Low Carbon Growth Plan for Gippsland

DETAILED ASSUMPTIONS & BIBLIOGRAPHY

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This document details the key assumptions underpinning the modelling of the emissions reduction opportunities for the *Low Carbon Growth Plan for Gippsland.*

The assumptions for each sector can be found as follows:

Opportunities are ordered from least cost to highest cost, as illustrated in the cost curve for each sector.

Opportunities modelled in the *Low Carbon Growth Plan for Gippsland* are based on the opportunities identified in the *Low Carbon Growth Plan for Australia* and have been scaled down and refined with local or state data wherever available.

For further information on the approach to the modelling for the *Low Carbon Growth Plan for Gippsland,* please contact ClimateWorks Australia on (03) 9902 0741 or info@climateworksaustralia.org

The Low Carbon Growth Plan for Gippsland can be accessed at www.climateworksaustralia.org

General assumptions

Energy price assumptions

The table below outlines the energy price assumptions in 2020 that have been used in ClimateWorks modelling for the *Low Carbon Growth Plan for Gippsland.* Forecast energy prices have been drawn from a range of sources and are conservative, and some estimates of future price rises indicate that some energy prices (in particular electricity and transport fuels) may be significantly higher by 2020. Higher energy prices would amplify the savings potential available through activities that reduce energy use.

Manufacturing, Mining and Freight	Price	Emissions intensity
Electricity	$104/MWh	1.47 tCO_2e/MWh
Electricity (coal mining - wholesale)	$40/MWh	1.22 tCO_2e/MWh
Natural gas	$66/MWh	0.18 - 0.22* tCO_2e/MWh
Refinery gas	$66/MWh	0.16 tCO_2e/MWh
Coal	$19/MWh	0.46 tCO_2e/MWh
Fuel oil	$37/MWh	0.25 - 0.33* tCO_2e/MWh
Biomass	$5.4/MWh	0 tCO_2e/MWh
Renewables – food and beverage	$60/MWh	0 tCO_2e/MWh
Renewables – Pulp, paper and print	$65/MWh	0 tCO_2e/MWh
Renewables – Other industry	$70/MWh	0 tCO_2e/MWh
Diesel	$1.5/L	0.003 tCO_2e/L
Petrol	$1.5/L	0.0027 tCO_2e/L
Biodiesel	$1.5/L	0.0003 tCO_2e/L
Bioethanol	$1.5/L	0.001 tCO_2e/L
Commercial and services		
Electricity	$189/MWh	1.47 tCO_2e/MWh
Natural gas	$105/MWh	0.22 tCO_2e/MWh
Oil	$106.2/MWh	0.33 tCO_2e/MWh
Diesel	$1.5/L	0.003 tCO_2e/L
Petrol	$1.5/L	0.0027 tCO_2e/L
Households		
Electricity	$238/MWh	1.47 tCO_2e/MWh
Natural gas	$150/MWh	0.22 tCO_2e/MWh
Wood	$31/MWh	0.005 tCO_2e/MWh
Diesel	$1.5/L	0.003 tCO_2e/L
Petrol	$1.5/L	0.0027 tCO_2e/L
On the land		
Electricity	$189/MWh	1.47 tCO_2e/MWh
Biomass	$5.4/MWh	0 tCO_2e/MWh

*Emissions intensity varies depending on the sector

Manufacturing, mining and freight

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Eco driving	Implementation eco-driving principles to reduce fuel consumption and associated greenhouse gas emissions in large articulated trucks. Drivers are typically trained through a combination of theoretical and practical lessons to prepare and drive their vehicles to reduce fuel consumption. Eco-driving may also have the co-benefit of enhancing safe driving practices. **Assumptions**: • 20% abatement penetration rate • 10% fuel savings at an upfront cost of approximately $180 in training per driver	-501	6.3
Freight operational efficiency improvement	Experience shows that improving operational efficiencies through the use of route optimisation or 'intelligent transport' systems can reduce fuel consumption by at least 10% and may also achieve more efficient use of labour and a reduction in the number of vehicles required. **Assumptions**: • 10% savings achievable across 50% of fleet • Upfront cost of approximately $10,000 per vehicle	-341	19.1
Large articulated truck efficiency improvements	Improved efficiency of new vehicle purchases of large articulated trucks. Efficiency improvements include rolling resistance reduction, aerodynamic improvements and conventional internal combustion engine improvements **Assumptions**: • Opportunity only allocated to vehicles in production year; no retrofits or early retirement • 20 year average life of vehicles • 2,400 new vehicles purchased between 2010 and 2020 • Incremental upfront cost in 2020 of between $2,125 and $10,825 to achieve savings between 3% and 11% as compared to typical fuel consumption	-334	9.1

