Environmental Protection Agency – Queensland

Office of Climate Change

An enhanced Queensland Marginal Abatement Cost Curve

Manufacturing and mining sector focus

December 2008

THE NOUS GROUP

THINKING DOING LEADING

Contents

Executive summary

Queensland's Office of Climate Change requested that The Nous Group (Nous) and Sinclair Knight Merz (SKM) extend their recent analysis of greenhouse gas abatement opportunities and costs – culminating in the construction of a Queensland marginal abatement cost curve – into a more detailed assessment of abatement potential and costs in Queensland's mining and manufacturing sectors. This report presents results from this additional research. The original multi-sector abatement cost report detailed the methodological framework for the analysis of abatement potential and costs: this report should be seen as an annex to, and an update of, the original report.

About one fifth of Queensland's economic growth comes from mining and manufacturing activity, contributing more to Queensland's economic prosperity than transport, retail trade, agriculture and forestry combined. As well as a strong – and growing – source of state wealth, mining and manufacturing are also responsible for nearly one third of Queensland's greenhouse gas emissions. As we confront one of the major issues of our time – the imperative to cut greenhouse gas emissions to reduce the impact of climate change – sectors like mining and manufacturing in Queensland pose an interesting challenge: meaningful greenhouse gas abatement needs to include these sectors, but the risk of impacting economic output from abatement effort needs to be managed carefully.

The reference case

If no extraordinary abatement efforts are undertaken in Queensland's mining and manufacturing sectors, associated emissions will increase from around 50 Mt $C0_2$-e currently to about 90 Mt $C0_2$-e by 2050, a 2 percent annual growth rate. Growth in emissions is driven by significant expansion in mining and manufacturing as demand for Queensland's mining exports continues along with strong demand for locally produced Queensland manufactures. However, this expansion in output only partially translates into emissions increases: factor in productivity and efficiency and Queensland will continue to improve (indeed, in many respects, Queensland's mining and manufacturing industries operate at world's best practice).

Abatement opportunities

Significant abatement potential in Queensland's mining and manufacturing exists in efficiency improvements. Abatement opportunities considered in this report include:

- Efficiency improvements in the aluminium processing sector
- Reduction in energy demand from mining through equipment efficiencies
- Efficiency improvements in food and beverage manufacturing
- Waste, heating, pump, and machinery efficiency improvements in chemicals and petroleum processing
- Reduction in energy demand from the manufacture of zinc, tin, silver, lead and copper
- General improvements in efficiency across small and medium-sized manufacturers

Other abatement opportunities considered include large industrial cogeneration, and PFC reduction in aluminium smelting.

Modelling for this report showed that abatement potential realised through these activities would increase to nearly 15 Mt $C0_2$-e annually by 2050, a 16 percent reduction of mining and manufacturing reference case emissions.

Abatement costs

Abatement potential associated with each option was costed. While much of the abatement potential involves improvements in machinery and process efficiency, nearly all initiatives incur net economic costs. This is in contrast to efficiency improvements in other sectors (for example, appliance and building efficiency in residential and commercial energy consumption) which are associated with net economic benefits. Extraordinary abatement in the mining and manufacturing sectors is more expensive than in other sectors because Queensland's mining and manufacturing sectors – often involved in intense trade competition – are highly efficient already. The marginal efficiency gains associated with extraordinary abatement efforts therefore incur additional costs which are not offset completely.

The following table shows the abatement potential (cumulative, to 2050) and (discounted) costs associated with the modelled initiatives, while the chart that follows shows a marginal abatement cost curve aggregated to major sectors:

Initiative	Abatement ($C0_2e$)	Cost of abatement ($/tonne of C02e)
Machinery and equipment	3,460	-$31.73
Manufacturing	24,479	-$6.97
Mining energy efficiency	20,590	-$0.63
Large industrial cogeneration	116,954	$1.32
Non ferrous metals	13,222	$2.28
Basic chemical and petroleum industry efficiency	14,318	$2.63
Aluminium smelting efficiency	38,490	$3.37
Food and beverage industry	38,375	$5.42
Aluminium PFC reductions	19,008	$13.33
Solar thermal lime production	9,865	$41.78
Iron & steel: biomass to reduce coal in smelting	3,191	$56.46
Cement extenders/ geopolymers	4,255	$78.98

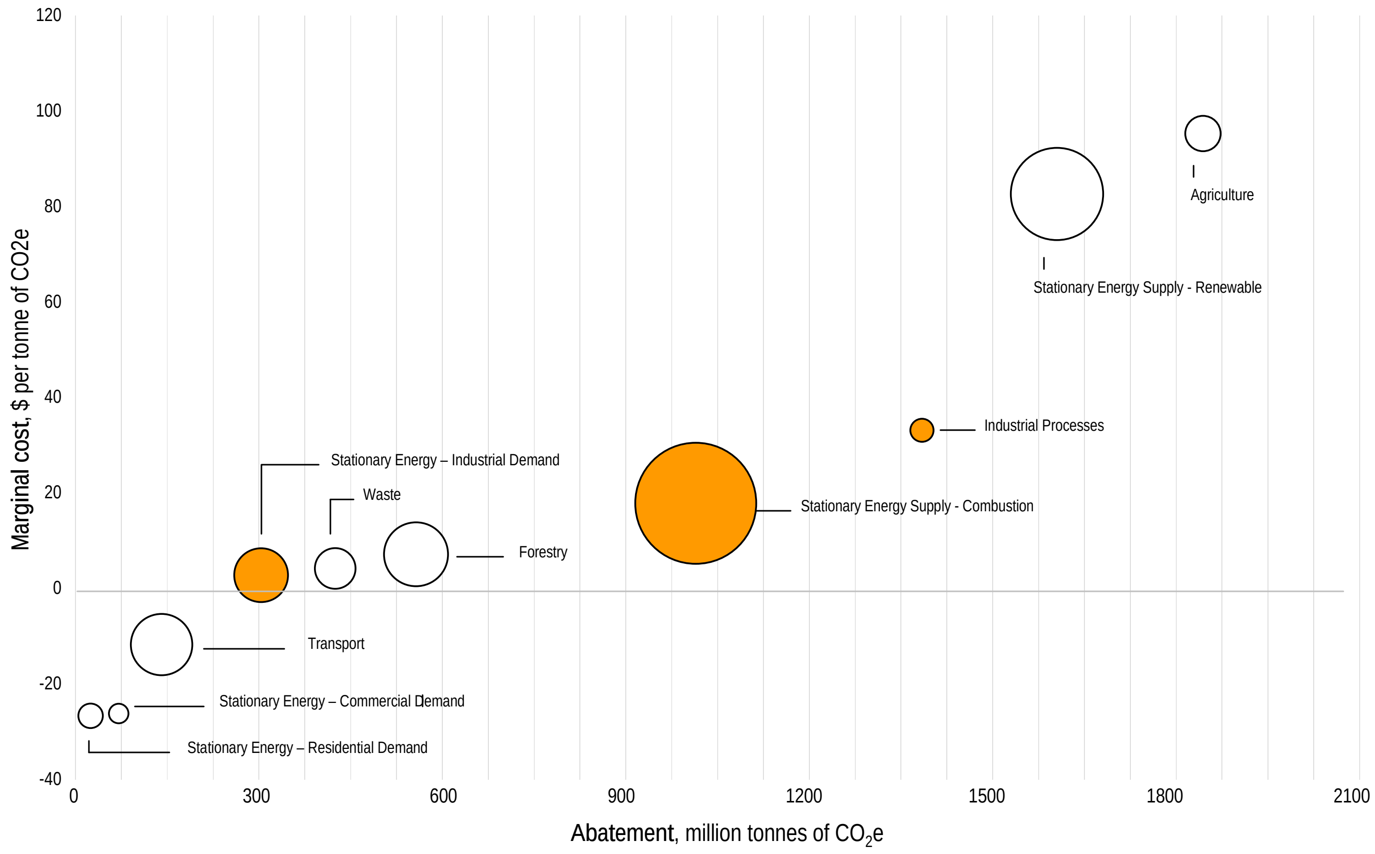


Figure 1 – Marginal abatement cost curve showing cumulative abatement potential of each aggregated sector out to 2050.

1 Queensland's manufacturing and mining sectors

Queensland's manufacturing sector is especially heterogeneous, encompassing a broad range of sub-sectors including the production of food, clothing, chemicals, non-metallic minerals, metals and machinery. Queensland's mining sector includes coal mining, oil and gas extraction, metal ore mining, other mining and other non-metallic minerals.

