volition ST2000 DH	Ubco 2X2	Electric Motion EScape	Electric Motion ETrek	Beta XTrainer *
Seat Height mm	815	910-1030	820	795	875	915
Wheelbase mm	1250	1180	1230	1335	1395	1470
Ground Clearance mm	260	255	245	295	290	330
Total Weight Kg	54.4	29.2	74	79.4	107	106.5
Front wheel Weight Kg	27	14.6	35	38.2	51.2	50.4
Rear Wheel Weight Kg	27.4	14.6	39	41.2	55.8	56.1
Fork Angle Degrees	64	64	64	66	65	61
Front wheel Trail mm	116	143	90	95	90	135
Swingarm Length mm	475	420	390	520	560	560
Handlebar Height mm	1070	1130	1050	1130	1160	1205
Handlebar Width mm	810	680	750	810	810	810
Front wheel travel used mm	200	180	120	170	170	235
Rear Wheel travel used mm	245	180	120	180	210	265
Handlebar, horizontal to foot beg position mm	440	410	355	520	490	470
Engine KW	5	2	2	6	9	N/A
Battery KW	1.9	0.91	2.4	1.9	2.7	N/A
Charge rate Kw	0.7	0.2	0.35	0.8	0.8	N/A
Charge time Hrs	3	5	7	3	3.5	N/A
Motor Volts	60	52	48	48	48	N/A
Front wheel Inches	19	29	17	21	21	21
Rear Wheel Inches	19	27.5	17	18	18	18
Farm riding distance @ 40km/hr on tracks; Km	51	36	66	56	48	205
Farm riding time @10km/hr	5	4	7	6	5	15
Power modes	2	5	1	3	3	2
Regenerative braking			Y	Y	Y	N/A
Reduction gearbox	Y	Y	N	Y	N	Y
Carry rack as standard	N	N	Y	N	N	N
Swappable battery	Y	Y	Y	N	N	N/A

* Beta XTrainer is the petrol comparison bike.

4.2 Performance differences between bikes

Table 2: Performance differences between bikes

Long term rider rank 1=best to 6=worst	Sur Ron Light Bee	Volition ST2000 DH	Ubco 2X2	Electric Motion EScape	Electric Motion ETrek	Beta XTrainer
100m sprint time (mins)	9.15	11.28	12.97	8.54	8.22	7.05
Barrel race time (mins)	24.19	27.61	29.89	23.15	23.45	22.8
Obstacle course time (mins)	26.79	30.38	34.22	26.92	28.59	29.96
100m sprint rank	4	5	6	3	2	1
Barrel race rank	4	5	6	2	3	1
Obstacle course rank	1	5	6	2	3	4
Hill climb rank	4	5	6	1	3	2
Log jump rank	4	5	6	1	3	2
Average Rank	**3.4**	**5.0**	**6.0**	**1.8**	**2.8**	**2.0**

Note: The Ubco and Volition were unable to complete the hill climb and log jump.

4.3 Farmer preferences between bikes

Table 3 shows the average rank (1 best to 6 Last) from the 7 farm test riders.
Note: The average rank (last row) shows the Petrol powered comparison bike (Italian built, Beta XTrainer) has the best calculated average rank of the 14 characteristics, showing we found a great petrol powered bike that farmers were impressed by, however the Electric Motion ETrek had the overall best purchase preference, with its silent operation, no gears or clutch and no warming up. Interestingly the only bike tested that was specifically designed as an Ag bike, the Ubco 2X2 was second last, only to the pushbike due to its lack of power and handling.