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Mining energy efficiency	For brown coal mining, includes operational and equipment improvements in dredger/shovel and conveyer For other types of mining, includes operational improvements (reduce idle time of shovels/trucks, improved fuel monitoring and maintenance, etc), improved control and planning (control of transport equipment, truck dispatch optimisation, etc), and equipment improvements (truck light weight dump bodies, improved weighing system, shovel light weight dippers, autonomous drilling, replacement of light vehicles with hybrid cars) **Assumptions**: *Brown coal mining:* • Average of 2% electricity savings achievable across all mines • Upfront cost of $700 per MWh of energy saved in one year, average lifespan of 15 years *Other mining:* • Average of 5% energy savings • Operations and controls: Progress to a 100% penetration rate in 2020 from a BAU penetration rate of 50%. Upfront cost of $100 per MWh of energy saved in one year, average lifespan of 10 years • Equipment improvement: Progress to a 66% penetration rate in 2020. Upfront cost of $535 per MWh of energy saved in one year, average lifespan of 20 years	-234	30.3
Food, and beverage manufacturing energy efficiency	Major opportunities include improved control systems (automated or manual); reduction of duplicated or oversized equipment; boilers and steam distribution systems; waste heat recovery (e.g. used for pre-heating or other sites); building utilities **Assumptions**: • Energy savings of 13% overall are achievable by 2020 • Upfront cost of $150 per MWh saved in one year, average lifespan of 10 years	-102	28.9

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Pulp, paper and print energy efficiency	Energy efficiency opportunities including improving control systems (automated or manual); reduction of duplicated or oversized equipment; boilers and steam distribution systems; waste heat recovery (e.g. used for pre-heating or other sites); building utilities **Assumptions**: • Energy savings of 13% overall are achievable by 2020 • Upfront cost of $140 per MWh saved in one year, average lifespan of 10 years	-96	31.9
Dairy Food Processing Energy Efficiency	Energy efficiency opportunities including heat recovery from services, VSD control fans, pumps and air compressors, new system cooling technology **Assumptions**: • Energy savings of 13% overall are achievable by 2020 • Upfront cost of $155 per MWh saved in one year, average lifespan of 15 years	-82	107.8
On site electricity generation from biomass/biogas	Utilisation of on-site or local waste resources to generate electricity that displaces grid electricity consumption **Assumptions**: • Overall 685 kt (dry) of waste available in the region each year (excluding wood waste from sawmills which is assumed to be used in centralised power generation), with an overall energy content of 3.1 TWh (average energy content of 4,550 kWh/t dry) • Approximately 5% of the total waste is used to generate electricity • 30% average efficiency for conversion to electricity • Upfront costs of $6,000/kW, average lifespan of 20 years • Fixed operation and maintenance costs $54,000/MW/year and variable $50/MWh	-52	73.6

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Other industry energy efficiency	Improve energy efficiency through improving control systems (automated or manual); reducing duplicated or oversized equipment, improving efficiency of boilers and steam distribution systems; waste heat recovery; improving building utilities. The greatest benefits are usually achieved when energy use is considered as a whole system. **Assumptions**: • Energy savings of 13% of are achievable by 2020 • Upfront costs of $140 per MWh saved in one year, average lifespan of 10 years	-44	74.2
On site heat generation from biomass/biogas	Utilisation of on-site or local waste resources to generate electricity that displaces direct fuel use **Assumptions**: • Overall 685 kt (dry) of waste available in the region each year (excluding wood waste from sawmills which is assumed to be used in centralised power generation), with an overall energy content of 3.1 TWh (average energy content of 4,550 kWh/t dry) • Bioenergy to replace use of gas/coal/oil • Approximately 5% of the total waste is used to replace direct fuel consumption • Upfront costs of $1000/KW, average lifespan of 15 years • Operation and maintenance costs of $6/MWh	-40	66.9
Other industry cogeneration	Generation of electricity and thermal energy in a single, integrated system **Assumptions**: • Cogeneration systems generate 5% of electricity usage by 2020 • Upfront costs of approximately $800 per MWh generated in one year (depending on sector), average lifespan of 20 years	-8.1	25.0