These sectors contribute significantly both to Queensland economic growth and prosperity, and to Queensland's greenhouse gas emissions. The following chart shows proportional gross value added across ANZSIC sectors A-Q in Queensland:

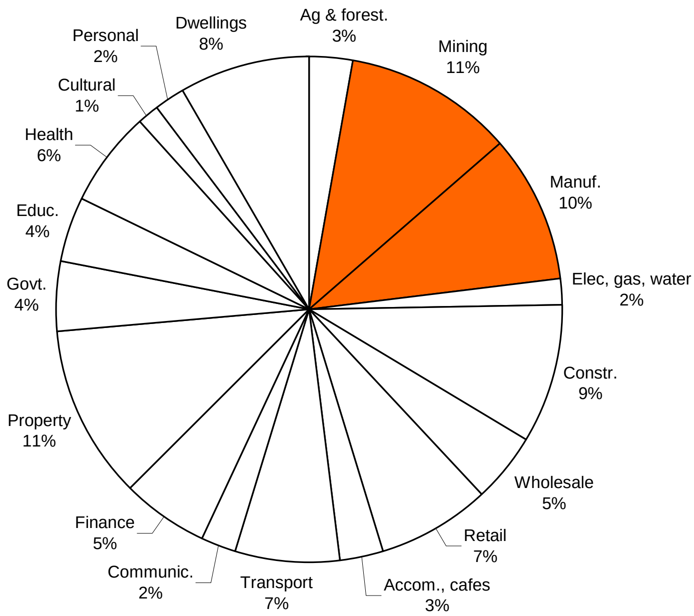


Figure 2: Gross value added, chain volume measures, Queensland, financial year to June 2008[1]

Mining and manufacturing contributed 21 percent to wealth generated in Queensland in the year to June 2008. Along with property and business services (11 percent), Mining and manufacturing account for the largest share of gross value added in Queensland.

To quantify greenhouse gas emissions from these sectors requires the reconciliation of National Greenhouse Gas Inventory accounting principles and ANZSIC sector definitions. Complicating this task is that, under NGGI accounting principles, emissions are allocated to sectors according to the point of greenhouse gas production. Sectors in the ANZSIC framework are defined according to the source of industrial activity. Given these differing

[1] ABS Cat. 5220.0 Australian National Accounts: State Accounts

methodologies, some degree of subjective reconciliation is required. The reconciliation conducted for this report included the following assumptions:

- Mining emissions include those associated with mining's share of (NGGI) stationary energy demand, and exclude transport emissions and fugitive emissions related to the extraction of coal for electricity generation
- Manufacturing emissions include those associated with manufacturing's share of (NGGI) stationary energy demand, and (NGGI) industrial processes emissions
- Both mining and manufacturing shares are determined using ABARE's Table F, Australian energy consumption, by industry and fuel type, 2006-07 figures.

Using these assumptions, the following table includes 2006 emissions associated with manufacturing and mining. The table shows that, together, mining and manufacturing accounted for about 30 percent of Queensland emissions

	2006 emissions (tonnes $C0_2$-e)	% of Queensland total
Manufacturing and mining stationary energy	47,243	27.7%
Industrial processes	3,689	2.2%
Total	170,933	

Table 1: Manufacturing and mining emissions in Queensland, 2006

Employing the same methodology for reference case estimation as used in the Nous/SKM original report yields the following emissions forecast for the manufacturing and mining sectors in Queensland:

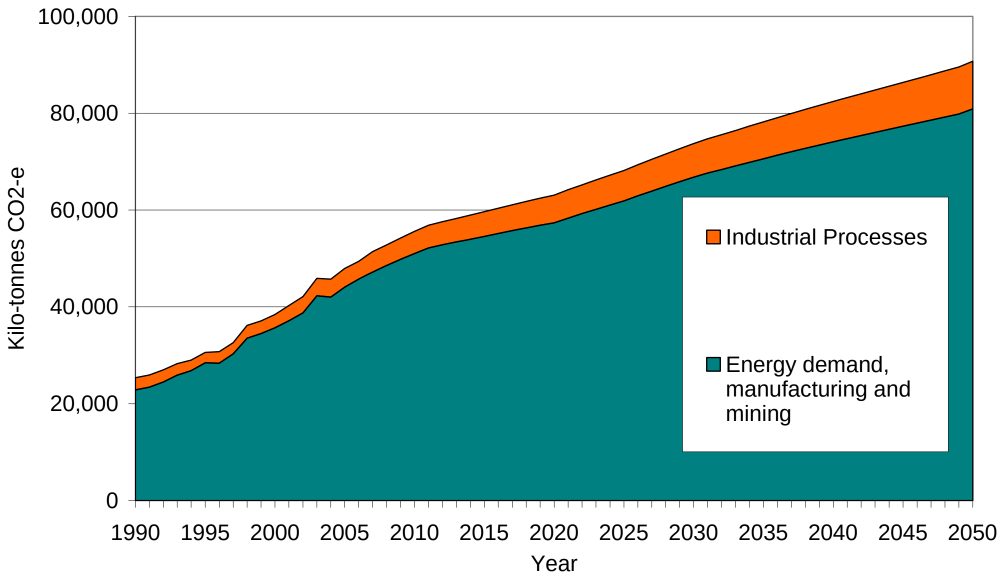


Figure 3: Past and future emissions from manufacturing and mining, Queensland

As a prelude to the next section – in which abatement opportunities are detailed – the following table shows the deconstruction of the mining and manufacturing sector into various ANZSIC sub-sectors, and the number of employees, wages and value added in each.

ANZIC	Description	Employees (000)	% of Qld mining & manuf.	Wages ($m)	% of Qld mining & manuf.	Value add ($m)	% of Qld mining & manuf.
Div B	Mining	18.7	9%	1652	17%	8935	36%
21	Food, beverage and tobacco mfg	42.8	20%	1681	18%	3213	13%
22	Textile, clothing, footwear and leather mfg	6.4	3%	169	2%	301	1%
23	Wood and paper product mfg	12.5	6%	480	5%	1106	4%
24	Printing, publishing and recorded media	14.8	7%	612	6%	1262	5%
25	Petroleum, coal, chemical and associated product mfg	15.4	7%	767	8%	1923	8%
26	Non-metallic mineral product mfg	9.5	5%	419	4%	875	4%
27	Metal product mfg - Iron and Steel - Aluminium - Other non-ferrous metals	37.3	18%	1649	17%	3853.00	15%
28	Machinery and equipment mfg	38.7	18%	1629	17%	2685	11%
29	Other industrial / manufacturing	14	7%	449	5%	803	3%

Table 2: Employee numbers, wages and value add by manufacturing and mining sub-sector, Queensland

Abatement initiatives in the mining and manufacturing sectors are associated in general – but not always – with improvements in energy efficiency. The sub-sectors listed above that contribute significantly to Queensland's productive income are therefore most likely both to offer the largest improvements in abatement and efficiency. To focus efforts, abatement opportunities identified and assessed in this project cover the following ANZSIC categories:

- B Mining
- 21 Food, beverage and tobacco manufacturing
- 25 Petroleum, coal, chemical and associated product manufacturing
- 27 Metal product manufacturing
- 28 Machinery and equipment manufacturing
- Other sectors combined.

2 Abatement opportunities

This section introduces the abatement initiatives associated with the sub-sector groupings listed at the end of section 1. Two abatement options are included in addition to energy efficiency initiatives. The first is large industrial cogeneration. The second is PFC reduction in the production of aluminium. The initiatives are explained in detail in **Appendix A**.

2.1 Stationary Energy - Demand

Aluminium (Industrial) – Aluminium smelting uses large quantities of electricity, mostly in the electrolytic process but also ancillary loads and anode production. While the Australian industry is already among the most efficient in the world, further improvements are possible and improved processes and materials are being developed.

Energy efficiency in mining (Industrial) - Reduction in energy demand from mining operations through improved boiler and heating efficiency, pumps fans and compressors, crushing and grinding, conveyors and stacking equipment.

Energy efficiency in Food and Beverage Manufacturing (Industrial) - Reduction in energy demand from food and beverage manufacturing through operating practices, reducing hot water use and wastage, improved efficiency in heating and refrigeration equipment, and improved controls.

Energy efficiency in energy and chemicals (Industrial) - Reduction in energy demand from the production of chemicals, petroleum and coal processing through waste and leakage minimisation, more efficient boilers and steam raising, improved motors and controls for pumps and fans, and process controls.