Table 3: Farmer preferences between bikes

Average rider rank **1= best to 6= worst**	**Sur Ron Light Bee**	**Volition ST2000DH**	**Ubco 2X2**	**Electric Motion EScape**	**Electric Motion ETrek**	**Beta XTrainer**
Rideability	3.6	5	4.2	2.6	1.4	2.1
Handling	4	4.4	4.4	2.1	1.9	1.5
Suspension travel	3.8	4.6	4.8	2	2	1.4
Damping	3.8	4	4.3	2	2	1.6
Total Power	3.7	5	4.8	2.3	2	1
Power delivery	3.5	4.6	4.6	1.8	1.9	1.3
Brakes	3.7	4.3	4.4	1.8	2	1.5
Wheels	4.1	4.3	4.8	2	1.8	1.8
Seat	3.6	3.3	3	4.3	2.1	1.8
Steering	4	4	4	2.1	2.1	1.2
Ride position	3.8	4.3	3.2	4	1.6	1.7
Long distance	3.8	4.3	3.6	3.3	1.9	1.5
Obstacle riding	3.3	4.3	4.8	1.8	2.4	1.3
Controls	3.6	5	3.8	2.4	2.3	1.5
Purchase Preference	**3.4**	**5**	**4.4**	**2.3**	**1.4**	**2**
Average rank	**3.7**	**4.4**	**4.2**	**2.5**	**1.9**	**1.5**

Table 4 shows the rank (1 best to 6 worst) on the long-term researcher's test farm.

The results were similar to the other test riders, with the Beta XTrainer having the best average ranking, but the EScape and ETrek were higher for purchase preference, with quiet operation, no gears or clutch. The EScape's ability to ride rough terrain, up steep hills, over logs, rocks and obstacles and superb power delivery put it first on the researcher's test farm results.

During the long-term test, modifications were made to the bikes to adapt them for farm work. The Sur Ron had higher handlebars, bigger wheels, rear sprocket, and forks fitted which improved its ranking. The Escape was fitted with a larger seat to improve comfort on longer rides.

Table 4: Long-term researchers farm test

Average rider rank 1=best to 6=worst	Sur Ron Light Bee	Volition ST2000DH	Ubco 2X2	Electric Motion EScape	Electric Motion ETrek	Beta XTrainer
Rideability	4	5	6	2	3	1
Handling	4	5	6	2	3	1
Suspension travel	5	4	6	3	2	1
Damping	5	4	6	3	2	1
Total Power	4	5	6	3	2	1
Power delivery	5	6	4	1	3	2
Brakes	6	5	3	2	4	1
Wheels	4	6	5	2	3	1
Seat	4	5	2	6	3	1
Steering	3	5	6	1	4	2
Ride position	6	5	4	3	2	1
Long distance	3	5	6	4	2	1
Obstacle riding	3	5	6	1	4	2
Controls	5	6	4	1	3	2
Purchase Preference	**4**	**6**	**5**	**1**	**2**	**3**
Average rank	**4.3**	**5.1**	**5.0**	**2.3**	**2.8**	**1.4**

4.4 Lifetime cost of ownership differences between bikes

Table 5: Lifetime cost of ownership differences between bikes

Cost per Km	Volition peddle assist	Ubco 2X2	Sur Ron Light Bee	Electric Motion EScape	Electric Motion ETrek	Beta X-Trainer	Quad bike	Side by side
Petrol @$1.50 +oil mix if req.						$0.11	$0.18	$0.30
Electricity @ solar $0.20/kwh	$0.01	$0.01	$0.01	$0.01	$0.01			
Service	$0.01	$0.02	$0.02	$0.02	$0.02	$0.05	$0.20	$0.30
Rebuild	$0.01	$0.02	$0.02	$0.02	$0.02	$0.30	$0.08	$0.12
Tyres	$0.02	$0.02	$0.02	$0.04	$0.04	$0.06	$0.08	$0.12
40,000km depreciation	$0.13		$0.15			$0.27	$0.30	$0.50
60,000km depreciation		$0.13		$0.26	$0.26			
Total lifetime cost/km	$0.18	$0.20	$0.22	$0.35	$0.35	$0.79	$0.84	$1.34

Note: Depreciation is the full life expectancy with no residual value. It is assumed most electric motors will last 1.5 times as long as a petrol engine.