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Gas processing energy efficiency	Decrease the amount of gas used for gas processing through operational improvements and equipment upgrade **Assumptions**: • 5% energy savings by 2020 • Upfront costs of $140 per MWh saved in one year, average lifespan of 10 years	-5	94.5
Chemicals process improvements	Includes improvement of chemical techniques, and the introduction of energy saving measures in motor systems, such as adjustable speed drive, more energy efficient motors, and mechanical system optimization **Assumptions :** *Motor systems:* • Approximately 17% savings in indirect energy compared to standard systems • 70% penetration rate in 2020 compared to 30% in BAU • Upfront costs of $575 per MWh saved in one year, average lifespan of 14 years *Chemical processes:* • Process intensification and catalyst optimisation achieves 5% energy savings • Upfront costs of $350 per MWh saved in one year, average lifespan of 40 years	147	5.6

Commercial and services

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Car and light commercial vehicle efficiency improvement	Improved efficiency of new cars and light commercial vehicles purchased. Efficiency improvements include: Variable valve control, engine friction reduction, low rolling resistance tyres, tyre pressure control system, weight reduction, electrification (steering, pumps), optimised gearbox ratio, improved aerodynamic efficiency, stop-start system with regenerative braking, air conditioning modification, improved aerodynamic efficiency, start-stop system with regenerative braking, direct pressure injection strong weight reduction, optimised transmission **Assumptions***:* • Opportunity only allocated to vehicles in production year; no retrofits or early retirement • 20 year average life of vehicles *For petrol:* • Fuel economy of 9.6 litres per 100 km in 2020 before efficiency improvements. Fuel economy range from 8.3 to 5.9 litres per 100 km after efficiency improvements • Incremental upfront costs range from $450 to $3,785 per vehicle depending on the level of fuel efficiency achieved *For diesel:* • Fuel economy of 9.2 litres per 100 km in 2020 before efficiency improvements. Fuel economy range from 8.1 to 6.0 litres per 100 km after efficiency improvements • Incremental upfront cost in 2020 ranges from $2,180 to $4,020 per vehicle depending on the level of fuel efficiency achieved	-398	20.3

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Hybrid cars	More fuel efficient diesel and petrol hybrid cars (full and plug-in hybrids) supplant less fuel efficient cars over the medium to long term **Assumptions***:* • Average penetration rate in 2020 is 9%. • The incremental cost from existing technology ranges from $4,800 to $9,000 per vehicle	-284	4.5
Commercial building heating, ventilation and air conditioning (HVAC)	Install highest efficiency system when current expires; improve HVAC control systems to adjust for building occupancy and minimise re-cooling of air. Experience also shows that significant downsizing of HVAC equipment can be done once other equipment improvements have been implemented (e.g. lighting, improved insulation for cooking and refrigeration). **Assumptions***:* • Energy savings of 28% on average across subsectors • Incremental upfront costs of $9/m^2, average lifespan of 20 years	-165	54.0
Commercial building energy waste reduction	Experience shows that significant savings can be achieved with minimal capital investment by getting rid of or downsizing unnecessary equipment **Assumptions***:* • Energy savings in 2020 estimated to be 10% across all end uses • Incremental upfront cost of A$4/m2	-141	59.0
Commercial building electronics and appliances	Replace traditional electronics, appliances, elevators/escalators and kitchen equipment with high efficiency equipment to reduce energy consumption **Assumptions***:* • Energy savings of 20% on average across subsectors for retrofits and 28% for new builds • Incremental upfront costs of $10/m^2 for retrofits and $16/m^2 for new builds, average lifespan of approximately 15 years	-84	79.9