Energy efficiency in other metal products (Industrial) - Reduction in energy demand from manufacture of other metals such as Zinc, Tin, Silver, Lead and Copper through process design and control improvements, continuous casting, heat and insulation.

Energy efficiency in machinery and equipment manufacturing (Industrial) - Reduction in energy demand from machinery and equipment manufacturing through improved boiler and heating efficiency, reduced waste and leakage, improved practices and controls, and better motors and controls for fans pumps and compressors.

Efficiency in other industrial and manufacturing (Industrial) - Reduction in energy demand from remaining industrial and manufacturing activities, including SMEs (small to medium enterprises) through a range of technologies including process improvements and controls, improved boiler efficiencies, improved motors and controls for fans and pumps, reduced waste and leakage, and improved practices.

2.2 Stationary Energy – Supply

Large industrial cogeneration - Cogeneration is a means of supplying a site's power and thermal energy needs from the combustion of a single fuel. Cogeneration improves overall supply efficiency by generating electricity adjacent to thermal loads, so the waste heat from the generator can supply the thermal load. While there may be some improvement in the greenhouse intensity of electricity generated, the primary benefit is in avoiding fuel for boilers and steam raising by using the waste heat from the generator.

The cogeneration initiative is applicable across the following sub-sectors:

- B Mining
- 25 Petroleum, coal, chemical and associated product manufacturing
- 27 Metal product manufacturing
- 29 Other industrial manufacturing

2.3 Industrial Processes

Aluminium PFC reduction (Industrial) – Aluminium smelting produces Perfluorcarbon (PFC) gases as a byproduct of the production process. Improved process control, and alternate cathode materials being developed, can reduce the emissions of PFCs. The Aluminium industry has a target to reduce PFCs from 1990 levels by 80% by 2010.

3 Abatement potential

The initiatives described in section 2, if fully implemented, would alter Queensland's emissions profile into the future, and reduce significantly emissions in the manufacturing and mining sectors. Total cumulative abatement to 2050 associated with the new initiatives would be 335.5 Mt. In 2050, annual abatement will reach 14.7Mt. The following charts show abatement potential against the State reference case, and against the combined manufacturing and mining reference case:

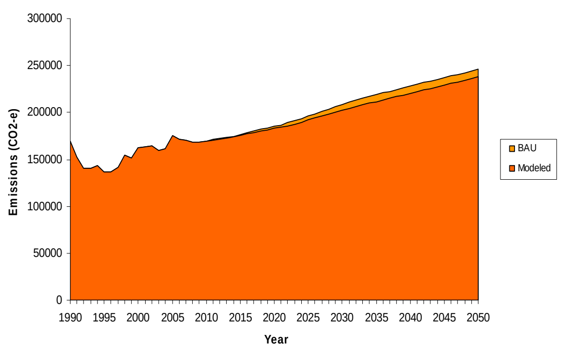


Figure 4: Manufacturing and mining sector abatement, state reference case

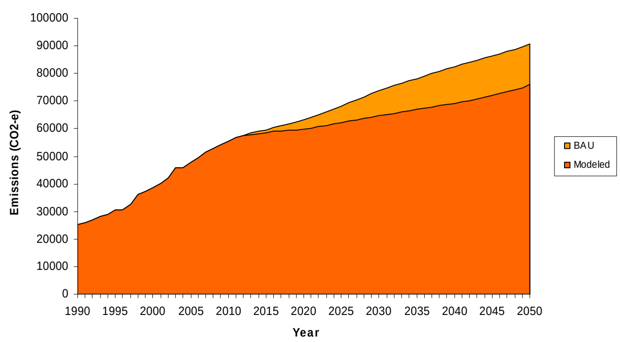


Figure 5: Manufacturing and mining sector abatement, combined manufacturing and mining sector reference case

The following table summarises the reductions depicted in the charts above:

New initiatives	Reference case, all state kt C02-e	Reference case, manuf. & mining kt C02-e	Abatement kt C02-e	% of all state	% of manuf. & mining
Cumulative to 2050, new initiatives	9,006,218	3,157,392	335,501	4	11
Annual at 2050, new initiatives	246,555	90,733	14,748	6	16

Table 3: New initiatives abatement summary

The new initiatives will also contribute more abatement potential to the economy-wide portfolio described and parameterised in the first report to the Office of Climate Change. The following chart shows new abatement potential associated with all initiatives:

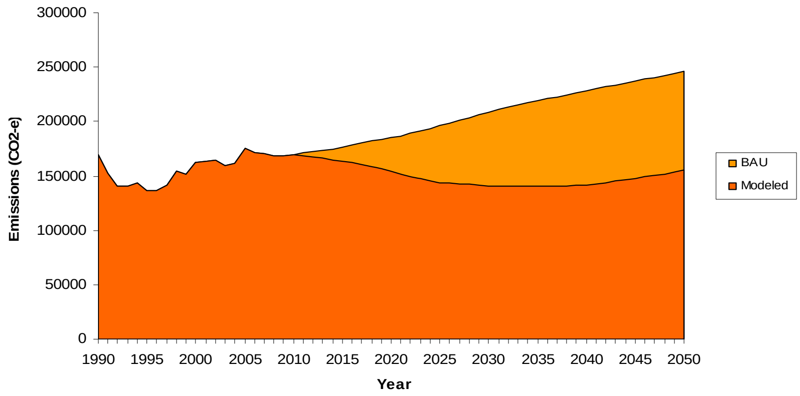


Figure 6: Total state-wide abatement (including new initiatives), state reference case

The following table summarises the reductions depicted in the charts above. In total , abatement realised by all initiatives combined, accounting for any interdependencies between initiatives and across sectors, is 25 percent assessed on a cumulative basis to 2050, and 36 percent in 2050 of annual emissions.

All initiatives	Reference case, all state kt $C0_2$-e	Abatement kt $C0_2$-e	% of all state
Cumulative to 2050	9,006,218	2,258,362	25
Annual at 2050	246,555	89,900	36

Table 4: Total initiatives abatement summary

4 Abatement cost curve

This section presents, first, a Queensland-wide marginal abatement cost curve, and a smaller curve specific to Queensland's mining and manufacturing sector.

4.1 Queensland-wide curve

Employing the same methodology used in the previous report, the project team generated abatement profiles and associated costs for the new initiatives, and included them in the construction of a new marginal abatement cost curve for Queensland. This cost curve and supporting data tables begin overleaf.

Highlights include:

- As was the case in the previous report, many abatement options exist which are associated with net economic benefits. These include residential and commercial energy efficiency initiatives and many transport initiatives.
- Only one of the new initiatives, manufacturing efficiency, accrues a net economic benefit. The remaining mining and manufacturing initiatives incur positive economic costs, but are not significant in size. This result is an artefact of an especially important observation: Queensland's manufacturing and mining sectors operate very efficiently, and often at world's best practice. This, we expect, will continue. As such, efficiency gains absent extraordinary abatement effort are built into the reference case. Any additional effort – captured by the abatement initiatives – will require added cost beyond that which generates optimal production efficiencies. When weighted for abatement potential, the combined cost for the new initiatives is positive (reflected in the bubble chart below).
- After comments on the preceding report, the project team reviewed the renewable energy initiatives. Wind, regarded by many to be an efficient source of renewable energy in Australia, is one of the least expensive renewable options in Queensland. However, reduced average wind velocity and frequency means the potential for wind power to displace other sources of energy is not as great in Queensland, and costs of wind are higher. In fact, if collected effectively, bagasse and crop / wood / food wastes are likely cheaper than wind. Further, while wind is cheaper than geothermal power generation when costs are not discounted, discounting weights more heavily the significant (and earlier) costs of wind than it does for geothermal, making geothermal cheaper when discounted.
- Finally, if initiatives were to be implemented from least cost to highest cost, over 1,300 Mt of cumulative abatement could be realised before net positive costs are incurred. This represents 60 percent of all abatement identified for this study.