4.5 Livestock behaviour differences, compared with petrol bikes

Sheep showed little variation in reaction if mustered by an electric or petrol bike. Lambs with their first human encounter were much easier to handle with the electric bike as they were not startled. The researcher was able to muster 600 ewes with lambs from their lambing paddock through 3 gates, in for lamb marking on the pedal assist bike only, with no dogs. (quiet, slow, and controlled, the lambs stayed with their mothers to find the gates).

If mustering large paddocks with little vision, where the stock respond to bike noise for mustering, the electric bikes have effective horns, which can be used if needed.

Cattle accustomed to petrol powered bikes, were initially spooked by the electric bikes with the absence of engine noise allowing the rider to get closer before the animals became aware of their presence. Once accustomed however, cattle did settle with electric bikes working around them. It could be argued this is similar to situations where cattle familiar with petrol bikes are mustered using a horse; eventually cattle adapt to a familiar mode of mustering.

4.6 CO_2 differences, compared with petrol bikes

If a petrol quad bike is replaced with a solar charged electric bike, the CO_2 saving could be over 16.5t for the 60,000km nominated life of the electric bike. Additionally, the electric bike would not need any oil, only bearings and grease and be expected to last 1.5 times as long as the petrol engine.

(replacing 12l/100km for 60,000km = 7,200L of petrol X 2.3 kg CO_2/L of petrol= 16.5t CO_2)

4.7 Discussion

4.7.1 Insights

Quad bike sales in Australia will be impacted by new government "roll over protection" rules due to be implemented in October 2021. Farmers are currently flocking to side by side vehicles as a replacement. But side by side vehicles are not suited to all terrain or mustering situations.

Although side-by-side vehicles have an integrated Roll Over Protection System (ROPS) this relies on the occupants using a seatbelt to prevent crush injuries. Electric two-wheeled bikes are between 4per cent and 15% of the weight of a side by side vehicle. As a result, the crush risk is substantially reduced.

4.7.2 Practical implication for the industry

A move to electric two-wheeled bikes would:

- Greatly improve the selection of mode of transport for the job.
- Slash the cost of personal transport and mustering.
- Cut CO_2 emissions when charged with solar or wind power.
- Give managers the ability to limit speed and power on bikes.
- Reduce accident injuries from death by quad bike, to bruises and grazed elbow and knees.

4.7.3 Farmer preference

Electric cars are leading the way with up to 600km range and 1,000,000km life. Electric cars represent 34% of car sales in the UK and 70% in Norway.

Farmers involved in testing the electric bikes were surprised by the refinement of the electric motors and the integration into different two-wheeled variations, from a pedal assist, to full size dirt bike.

Most riders preferred the full-sized electric bike, as it felt like their traditional bikes with the added advantage of quiet operation, no gears or clutch, light nimble handling, and no engine maintenance.

Interestingly, the only electric two-wheeled bike tested, that was specifically designed for farm work, was low on the list of desirable electric bikes amongst test riders. Farmers preferred better suspension, handling, and power.

The majority of farmers in the test panel identified a need for storage on the bikes. The safest option is saddle bags as they sit neatly beside the bike, behind the rider. Saddle bags may give a working dog additional grip to travel behind the rider. Cargo racks fitted to the rear are an

alternative option, however they increase weight and create more risk to the rider in the event of an accident. Most riders identified a preference for a larger seat.

4.7.4 Unanswered questions

- There are many new electric bikes coming to market that were not available for testing.
- Due to COVID-19, the trial was not able to extend into Queensland.
- The short trial period was not able to test the life of the batteries over numerous charging cycles.
- Could a national farmer body subsidise the bikes and collect carbon credits (If 10,000 electric bikes were sold each year, offsetting 16.5t of CO_2 over the bikes life @ $16/t = $2,640,000 annually)
- Testing Electric 4x4 pick-up trucks, due to be released over 2021 to 2023.