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Commercial building lighting	Replace CFLs with LEDs, replace inefficient T12s or T8s with new super T8s and T5s, install lighting control systems (dimmable ballasts, photo-sensors to optimise light for occupants in room) **Assumptions***:* • Energy savings of 24% on average across subsectors • Incremental upfront costs of $6/m^2	-77	28.6
Street lighting energy efficiency	Replace current streetlights with energy efficient T5 lamps **Assumptions***:* • 100% of light bulbs replaced by 2020 • 60% electricity savings potential • Upfront cost of $300 per street light for fixture, average lifespan of 30 years, and incremental upfront cost of $40 per light bulb	-57	2.3
Commercial building insulation	Improve building air tightness by sealing areas of potential air leakage, weather strip doors and windows **Assumptions***:* • Energy savings of 18% on average across subsectors • Incremental upfront cost of $26/m^2, average lifespan of 56 years	-37	34.0
New builds to 6 stars	New builds achieve an average 6 star equivalent in the NABERS rating system (office buildings are taken as a reference as they correspond to the average energy consumption per m2 in the building fleet) **Assumptions***:* • Energy savings estimated to be 41% across all sub-sectors • Incremental upfront cost of $90/m^2	-34	41.5

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Electric vehicles	By 2020, electric vehicles replace 3% of all new vehicle purchases in the Gippsland region **Assumptions**: • Fuel savings of 35% per electric vehicle • Incremental upfront cost of $5,835 per vehicle (plus infrastructure costs of $500 per vehicle), average lifespan of 20 years	-23	3.2
Commercial building water heating	Replace standard gas water heaters with tankless gas, condensing gas, or solar water heater; replace electric water heater with heat pump or solar water heater **Assumptions**: • Energy savings estimated to be 22% across all sub-sectors • Incremental upfront cost of $6/m^2, average lifespan of 20 years	-23	8.8
Commercial cogeneration	Generation of electricity and thermal energy in a single, integrated system **Assumptions**: • 10MW capacity installed across the region by 2020 • Upfront cost of $3000/kW, average lifespan of 20 years • 25% capacity factor	2	32.6
Bus and rigid truck efficiency improvement	Improved efficiency of new buses and trucks purchased. Efficiency improvements include rolling resistance reduction, aerodynamics improvement and conventional internal combustion engine improvements. **Assumptions**: • Assume 20 year lifespan of vehicles • Fuel economy of 28 litres per 100 km in 2020 before efficiency improvements. Fuel economy ranges from 27 to 25 litres per 100 km after efficiency improvements • Incremental upfront cost ranges from $1,200 to $7,980 per vehicle depending on the level of fuel efficiency achieved	126	2.0

Households

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Choosing more efficient new vehicles	Improved efficiency of new cars purchased. Efficiency improvements include: Variable valve control, engine friction reduction, low rolling resistance tyres, tyre pressure control system, weight reduction, electrification (steering, pumps), optimised gearbox ratio, improved aerodynamic efficiency, stop-start system with regenerative braking, air conditioning modification, improved aerodynamic efficiency, start-stop system with regenerative braking, direct pressure injection strong weight reduction, optimised transmission **Assumptions**: • Opportunity only allocated to vehicles in production year; no retrofits or early retirement • 20 year average life of vehicles *For petrol cars:* • Fuel economy of 9.6 litres per 100 km in 2020 before efficiency improvements. Fuel economy ranges from 8.3 to 5.9 litres per 100 km after efficiency improvements • Incremental upfront costs range from $450 to $3,785 per vehicle depending on the level of fuel efficiency achieved *For diesel:* • Fuel economy of 9.2 litres per 100 km in 2020 before efficiency improvements. Fuel economy ranges from 8.1 to 6.0 litres per 100 km after efficiency improvements • Incremental upfront cost in 2020 ranges from $2,180 to $4,020 per vehicle depending on the level of fuel efficiency achieved	-398	20.3
Shift some commuter car travel to rail	Shift approximately 420 return commuter car trips and general car trips per day to train journeys by the provision of additional services on existing infrastructure **Assumptions**: • Shifted journeys are on average 109km return	-315	3.0

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Hybrid cars	More fuel efficient diesel and petrol hybrid cars (full and plug-in hybrids) supplant less fuel efficient cars over the medium to long term **Assumptions***:* • Average penetration rate in 2020 is 9%. • The incremental cost from existing technology ranges from $4,800 to $9,000 per vehicle	-284	4.5
Residential heating, ventilation and air conditioning	New air-conditioners and space heaters purchased are in the top performers of their category (named high-efficiency). Systems are maintained more frequently (improved duct insulation, correct level of refrigerant and new air filters). **Assumptions***:* • 20% savings for air conditioners, 20% for gas heaters, 48% for electric heaters and 10% for maintenance • Penetration rate 30% above BAU in 2020 for air conditioners; 30% above BAU in 2020 for space heaters; 15% above BAU in 2020 for maintenance • Incremental upfront cost of $575 for air conditioners, $800 for gas heaters, $3,760 for electric heaters and around $1,150 to cover a 150 m^2 house over lifespan of equipment for maintenance	-171	4.6
Residential appliances and electronics	New appliances and electronics purchased are in the top performers of their category (named high-efficiency) **Assumptions***:* • 35% savings for high-efficiency appliances compared to average new buys, 37% for electronics • Penetration rate of high efficiency appliances increases from 6% in 2010 to 67% in 2020 compared to 33% in 2020 in BAU • Penetration rate of high efficiency electronics increases from 9% in 2010 to 57% in 2020 compared to 27% in 2020 in BAU • Price premium is about 1% for electronics and 12% for appliances	-141	39.3