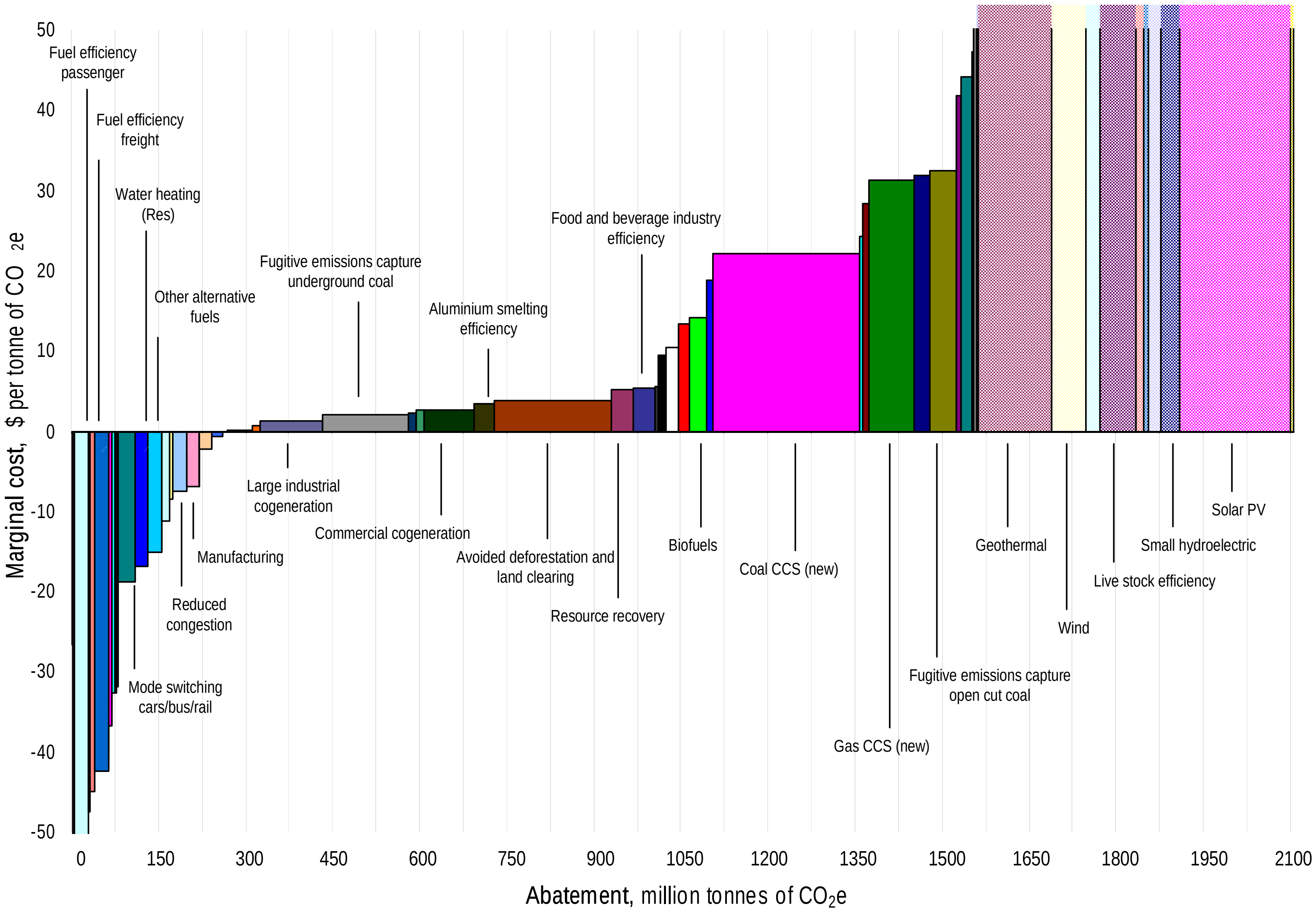
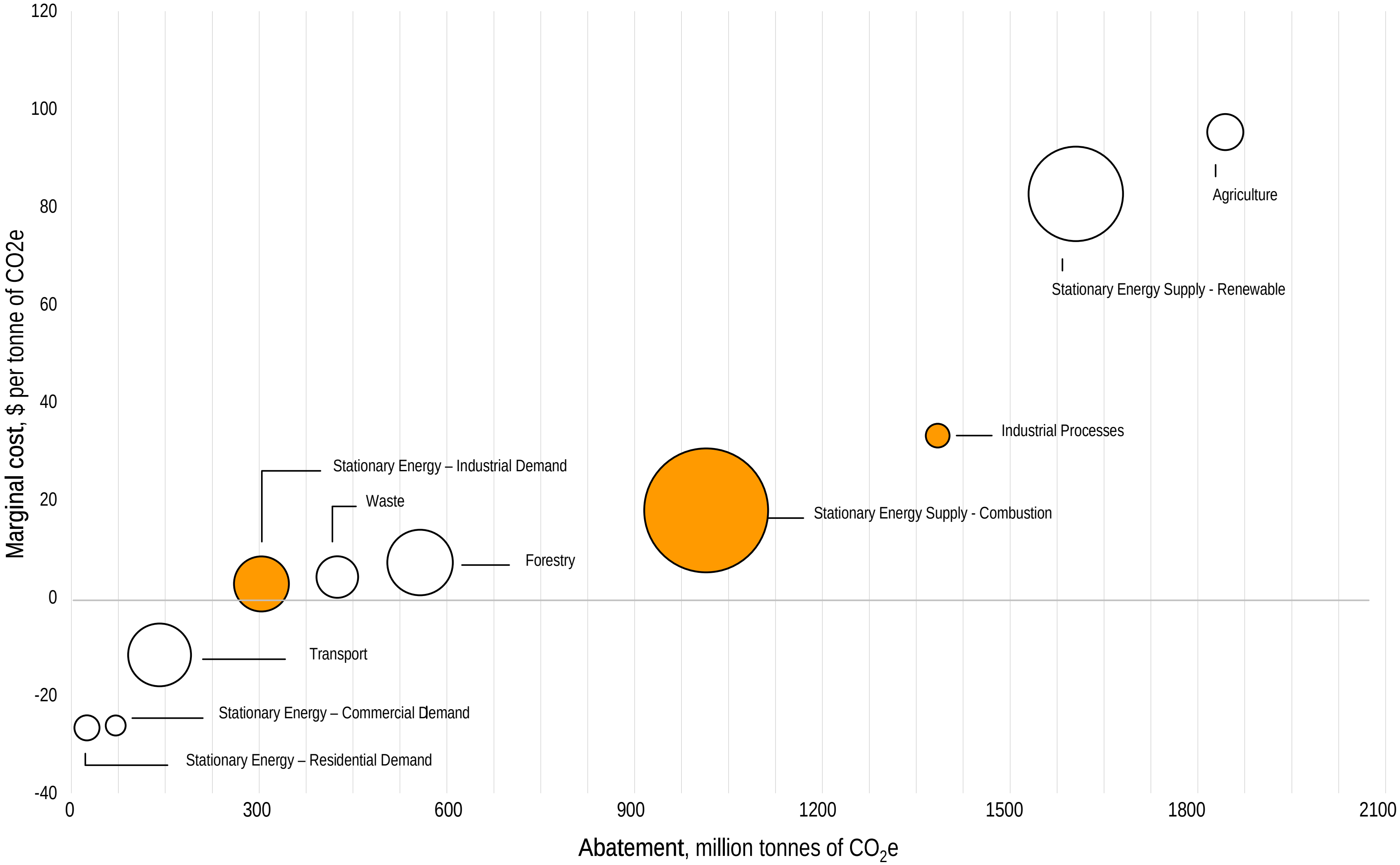


Figure 7: Queensland marginal abatement cost curve, discounted costs, cumulative abatement to 2050



120
100
80
60
40
20
0
-20
-40
Marginal cost, $ per tonne of CO2e
Agriculture
Stationary Energy Supply - Renewable
Industrial Processes
Stationary Energy – Industrial Demand
Waste
Stationary Energy Supply - Combustion
Forestry
Transport
Stationary Energy – Commercial Demand
Stationary Energy – Residential Demand
0
300
600
900
1200
1500
1800
2100
Abatement, million tonnes of CO_2e