4.7.5 Project highlights

- Farmers were very eager to try the bikes and overwhelmingly preferred them.
- Electric two-wheeled bikes are a rapidly expanding market segment.
- Battery technology is improving exponentially.
- Bikes can be fitted with upgraded batteries as the technology evolves.

4.7.6 Project recommendations for improvement

- Further investigations into future bikes and batteries.
- Long term trials on battery life. (collect owner statistics)
- Farm to farm visits needs a biosecurity plan (we washed bikes between visits).
- Try to avoid virus pandemics when running farm trial.
- Allow longer delivery time for international manufacturer production and shipping delays.

5. Conclusion

5.1 Key messages

5.1.1 Rider response

- Electric two-wheeled bikes were preferred by the test riders, above petrol two-wheelers and quad bikes for mustering and personal transport for the following reasons:
- Quiet, gentle operation
- No clutch or gears, always ready for maximum torque, when required.
- Lifetime cost of operation is lower than traditional bikes
- Responsive, predictable linear power delivery
- Easy communication between riders/dogs/phone calls whilst riding

5.1.2 Lower running costs

- No petrol required
- No petrol engine to service

5.1.3 Improved safety

Electric two-wheeled bikes are:

- 4% to 15% the weight of a side by side vehicle (low crush risk and running cost)
- 10% to 30% the weight of a quad bike (low crush risk)
- 25% to 80% the weight of a two-wheeled petrol Ag bike. (more manoeuvrable)
- Able to limit speed and power by the manager.
- Reduced farmers' exposure to fuels, oil and hot engine components.

When electric bikes are compared to conventional two-wheeled "Ag bikes", the petrol ag bike is much heavier with the motor having a large rotating mass, creating a gyroscopic effect that makes direction changes more difficult. Slow riding through rocks with a petrol bike takes co-ordination of gears, clutch, throttle and balance, which are cut down to only throttle control and easier balance with an electric bike making them more capable to the average ridder than conventional ag bikes.

5.1.4 Livestock response

Sheep showed little difference if mustered by an electric or petrol bike. Lambs with their first human encounter were much easier to handle with the electric bike as they were not startled.

Cattle accustom to petrol powered bikes, were initially spooked by the electric bikes, but once accustomed they settled quickly.

5.1.5 Statistics about batteries

- Battery technology is advancing rapidly
- Current Lithium batteries are only 10% the weight of conventional lead acid batteries for the equivalent power output. (Higher energy density)
- Latest LiFePo4 formulations can handle up to 8000 charge cycles
- Latest “lightning charge” batteries can charge in 20 minutes.
- Electric cars have up to 600km range and 1,000,000km lifespan.
- Electric bike have ongoing records of 7yrs(Electric Motion) or 360,000km (Tacita) and counting.
- Test bikes had 36-66km, range with 2 to 7h charge times. (longer range bikes available)

5.1.6 Environmental benefits

- If a petrol quad bike is replaced with a solar charged electric bike, the CO_2 saving would be over 16.5t for the 60,000km life of the electric bike.
- No engine oil is required for an electric bike
- No sound pollution for wildlife or neighbours

5.2 Benefits to industry

5.2.1 Practical implications for the industry

- Electric two-wheeled bikes are ideal for personal transport and mustering.
- Electric bikes were preferred by riders for the quiet operation, low weight, low total cost of operation, no gears, no clutch, no petrol or hot parts and ease of handling tough terrain.
- Solar or wind charged, electric bikes reduce the CO_2 emissions from conventional bikes.
- The light weight of the electric bikes reduces the crush risk of quads and side by sides vehicles.
- The image of farmers on electric bikes is appealing to the public, improving licence to farm.

5.2.2 Development

Further modification and manufacturer development are needed to most of these bikes to:

- Adding carrying ability with saddle bags or carry racks.
- Adding a dog carrying platform on the rear to help dogs balance.
- Improving the seat softness, for longer time in the saddle.
- Improving puncture resistance in the smaller-tyred bikes.