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Residential building improved thermal efficiency	Basic retrofit including sealing areas of air leakage, weather stripping doors and windows, insulating attic and wall cavities In addition, advanced building envelope upgrades to "passive" standard are undertaken in conjunction with regular building renovations. Includes installing high efficiency windows and doors; increasing outer wall, roof, and basement ceiling insulation; mechanical ventilation with heat recovery, basic passive solar principles **Assumptions***:* *Basic building envelope:* • 30% savings on heating and 20% on cooling • Cost premium of A$9/m2 • Penetration rate of 12% above business-as-usual in 2020 *Advanced building envelope:* • 60% savings on heating and cooling • Cost premium of A$120/m2 in 2010 and A$105/m2 in 2020 • Penetration rate of 29% of households in 2020 above business-as-usual	-139	24.4
Residential lighting	Replace compact fluorescent lamp (CFL) by light emitting diode (LED) and standard quartz halogen bulbs by high-efficiency halogen bulbs **Assumptions:** *CFLs to LEDs:* • In 2020, 30% of non-living areas and 50% of living area CFLs are replaced by LEDs • Incremental upfront cost of $62 in 2010 decreasing to A$32 in 2030 for LEDs *Halogen bulbs:* • 30% energy savings • Penetration rate increases progressively to 30% above BAU in 2020 • Cost premium of A$7 per bulb	-90	19.9

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Residential new builds	New houses are built to at least 7 stars in the NatHERS rating system from 2015 onwards, as compared to the baseline 6 stars **Assumptions**: • Heating, ventilation and air conditioning (HVAC) energy consumption of households decreases from 49 KWh/m^2 to 25 kWh/m^2 • Incremental upfront cost of $24/m^2 • 100% of new homes are built to higher standard from 2013 on	-76	34.6
Electric cars	By 2020, electric vehicles replace 3% of all new vehicle purchases in the Gippsland region **Assumptions***:* • Fuel savings of 35% per electric vehicle • Incremental upfront cost of $5,835 per vehicle (plus infrastructure costs of $500 per vehicle), average lifespan of 20 years	-23	3.2
Solar PV	Installation of residential rooftop solar PV panels by 2020 to reduce demand for grid-supplied electricity. **Assumptions**: • Penetration rate of 5% of households by 2020 • Typical installed capacity: 2.25 kW • Upfront cost of $3,000/kW, average lifespan of 25 years • Fixed maintenance cost in 2020: $41/kW p.a. • Variable maintenance cost in 2020: $3.5/MWh p.a.	70	23.9

On the land

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Reduced cropland soil emissions	For cropland that has 3 or more cultivations, reduce tillage to zero. For cropland that is cultivated less than 3 times per year, reduce tilling to 1 or 2 times. Use fertilisers more efficiently: adjust application rates based on precise estimation of crop needs, place Nitrogen more precisely in soil, avoid application in times when susceptible to loss, use coated, slow release fertilisers. **Assumptions***:* *Reduced tillage:* • No till: Penetration increases from 5% in 2010 to 35% in 2020 • Reduced till: Penetration rate increases from 40% in 2010 increasing to 60% by 2020 • Reducing tillage practices can reduce emissions at a weighted average rate of 0.30 tCO$_2$e/ha/yr. *Fertiliser usage:* • Apply to approximately 37,000 ha of cropping land, improve Nitrogen application to reduce fertiliser use by 25%, reducing emissions by 0.03 tCO$_2$e/ha/yr • Penetration rate increases from 65% in 2010 to 90% in 2020	-110	2.9
Dairy farm energy efficiency	Installation of a heat recovery unit on the refrigeration compressor lowers the temperature of refrigeration gases **Assumptions:** • Assume that systems are replaced when current systems fail and that half of these upgrade to an efficient system • Average savings of 19% on refrigeration and water heating energy use • Penetration rate of 33% of farm systems by 2020	-84	10.1