Initiative	Abatement ($C0_2e$)	Cost of abatement ($/tonne of C02e)	Initiative	Abatement ($C0_2e$)	Cost of abatement ($/tonne of C02e)	Initiative	Abatement ($C0_2e$)	Cost of abatement ($/tonne of C02e)
Cropland management	2,602	-$311.89	Manufacturing	24,479	-$6.97	Vehicle turnover -- passenger	10,208	$18.88
Lighting (Res)	1,014	-$55.58	Cooking (Comm)	950	-$6.88	Coal gasification	628	$19.06
Fuel efficiency -- passenger	25,520	-$50.34	Waste Avoidance	20,492	-$2.19	Coal CCS (new)	271,216	$22.07
Standby Power (Res)	2,191	-$47.54	Mining energy efficiency	20,590	-$0.63	Improve generator efficiency (retrofit)	3,281	$24.21
Other Appliance Efficiency (Res)	7,510	-$45.02	Logistics efficiency	6,805	$0.00	Vehicle turnover -- freight	13,611	$28.32
Fuel efficiency -- freight	27,221	-$42.48	Improved driving	1,701	$0.00	Gas CCS (new)	82,057	$31.37
Office Equipment (Comm)	405	-$40.91	Management of savannah fires	6,438	$0.06	Biofuels (power generation)	29,083	$31.92
Other Appliance Efficiency (Comm)	310	-$39.24	Improve generator efficiency (new)	39,256	$0.19	Fugitive emissions capture - open cut coal	49,313	$32.47
Refrigeration (Comm)	4,910	-$36.76	Methane recovery (Waste -energy)	14,375	$0.73	Solar thermal lime production	9,865	$41.78
Elevators (Comm)	67	-$34.70	Large industrial cogeneration	116,954	$1.32	Afforestation (harvested)	20,029	$44.20
Lighting (Comm)	4,281	-$32.62	Fugitive emissions capture - underground coal	159,338	$2.12	Reduced travel distances	3,403	$47.20
Air Handling (Comm)	4,281	-$32.62	Non ferrous metals	13,222	$2.28	Iron & steel: biomass to reduce coal in smelting	3,191	$56.46
Cooling/Pumping (Comm)	1,489	-$31.90	Basic chemical and petroleum industry efficiency	14,318	$2.63	Cement extenders/ geopolymer	4,255	$78.98
Machinery and equipment	3,460	-$31.73	Commercial cogeneration	91,847	$2.71	Geothermal	133,937	$82.27
Building Shell, Heating and Cooling (Res)	3,333	-$26.58	Aluminium smelting efficiency	38,490	$3.37	Wind	64,672	$86.58
Mode switching - cars/bus/rail	34,027	-$18.88	Avoided deforestation and land clearing	215,488	$3.79	Coal CCS (retrofit)	26,839	$90.34
Water Heating (Res)	21,607	-$16.77	Resource recovery	40,912	$5.10	Livestock efficiency	65,620	$120.73
Other alternative fuels	25,520	-$15.10	Food and beverage industry	38,375	$5.42	Gas CCS (retrofit)	14,661	$125.06
Mode switching -- road/rail	14,291	-$11.24	Afforestation (permanent)	6,676	$5.49	Wave and Ocean	8,594	$237.29
Water Heating (Comm)	2,044	-$8.79	LNG and petroleum production - CCS	14,919	$9.37	Solar Thermal	21,840	$329.75
Space Heating (Comm)	4,056	-$8.43	Increased recycling	23,043	$10.49	Small hydroelectric	34,394	$416.65
Reduced congestion	25,520	-$7.55	Aluminium PFC reductions	19,008	$13.33	Solar PV	205,314	$740.82
			Biofuels	34,027	$14.16	Manure management	5,892	$16,991

Table 5: Input data for Queensland marginal abatement cost curve

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Initiative	Cumulative abatement (MT CO_2-e)	Net cost per tonne of abatement (Net $NPV / T CO_2-e abated)	Total net cost of reductions (Net $NPV)	Cumulative net cost (Net $NPV)	Net cost per tonne of abatement (Net $2008 / T CO_2-e abated)	Total net cost of reductions (Net $2008)	Cumulative net cost ($/tonne) (Net $2008)
Cropland management	2,602	-$311.89	-$811,691	-$811,691	-$1,280.48	-$3,332,434	-$3,332,434
Lighting (Res)	1,014	-$55.58	-$56,357	-$868,048	-$263.37	-$267,053	-$3,599,487
Fuel efficiency -- passenger	25,520	-$50.34	-$1,284,745	-$2,152,793	-$227.09	-$5,795,333	-$9,394,820
Standby Power (Res)	2,191	-$47.54	-$104,161	-$2,256,954	-$272.85	-$597,827	-$9,992,647
Other Appliance Efficiency (Res)	7,510	-$45.02	-$338,118	-$2,595,072	-$261.50	-$1,963,910	-$11,956,557
Fuel efficiency -- freight	27,221	-$42.48	-$1,156,271	-$3,751,343	-$191.61	-$5,215,800	-$17,172,357
Office Equipment (Comm)	405	-$40.91	-$16,571	-$3,767,914	-$216.02	-$87,508	-$17,259,864
Other Appliance Efficiency (Comm)	310	-$39.24	-$12,153	-$3,780,067	-$218.01	-$67,527	-$17,327,391
Refrigeration (Comm)	4,910	-$36.76	-$180,481	-$3,960,548	-$220.92	-$1,084,785	-$18,412,176
Elevators (Comm)	67	-$34.70	-$2,312	-$3,962,860	-$223.50	-$14,891	-$18,427,068
Lighting (Comm)	4,281	-$32.62	-$139,655	-$4,102,515	-$226.12	-$968,069	-$19,395,137
Air Handling (Comm)	4,281	-$32.62	-$139,655	-$4,242,171	-$226.12	-$968,069	-$20,363,206
Cooling/Pumping (Comm)	1,489	-$31.90	-$47,509	-$4,289,680	-$227.67	-$339,037	-$20,702,243
Building Shell, Heating and Cooling (Res)	3,333	-$26.58	-$88,593	-$4,378,273	-$181.43	-$604,714	-$21,306,957
Mode switching -- cars/buses/rail	34,027	-$18.88	-$642,373	-$5,020,645	-$85.16	-$2,897,667	-$24,204,624
Water Heating (Res)	21,607	-$16.77	-$362,357	-$5,383,003	-$96.25	-$2,079,730	-$26,284,353
Other alternative fuels	25,520	-$15.10	-$385,424	-$5,768,426	-$68.13	-$1,738,600	-$28,022,953
Mode switching -- road/rail	14,291	-$11.24	-$160,593	-$5,929,019	-$50.69	-$724,417	-$28,747,370
Water Heating (Comm)	2,044	-$8.79	-$17,975	-$5,946,995	-$52.85	-$108,042	-$28,855,412

Initiative	Cumulative abatement	Net cost per tonne of abatement	Total net cost of reductions	Cumulative net cost	Net cost per tonne of abatement	Total net cost of reductions	Cumulative net cost ($/tonne)
	(MT CO_2-e)	(Net $NPV / T CO_2-e abated)	(Net $NPV)	(Net $NPV)	(Net $2008 / T CO_2-e abated)	(Net $2008)	(Net $2008)
Space Heating (Comm)	4,056	-$8.43	-$34,190	-$5,981,185	-$57.54	-$233,374	-$29,088,786
Reduced congestion	25,520	-$7.55	-$192,712	-$6,173,897	-$34.06	-$869,300	-$29,958,086
Manufacturing	24,479	-$6.97	-$170,699	-$6,344,596	-$107.72	-$2,636,862	-$32,594,948
Cooking (Comm)	950	-$6.88	-$6,542	-$6,351,138	-$41.38	-$39,323	-$32,634,271
Waste Avoidance	20,492	-$2.19	-$44,857	-$6,395,996	-$25.07	-$513,665	-$33,147,936
Mining energy efficiency	20,590	-$0.63	-$12,911	-$6,408,906	-$28.34	-$583,615	-$33,731,551
Logistics efficiency	6,805	$0.00	$0	-$6,408,906	$0.00	$0	-$33,731,551
Improved driving	1,701	$0.00	$0	-$6,408,906	$0.00	$0	-$33,731,551
Management of savannah fires	6,438	$0.06	$381	-$6,408,526	$0.12	$750	-$33,730,801
Improve generator efficiency (new)	39,256	$0.19	$7,369	-$6,401,157	$0.70	$27,351	-$33,703,450
Methane recovery (Waste to energy)	14,375	$0.73	$10,470	-$6,390,687	$4.73	$68,008	-$33,635,442
Fugitive emissions capture - underground coal	159,338	$2.12	$337,406	-$6,053,281	$15.00	$2,390,071	-$31,245,371
Non ferrous metals (excl aluminium) industries energy efficiency	13,222	$2.28	$30,132	-$6,023,149	-$13.13	-$173,562	-$31,418,933
Basic chemical and petroleum industry efficiency	14,318	$2.63	$37,590	-$5,985,558	-$13.64	-$195,365	-$31,614,298
Commercial cogeneration	91,847	$2.71	$249,132	-$5,736,426	$7.93	$728,606	-$30,885,692
Aluminium smelting efficiency	38,490	$3.37	$129,653	-$5,606,773	$2.88	$110,675	-$30,775,017
Avoided deforestation and land clearing	215,488	$3.79	$816,126	-$4,790,648	$18.68	$4,024,935	-$26,750,081
Resource recovery	40,912	$5.10	$208,477	-$4,582,170	$34.98	$1,431,105	-$25,318,976