- Integrate improvements in battery technology to extend range and reduce charge time.
- Integrate fast chargers on the bikes to allow charging at any power source.

5.2.3 Adoption activities

- Publish trial results in MLA, “Feedback” and Kondinin “Farming Ahead”
- Publish the results on the MLA and Kondinin web sites.
- Funding to take the bikes to field days such as Ag-Quip and Henty.
- Funding to piggyback on-farm visits and with other farm event gatherings.

6. Future research and recommendations

6.1 Future Research and Development

Future research and development could include testing the next generation of electric two-wheeled bikes, to be released by 2022. Continued long term testing of the electric bikes and reporting into the lifespan and maintenance costs would benefit future users. A solar charging station could be developed that can be placed at remote yard locations. A future project could expand testing into 4x4 pick-up trucks due for release in 2021 to 2023.

7. References

ACCC- Australian Competition and Consumer Commission. Report: Quad Bike Safety. Consultation Regulation Impact Statement March 2018. Office of Best Practice Regulation Reference 22969.

Bowman- Hopkins Research Centre, October 6th, 2010. Two wheels safer than four. Stephen M Bowman. https://www.hopkinsmedicine.org/news/media/releases/surprise_two_wheels_safer_than_four_in_off_road_riding_and_racing_johns_hopkins_study_shows Media release accessed online June 2020.

SWA- Safe Work Australia, Quad Bike Fatality Data 2019 accessed online June 2020 https://www.safeworkaustralia.gov.au/quad-bike-fatality-data

8. Appendix

8.1 List of electric bikes

(Highlighted models indicate inclusion in this trial)

Make	Model	Tested	Style	Engine kW	Battery KW	Wheels F/R inches
Tacita	T Race	Not available	Enduro. liquid cooled, hydraulic clutch and gears	34	9	21/18
Armonia	Duo X	Not available	2WD small dual sport bike	11	6.1	21/18
Alta Moto	Redshift EXR	No production	Enduro. liquid cooled, oil bath reduction gear	35	5.8	21/18
Quantya	Track	Not available	Small Dual sport, air cooked, no oil.	12	1.9	21/18
KTM	Freeride E XC	shipping soon	Cross training, liquid cooled.	9	3.9	21/18
Electric Motion	**E Trek**	**Yes**	**Small Dual sport, air cooked, no oil.**	**9**	**2.7**	**21/18**
Electric Motion	**Escape Sport**	**Yes**	**Trials bike with a seat, air cooled, no oil**	**6**	**1.9**	**21/18**
Mrazek	RevX	Not available	Trail bike/Push bike, air cooled, no oil.	10	3	26/24
Trinity	Neon X	Not available	Small Dual sport, air cooked, no oil.	6	3.8	21/18
Sur Ron	**Light Bee**	**Yes**	**Trail bike/Push bike, air cooled, no oil.**	**5**	**1.9**	**19/19**
Stealth	H52	no	Push bike/Trail bike, air cooled, no oil or chain	5.2	2	24/24
Ubco	**2x2**	**Yes**	**Utility posty bike, air cooled, no oil or chain**	**2**	**2.4**	**17/17**
Ubco	FRX1	shipping soon	Big push bike with electric strong assistance	15	2.4	26/24
Merida	One Sixty 900E	No	Push bike with electric assistance	0.25	0.5	27.5/27.5
Gas Gas	EContact	No	Trials bike with a seat, air cooled, no oil	4.8		21/18
Volitation	**XT2000 DH**	**Yes**	**Push bike with electric assistance**	**2**	**0.91**	**29/27.5**
EZ Raider	DSR Raider	shipping soon	4x4 scooter	4.8	3	
Gas Gas	Endro two E12	Yes	kids electric	1.5		12/12
Gas Gas	300 Ranger	No	petrol comparison 2t light enduro	40		21/18
Beta	**Xtrainer 300**	**Yes**	**petrol comparison 2t light enduro**	**35**		**21/19**

8.2 On-farm safety and induction

Welcome to the "Trial of Electric Two-Wheel Motorbikes on grazing properties"

This is a joint trial between "Meat and Livestock Australia, Donner company", the "Kondinin Group" and myself.