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Reforestation of less productive land with timber plantation	Plant timber for harvest on 1,500 ha of less productive land **Assumptions**: • Planting undertaken on 1,500 ha of land by 2020 • Technical emissions reduction potential 14.0 tCO$_2$e/ha/yr • Planting cost $2,250/ha • Annual operating cost $126/ha/year	4	21.4
Improved pasture and grassland management to reduce livestock emissions	Actions undertaken through *Improved pasture and grassland management to improve soil carbon* (below) also reduce livestock emissions via better feed quality & animal management **Assumptions**: • 5% reduction in cattle enteric emissions • 1.4 cattle/ha on improved-pastures and 0.7 cattle/ha on natural grasslands brought under improved management	5	15.5
Improved pasture and grassland management to improve soil carbon	Optimise grazing intensity and timing for carbon sequestration and productivity; promote land productivity; fire management; species introduction, e.g. perennial grasses with higher productivity or greater sequestration through deeper roots. **Assumptions**: • Apply to approximately 545,000 ha of improved pastures land and 235,000 ha of natural grasslands • Technical emissions reduction potential 0.3 tCO$_2$e/ha/yr sequestered in soil • Penetration rate increases from BAU of 25% to 50% in 2020 for improved pastures and from BAU of 5% to 15% in 2020 for natural grasslands	6	52.7

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Anti-methanogenic treatments	Addition of dietary additives, injections, water medication, vaccines to reduce enteric emissions from cattle **Assumptions***:* • Technical emissions reduction potential – reduce livestock enteric emissions by 10% per head • Penetration rate increases to 50% above BAU in 2020	7	65.6
Strategic reforestation of productive land with environmental forest	Plant environmental forests on 2% of productive land in line with best practice (wind breaks, riparian plantings, shade islands for livestock) **Assumptions***:* • Planting undertaken on approximately 8,150 ha of productive farmland • Technical emissions reduction potential 10.7 tCO2e/ha/yr • Planting cost $1,050/ha • Annual operating cost $142/ha/year	24	87.4
Reforestation of less productive land with environmental forest	Plant environmental forests that are not for harvest on less productive land **Assumptions***:* • Planting undertaken on approximately 8,650 ha of less productive land • Technical emissions reduction potential 10.8 tCO2e/ha/yr • Planting cost $1,050/ha • Annual operating cost $83/ha/year	26	65.0

Opportunity	Description	Cost A$/tCO^{2}e	Emissions reduction potential - ktCO$_2$e
Improved forest management	Increase amount of woody growth in forests by: • Removal of weeds such blackberry that limit native woody vegetation growth • Removal of feral animal species • Insect/plant pest control to promote tree growth • Fire control **Assumptions***:* • 43,200 ha of forest brought under improved management by 2020 • Technical emissions reduction potential 1.0 tCO$_2$e/ha/yr	53	43.2
Restoration of less productive pasture and grassland	Restore less productive pastures to improve soil carbon sequestration. Reduce salinity, acidification and erosion by re-vegetation, applying lime, improving fertility via nutrient application. Apply organic substrates. **Assumptions***:* 20% of improved-pasture and natural grass land is degraded (136,400 ha land in improved pastures and 58,000 ha of natural grassland) Technical emissions reduction potential 1.0 tCO$_2$e/ha/yr Penetration rate increases progressively from 5% in 2010, rising to 15% in 2020 for improved pastures Penetration rate increases progressively from 0% in 2010, rising to 8% in 2020 for natural grasslands	82	18.0

Bibliography

In addition to the documents listed below, the analysis for the *Low Carbon Growth Plan for Gippsland* draws on a range of other sources that underpin the analysis in the *Low Carbon Growth Plan for Australia.* A full list of these sources can be found in the Bibliography of the *Low Carbon Growth Plan for Australia,* available at www.climateworksaustralia.org

Data inputs and refinement were also collected through extensive consultation with sector experts, industry professionals and businesses throughout the process of developing the Plan. A list of those who provided input can be found on the Acknowledgements page of the *Low Carbon Growth Plan for Gippsland.*

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