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Initiative	Cumulative abatement	Net cost per tonne of abatement	Total net cost of reductions	Cumulative net cost	Net cost per tonne of abatement	Total net cost of reductions	Cumulative net cost ($/tonne)
	(MT CO_2-e)	(Net $NPV / T CO_2-e abated)	(Net $NPV)	(Net $NPV)	(Net $2008 / T CO_2-e abated)	(Net $2008)	(Net $2008)
Food and beverage industry efficiency	38,375	$5.42	$208,109	-$4,374,062	$5.25	$201,452	-$25,117,525
Afforestation (permanent plantations)	6,676	$5.49	$36,668	-$4,337,394	$38.26	$255,467	-$24,862,058
LNG and petroleum production - CCS	14,919	$9.37	$139,828	-$4,197,566	$40.04	$597,350	-$24,264,708
Increased recycling	23,043	$10.49	$241,704	-$3,955,862	$57.30	$1,320,256	-$22,944,452
Aluminium PFC reductions	19,008	$13.33	$253,298	-$3,702,565	$52.56	$999,000	-$21,945,452
Biofuels	34,027	$14.16	$481,779	-$3,220,785	$63.87	$2,173,250	-$19,772,202
Vehicle turnover -- passenger	10,208	$18.88	$192,712	-$3,028,073	$85.16	$869,300	-$18,902,902
Coal gasification	628	$19.06	$11,965	-$3,016,109	$72.93	$45,780	-$18,857,122
Coal CCS (new)	271,216	$22.07	$5,986,565	$2,970,457	$143.95	$39,040,781	$20,183,659
Improve generator efficiency (retrofit)	3,281	$24.21	$79,428	$3,049,885	$89.90	$295,008	$20,478,667
Vehicle turnover -- freight	13,611	$28.32	$385,424	$3,435,308	$127.74	$1,738,600	$22,217,267
Gas CCS (new)	82,057	$31.37	$2,574,305	$6,009,613	$211.19	$17,329,885	$39,547,152
Biofuels (power generation)	29,083	$31.92	$928,294	$6,937,907	$245.38	$7,136,468	$46,683,620
Fugitve emissions capture - open cut coal	49,313	$32.47	$1,601,137	$8,539,044	$230.00	$11,341,927	$58,025,546
Solar thermal lime production	9,865	$41.78	$412,110	$8,951,154	$310.60	$3,064,000	$61,089,546
Afforestation (harvested plantations)	20,029	$44.20	$885,207	$9,836,361	$307.91	$6,167,271	$67,256,817
Reduced travel distances	3,403	$47.20	$160,593	$9,996,954	$212.90	$724,417	$67,981,234
Iron & steel: biomass to reduce coal in smelting	3,191	$56.46	$180,186	$10,177,140	$330.59	$1,055,000	$69,036,234
Cement extenders/ geopolymer cements	4,255	$78.98	$336,045	$10,513,185	$481.20	$2,047,500	$71,083,734

Initiative	Cumulative abatement	Net cost per tonne of abatement	Total net cost of reductions	Cumulative net cost	Net cost per tonne of abatement	Total net cost of reductions	Cumulative net cost ($/tonne)
	(MT CO_2-e)	(Net $NPV / T CO_2-e abated)	(Net $NPV)	(Net $NPV)	(Net $2008 / T CO_2-e abated)	(Net $2008)	(Net $2008)
Geothermal	133,937	$82.27	$11,018,386	$21,531,571	$403.05	$53,982,823	$125,066,557
Wind	64,672	$86.58	$5,599,492	$27,131,063	$243.42	$15,742,457	$140,809,014
Coal CCS (retrofit)	26,839	$90.34	$2,424,655	$29,555,718	$585.25	$15,707,306	$156,516,320
Livestock efficiency	65,620	$120.73	$7,922,382	$37,478,100	$738.34	$48,449,944	$204,966,264
Gas CCS (retrofit)	14,661	$125.06	$1,833,448	$39,311,548	$828.76	$12,150,394	$217,116,659
Wave and Ocean	8,594	$237.29	$2,039,238	$41,350,786	$1,660.67	$14,271,512	$231,388,171
Solar Thermal	21,840	$329.75	$7,201,804	$48,552,591	$4,169.81	$91,069,664	$322,457,835
Small hydroelectric	34,394	$416.65	$14,330,108	$62,882,698	$1,681.28	$57,825,257	$380,283,092
Solar PV	205,314	$740.82	$152,101,354	$214,984,052	$2,091.03	$429,317,290	$809,600,382
Manure management	5,892	$16,991.50	$100,114,007	$315,098,059	$110,150.70	$649,008,684	$1,458,609,066

Table 6: Abatement totals and abatement costs, NPV and undiscounted, cumulative to 2050

4.2 Queensland's mining and manufacturing curve

The following marginal abatement cost curve and supporting table shows the initiatives specific to Queensland's mining and manufacturing sectors:

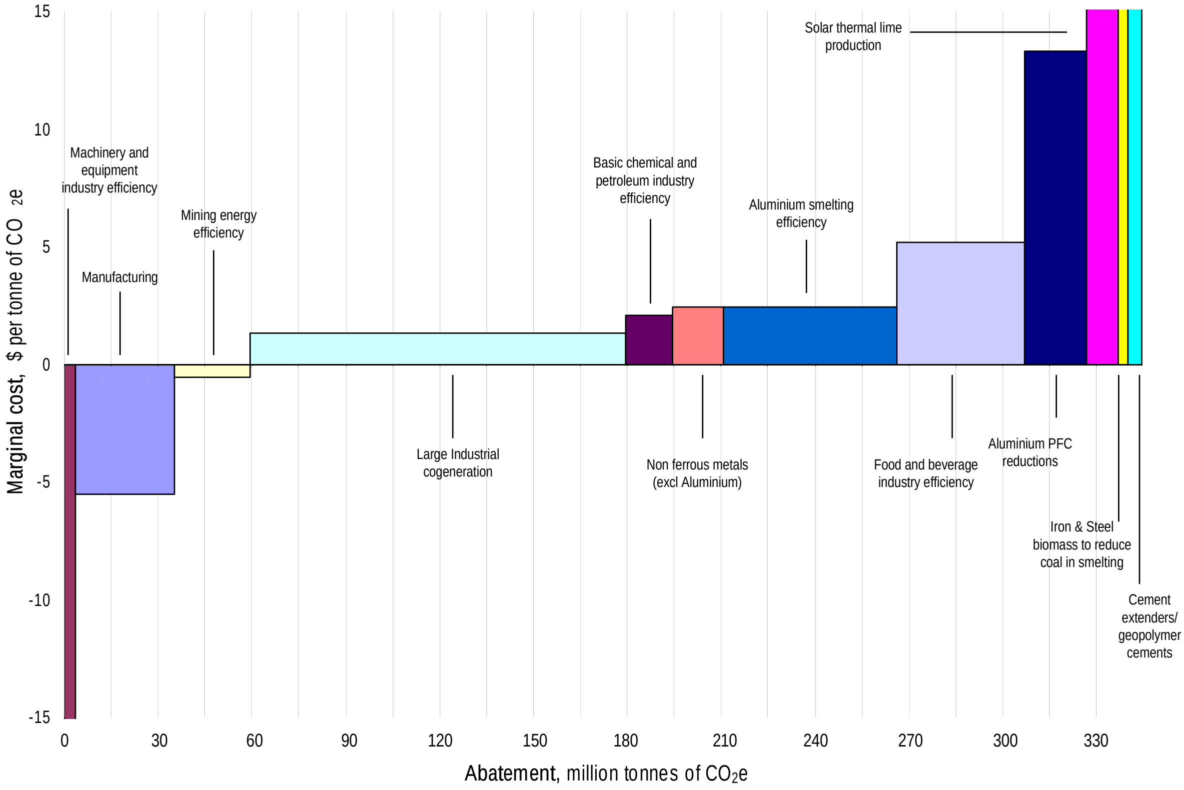

Figure 9: Abatement cost curve for Queensland's mining and manufacturing sector, cumulative to 2050, discounted

Initiative	Abatement ($C0_2e$)	Cost of abatement ($/tonne of C02e)
Machinery and equipment	3,460	-$31.73
Manufacturing	24,479	-$6.97
Mining energy efficiency	20,590	-$0.63
Large industrial cogeneration	116,954	$1.32
Non ferrous metals	13,222	$2.28
Basic chemical and petroleum industry efficiency	14,318	$2.63
Aluminium smelting efficiency	38,490	$3.37
Food and beverage industry	38,375	$5.42
Aluminium PFC reductions	19,008	$13.33
Solar thermal lime production	9,865	$41.78
Iron & steel: biomass to reduce coal in smelting	3,191	$56.46
Cement extenders/ geopolymers	4,255	$78.98

Table 7: Ordered abatement potential and costs for mining and manufacturing initiatives, Queensland, cumulative to 2050, discounted

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Appendix A Queensland mining and manufacturing initiatives

This appendix includes templates that describe the initiatives modelled for this report, including barriers to initiative implementation.