I initiated the trial to find new tech., greener, safer, alternatives to quad bikes, in response to the growing number of farmers being harmed or killed using quad bikes.

https://www.safeworkaustralia.gov.au/quad-bike-fatality-data
https://www.safeworkaustralia.gov.au/quad-bike-fatality-data#2001
https://ris.pmc.gov.au/sites/default/files/posts/2018/04/quad_bike_safety_ris.pdf

There have been over 240 quad bike related deaths in Australia and over 600 hospitalized injuries per year. Quad bikes have become the number one killer of Australian farmers.
The cost of quad bike and side by side deaths and injuries in Australia is estimated to be $208 million annually.

Hospitalized, recreational riders in the US, who had been riding ATVs were 50 percent more likely to die, and 50 percent more likely to need treatment in an intensive care unit, compared with two-wheeled, motorcycle riders.

The electric two-wheeled bikes in this trial are, lighter, have no gears, limited power and speed and are easy to ride, compared to traditional recreational and agricultural two-wheeled bikes. These bikes will expand farmers ability to selecting the correct machine for the task and cut on-farm fatalities.

This farm trial is to assess the different styles of electric bikes for personal transport and mustering, on grazing properties.

Following the trial riders will be asked to fill in a questionnaire to assess the bikes.

Safety is of the upmost importance and takes precedence over completing the tasks.

All riders will be required to wear personal protective clothing and an Australian standards helmet.
All riders will be shown the bikes controls/operation and given bike specific instruction.
All riders will be assessed for competency on a flat course with witches' hats on the smallest bike working up to the largest. Riders assessed not competent will not complete the trial.
Riders are expected to ride in a sensible manner and will be excluded for inappropriate behaviour.
(The farm manager and I will outline safety requirements and no-go zones specific to the site)

8.2.1 Safe operating procedures

1. Decide the right vehicle for the activity.
2. Ensure you are properly qualified/trained for the bike and the terrain/task.
3. Complete a pre-rider inspection to ensure the bike is in a safe working condition.
4. Always wear a helmet certified to AS/NZS 1698:2006: standards.
5. Wear protective clothing- long sleeves, long pants, goggles, boots and gloves.
6. Do not carry any passengers.
7. Never ride under the influence of alcohol/drugs.
8. Ensure children are supervised at all times near any activity.
9. Always carry a mobile phone or radio device so you can contact for help in case of an emergency.
10. Before you leave, always tell someone where you plan to go and when you expect to return.
11. Always use good riding techniques and only ride on terrain that your individual skill level can handle.
12. Ride at a speed appropriate for the situation, not exceeding your skill level.
13. Operate the controls smoothly, including throttle, steering and brakes.
14. Place feet horizontally on the footrests, with toes pointed straight when moving.
15. Keep elbows away from the body for stability, and keep arms bent to allow for movement.
16. To help balance, press your knees against the bike.
17. Use body position to influence stability and balance when cornering and riding on a slope.
18. When riding on steep or rough ground stand on the foot pegs when required, move and use your bodyweight to stabilise the bike.
19. Lean forward going uphill and lean backwards going downhill.
20. Use smooth throttle operation to avoid wheel spin.
21. Look out for rocks, logs, holes, wires, irrigation pipes and other objects that you could run into.
22. Keep a slow speed and look at the terrain so you can see hazards or obstructions.
23. Stop the bike and get off before doing other tasks.

https://www.cwaofnsw.org.au/visageimages/Misc/farm_vehicle_prepurchase_checklist_3081.pdf