Initiative Overview: Aluminium Smelting Energy Efficiency			
Sector:	Stationary Energy		
Summary Description:	Aluminium smelting uses large quantities of electricity, mostly in the electrolytic process but also ancillary loads and anode production. While the Australian industry is already among the most efficient in the world, further improvements are possible and improved processes and materials are being developed.		
Abatement to 2050	38,490 MT CO_2e		
$ / t CO_2-e avoided	$3.37		
Confidence	Medium – difficult to get Qld specific data, or data comparing Qld to other states.		
Impact of ETS	Strong – energy is a high proportion of costs, industry is highly price sensitive		
Kyoto consistent?	Yes (any energy efficiency will save power station emissions)		
Who pays / benefits?	Smelter owner / Smelter owner		
Initiative detail for the Queensland context	Aluminium smelting uses an electrolytic reduction process that is very electricity intensive, plus around 10% ancillary electricity use and production of carbon anodes etc. While the Australian industry performs well by world standards, energy consumption varies by up to 24% between the best and worst Australian operations. Improvements are expected in new anode materials (that can also reduce PFC emissions), fume control systems and bag filters, compressed air, and anode baking processes. Improved insulation and heat recovery in the pots and casting process, and pot line additive are also possible areas for improvement.		
Barriers to implementation	With energy being a major cost item for the Aluminium industry, efficiency is already at a high level. Barriers to further improvements include success in ongoing industry R&D into improved materials and processes, and certainty regarding greenhouse policies as a consideration in major plant upgrade investments.		
Modelled Effects	Effect 1	Effect 2	Sources
Start Date	2015		*Sustainability Report 2007,* Australian Aluminium Council *Energy Efficiency best practice in the Australian aluminium industry*, Dept Industry Tourism and Resources 2000 *NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. *Various publications* – International Aluminium Institute *Life cycle assessment of aluminium: inventory data for*
Ramp-up Time	20		
NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	56%	3%	
Technical Potential	10% Electricity	2% Gas	

Qld take-up	85%	75%	*the primary aluminium industry 2005 update* - International Aluminium Institute 2007
Modelled Costs	$000		Sources
Implementation	$472,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$60 / GWh $6 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Energy efficiency in Mining			
Sector:	Stationary Energy		
Summary Description:	Reduction in energy demand from mining operations through improved boiler and heating efficiency, pumps fans and compressors, crushing and grinding, conveyors and stacking equipment.		
Abatement to 2050	20,590 MT CO_2e		
$ / t CO_2-e avoided	-$0.63		
Confidence	Medium – taken from specific industry case studies		
Impact of ETS	Medium		
Kyoto consistent?	Yes		
Who pays / benefits?	Industry / industry		
Initiative detail for the Queensland context	Mining is quite energy intensive, with major energy uses being compressors, pumps, crushing and grinding, conveyors and stackers, excavation and flaring. Opportunities for improvement exist in areas such as fixing compressed air leaks, improved control of pumps conveyors and crushing equipment (including when not in use), boiler tuning controls and efficiency, high efficiency motors and controls on pumps fans conveyors and grinders, VSD controls etc.		
Barriers to implementation	Barriers to further uptake of energy efficiency improvements will be cultural ("nothing gets in the way of production"), risk perception (where solutions that don't have proven safety and reliability performance will be rejected), business interruption, and introducing specialised technologies in remote sites that can add to concerns about spares and repair times.		
Modelled Effects	Effect 1	Effect 2	Sources
Start Date	2009 (immediate)		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004.
Ramp-up Time	20		
NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	13%	17%	

Technical Potential	8%	10%	
Qld take-up	75%	75%	
Modelled Costs	$000		**Sources**
Implementation	280,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$100 / GWh $6 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Energy efficiency in Food and Beverage Manufacturing			
Sector:	Stationary Energy		
Summary Description:	Reduction in energy demand from food and beverage manufacturing through operating practices, reducing hot water use and wastage, improved efficiency in heating and refrigeration equipment, and improved controls.		
Abatement to 2050	38,375 MT CO_2e		
$ / t CO_2-e avoided	$5.42		
Confidence	Medium – taken from specific industry case studies		
Impact of ETS	Medium		
Kyoto consistent?	Yes		
Who pays / benefits?	Industry / industry		
Initiative detail for the Queensland context	The food and beverage industry is a large energy user, with major uses being heating, refrigeration, process equipment, hot water, pumps and fans, and baking. Energy efficiency opportunities exist in behaviour changes (using less hot water for cleaning, closing freezer doors…), higher efficiency equipment and boilers, improved maintenance (eg freezer seals and compressors), efficiency and insulation in ovens and refrigerators, improved efficiency and control including VSD for motors in pumps fans mixers and compressors, process optimisation, maximise condensate return, waste heat recovery and high efficiency heat exchangers.		
Barriers to implementation	Barriers include lack of knowledge and focus (lots of small enterprises without a dedicated energy manager), the cost identifying and developing opportunities, process and business interruption costs, and risk perceptions with new technologies (particularly where food hygiene or contamination issues are a factor). Cultural and behaviour change require significant effort and reinforcement.		
Modelled Effects	Effect 1	Effect 2	**Sources**
Start Date	2015		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004.
Ramp-up Time	20		

NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	3%	34%	
Technical Potential	19%	14%	
Qld take-up	75%	75%	
Modelled Costs	$000		Sources
Implementation	711,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$130 / GWh $10 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Energy efficiency in energy and chemicals			
Sector:	Stationary Energy		
Summary Description:	Reduction in energy demand from the production of chemicals, petroleum and coal processing through waste and leakage minimisation, more efficient boilers and steam raising, improved motors and controls for pumps and fans, and process controls.		
Abatement to 2050	14,318 MT CO_2e		
$ / t $C0_2$-e avoided	$2.63		
Confidence	Medium		
Impact of ETS	Medium		
Kyoto consistent?	Yes		
Who pays / benefits?	Industry / industry		
Initiative detail for the Queensland context	Chemical and energy processing is another energy intensive sector, with major uses including boilers and steam raising, evaporation and distillation, drying, compressors, pumps and fans. Opportunities to improve efficiency include waste minimisation, condensate return maximisation, improved controls and insulation for boilers and steam raising, compressed air efficiency and leaks, high efficiency motors and controls for compressors pumps and fans, waste heat recovery, and improved maintenance and tuning.		
Barriers to implementation	Processing facilities are generally large and energy intensive, and tend to have sophisticated and informed energy management, so barriers are mostly financial. Process byproducts are often treated as wastes with little or no value, so a culture change to look at the carbon emissions as a cost will be important.		
Modelled Effects	Effect 1	Effect 2	Sources
Start Date	2015		*NFEE: Energy Efficiency Improvement Potential Case*

Ramp-up Time	20		*Studies – Industrial Sector*, Energetics for SEAV 2004.
NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	3%	25%	
Technical Potential	15%	6%	
Qld take-up	75%	75%	
Modelled Costs	**$000**		**Sources**
Implementation	273,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$60 / GWh $6 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Energy efficiency in other metal products	
Sector:	Stationary Energy
Summary Description:	Reduction in energy demand from manufacture of other metals such as Zinc, Tin, Silver, Lead and Copper through process design and control improvements, continuous casting, heat and insulation.
Abatement to 2050	13,222 MT CO_2e
$ / t $C0_2$-e avoided	$2.28
Confidence	Medium – low (no detailed case studies for these specific industry sub-sectors)
Impact of ETS	High – medium – energy intensive industry with high price sensitivity
Kyoto consistent?	Yes
Who pays / benefits?	Industry / industry
Initiative detail for the Queensland context	Minerals processing requires high amounts of energy and heat, with auxiliary loads including pumps and conveyors. Efficiency improvement opportunities exist in areas including high efficiency boilers kilns and steam raising, improved insulation, waste heat recovery, improved controls, high efficiency motors and controls for pumps compressors and fans. Process improvements such as continuous casting reduce waste heat and process energy lost during downtime and changeovers.
Barriers to implementation	Metals processing and machinery manufacturing are often energy intensive industries, but facility size ranges from very small to very large. At the smaller sites a lack of knowledge and focus and transaction costs will be significant barriers. The high cost of upgrading equipment and processes, and re-training and new skills required for some new processes will also be an issue. Risk perceptions for new technologies that are unproven or of uncertain reliability will impede some technologies.

Modelled Effects	Effect 1	Effect 2	Sources
Start Date	2015		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004.
Ramp-up Time	20		
NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	7%	23%	
Technical Potential	6%	6%	
Qld take-up	75%	75%	
Modelled Costs	**$000**		**Sources**
Implementation	230,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$100 / GWh $10 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Energy efficiency in machinery and equipment manufacturing	
Sector:	Stationary Energy
Summary Description:	Reduction in energy demand from machinery and equipment manufacturing
Abatement to 2050	3,460 MT CO_2e
$ / t $C0_2$-e avoided	-$31.73
Confidence	Medium – low – no specific case studies for this industry
Impact of ETS	Medium – low – range of sizes from large to small – smaller players likely to have lower sensitivity to price and ability to fund large improvements to equipment and processes
Kyoto consistent?	Yes
Who pays / benefits?	Industry / industry
Initiative detail for the Queensland context	Energy efficiency opportunities exist in boiler and heating efficiency, reduced waste and leakage, improved practices and controls, and better motors and controls for fans pumps and compressors.
Barriers to implementation	Across the broader manufacturing sector a range of barriers exist. These range of awareness and focus (lack of dedicated and informed energy managers), competition for capital, transaction costs (finding and developing efficiency improvement options), business interruption (many efficiency improvements will require significant interruption or changes to existing processes), and technology risk perceptions. Understanding and trusting the energy cost savings and capital cost estimates can be a barrier in some instances, as is the availability of time and suitably skilled resources to prepare a business case for an efficiency improvement opportunity.

Modelled Effects	Effect 1	Effect 2	Sources
Start Date	2015		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004.
Ramp-up Time	20		
NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	2%	0.1%	
Technical Potential	15%	12%	
Qld take-up	75%	75%	
Modelled Costs	**$000**		**Sources**
Implementation	48,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$130 / GWh $10 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Efficiency in other industrial and manufacturing	
Sector:	Stationary Energy
Summary Description:	Reduction in energy demand from remaining industrial and manufacturing activities, including SMEs (small to medium enterprises) through a range of technologies including process improvements and controls, improved boiler efficiencies, improved motors and controls for fans and pumps, reduced waste and leakage, and improved practices.
Abatement to 2050	24,479 MT CO_2e
$ / t CO_2-e avoided	-$6.97
Confidence	Medium – low – no specific case studies so have relied on typical results across a range of industry sectors
Impact of ETS	Medium – low – will be many SMEs with less information or ability to respond to ETS
Kyoto consistent?	Yes
Who pays / benefits?	Industry (with Gov't assistance?) / industry
Initiative detail for the Queensland context	Energy efficiency opportunities in general industry will exist in heating and steam (high efficiency boilers and controls, insulation), heat recovery, pumps and fans (high efficiency motors and VSD controls), improved lighting, process controls, improved practices and waste minimisation etc

Barriers to implementation	Metals processing and machinery manufacturing are often energy intensive industries, but facility size ranges from very small to very large. At the smaller sites a lack of knowledge and focus and transaction costs will be significant barriers. The high cost of upgrading equipment and processes, and re-training and new skills required for some new processes will also be an issue. Risk perceptions for new technologies that are unproven or of uncertain reliability will impede some technologies.		
Modelled Effects	**Effect 1**	**Effect 2**	**Sources**
Start Date	2015		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004.
Ramp-up Time	20		
NGGI grouping	Electricity Demand (Indust) - All	Non-electricity Stationary Energy Demand – All	
Applicable % of NGGI grouping	16%	13%	
Technical Potential	13%	8%	
Qld take-up	75%	75%	
Modelled Costs	**$000**		**Sources**
Implementation	565,000		*NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. Tech potential based on 4yr payback criteria.
Non-carbon benefit	$130 / GWh $10 / GJ		SKM Estimates of real energy prices in the medium term

Initiative Overview: Aluminium PFC emissions	
Sector:	Industrial processes
Summary Description:	Aluminium smelting produces Perfluorcarbon (PFC) gases as a byproduct of the production process. Improved process control, and alternate cathode materials being developed, can reduce the emissions of PFCs. The Aluminium industry has a target to reduce PFCs from 1990 levels by 80% by 2010.
Abatement to 2050	19,008 MT CO_2e
$ / t $C0_2$-e avoided	$13.33
Confidence	Medium – difficult to get Qld specific data, or data comparing Qld to other states.
Impact of ETS	Strong - industry is highly price sensitive (once EITE exemptions are removed)
Kyoto consistent?	Yes (PFC is one of the 6 Kyoto gases)
Who pays / benefits?	Smelter owner / Smelter owner

Initiative detail for the Queensland context	Aluminium smelting produces PFC gas as a byproduct of the electrolytic reduction process, mostly due to "cathode effect" events where the process moves outside tightly defined conditions that avoid PFC gases. PFC emissions in 2005 are 70% lower than 1990, and the industry aims to reduce a further 10% by 2010. Improvements in process control can reduce PFC emissions, while alternate (non carbon) anode materials could eliminate PFC emissions.		
Barriers to implementation	PFCs have been reduced by 70% globally since 1990, and Australia is already at best practice levels. Further improvements will depend on successful outcomes in R&D into new processes and anode materials, and certainty regarding greenhouse policies as a consideration in major plant upgrade investments.		
Modelled Effects	**Effect 1**	**Effect 2**	**Sources**
Start Date	2015		*Sustainability Report 2007,* Australian Aluminium Council *Energy Efficiency best practice in the Australian aluminium industry*, Dept Industry Tourism and Resources 2000 *NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector*, Energetics for SEAV 2004. *Various publications* – International Aluminium Institute *Life cycle assessment of aluminium: inventory data for the primary aluminium industry 2005 update* - International Aluminium Institute 2007
Ramp-up Time	25		
NGGI grouping	Industrial emissions – PFC		
Applicable % of NGGI grouping	100%		
Technical Potential	28%		
Qld take-up	85%		
Modelled Costs	**$000**		**Sources**
Implementation	$90,000		*Sustainability Report 2007,* Australian Aluminium Council
Non-carbon benefit	Nil		

Initiative Overview: Large industrial cogeneration	
Sector:	Stationary Energy
Summary Description:	Cogeneration is a means of supplying a site's power and thermal energy needs from the combustion of a single fuel. There are a range of commercially available and established cogeneration technologies including: reciprocating gas or diesel engines, gas turbines, and steam turbines. Fuel cells on are on the verge of commercialisation and has the potential to expand the range of sites for which cogeneration is applicable.[2]
Abatement to 2050	116,954 MT CO_2e
$ / t $C0_2$-e avoided	$1.32
Confidence	Medium-High

- [2] http://www.seav.vic.gov.au/

Impact of ETS	Driven by ETS	
Kyoto consistent?	Yes	
Who pays / benefits?	Host site	
Initiative detail for the Queensland context	Host site through lower energy costs.	
Barriers to implementation	Low energy prices have been the traditional barrier to cogeneration in Australia. The CPRS will provide a direct price signal that will make many more cogeneration prospects commercially viable. Remaining barriers include transaction costs (the high costs of developing cogeneration proposals, understanding the network connection and electricity market rules and processes etc), trading risks in the electricity market, uncertainty and rising domestic gas costs as Australia moves to international parity pricing with the introduction of LNG facilities. For smaller sites the additional complexity and O&M costs of a cogen plant can be considered a barrier that will be reduced as packaged solutions reduce complexity and costs.	
Modelled Effects		**Sources**
Start Date	2012	
Ramp-up Time	30	
NGGI grouping	Coal Gen and Gas Gen	
Applicable % of NGGI grouping	100%	
Technical Potential	10%	
Qld take-up	75%	
Modelled Costs	$000	**Sources**
Implementation	229,000	
Operating	-$10,000	