ECONOMIC IMPACTS OF CLIMATE CHANGE ON THE GREAT BARRIER REEF

Image source: Toby Hudson (2010)

Report to the Land Court of Queensland for an objections hearing regarding the proposed Wandoan Coal Mine

Mining tenement numbers ML 50229, ML 50230 and ML 50231 and draft environmental authority (mining lease) number MIN100550607

Hans Hoegh-Guldberg
Principal of Economic Strategies Pty Ltd

4 August 2011

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QUALIFICATIONS AND RELEVANT EXPERIENCE

1. I am currently the principal of Economic Strategies Pty Ltd and my qualifications and experience are set out in my curriculum vitae in Appendix 1.

INSTRUCTIONS

2. I have been asked by the Friends of the Earth – Brisbane Co-Op Ltd to provide an expert report addressing the economic impacts that are likely to result from the impact of global warming and ocean acidification on the Great Barrier Reef. The request specified tourism as the focus. This request is made for the purpose of assisting the Land Court of Queensland in an objections hearing regarding the proposed Wandoan Coal Mine. I have also been asked to comment on the economics of likelihood of substitution of the coal from elsewhere if the mine is refused.

FACTS AND ASSUMPTIONS

3. This report is based on my experience as a consulting economist and is prepared relying on the Wandoan Integrated EIS Summary of December 2008 in addition to the literature and material specifically referenced throughout the report and in the list of references in Appendix 2.

OPINION

Section 1: Introduction

4. I have been requested in this matter to consider whether the threat from climate change to the long-term health of the Great Barrier Reef (GBR) has changed since Professor Ove Hoegh-Guldberg and I co-authored a report for WWF Australia and the Queensland Tourism Industry Association in 2004. In that report, Professor Hoegh-Guldberg provided the scientific evidence and its future implications, while I contributed the socioeconomic analysis and the scenario-planning framework which we chose with the clients' agreement for the analysis.

5. In summary, this statement provides evidence that scenario projections of tourism activity in the GBR and adjacent regions published in 2004 set the stage but did not sufficiently account for the magnitude of climate change that according to the overwhelming scientific consensus has developed since the 1990s when the Intergovernmental Panel on Climate Change (IPCC) developed its latest global emissions scenarios (Nakicenovic and Swart 2000).

6. Section 2 summarises the updated tourism statistics and derived analysis for the GBR based on a statistical appendix (Appendix 3). It benefits from analysis of the economic contribution of the GBR Marine Park carried out by Access Economics for the Great Barrier Reef Marine Park Authority (GBRMPA). The third and latest of the Access Economics reports combines the analysis of three years from 2004-05 to 2006-07 (Access Economics Pty Ltd 2009).

7. Section 3 refers briefly to my peer-reviewed socioeconomic study of climate change in the Florida Keys (Hoegh-Guldberg 2010). It provides evidence that climate change has become a heightened global threat, at a pace that has gathered intensity since about 2006. This was clearly relevant for my socioeconomic study and parallels the evidence provided in the expert reports by Professor Lowe and Dr Meinshausen.

8. Section 4 reviews the likely impact of the findings in previous sections on scenarios for the GBR.

9. Section 5 summarises the implications for what are possible total economic values (TEV) for ecosystems like the GBR. TEV was discussed in the 2004 GBR report but the problem of measuring "non-use" bequest and existence values was regarded as too difficult because of the lack of any market-based economic criteria. The 2004 report found, however, that any valuation based solely or mainly on market-based uses would provide an absolute minimum. Since 2004, some analytic progress has been made, and a valuation study of the GBR has been carried out (Oxford Economics 2009). The Florida Keys study (main report Section 6.5, pp 99-108) takes a critical look at the 2009 GBR valuation study.

10. The estimated impact of the proposed mine is discussed in Section 6, with specific reference to the GBR. It is noted, however, that the greenhouse gas emissions associated with the mine will be global and not confined to any one region. Approximately 99% of the Project's emissions are attributable to end-use of coal for electricity production which will be totally or predominantly overseas. To this end, the demand for coal for electricity production would exist regardless of the location of the source (Wandoan Integrated EIS summary, p 27). However, Section 7 demonstrates that alternative supplies from other coal mines are unlikely to match this demand if the Wandoan mine does not go into operation.

Section 2: Updated GBR tourism-related statistics and assessments

11. The appended statistical tables are arranged in four groups:

    a. In the first group, Table 1 compares annual population growth in each Statistical Division in Queensland, between 2001 and 2009. During this period the population in what has been called the GBR Catchment Area (GBRCA) increased from just under one million to 1.18 million. The growth rate (2.45% per annum) was just below the state average but much in excess of the national average of 1.5% pa. The strongest growth occurred in the Gold and Sunshine Coasts, at a rate of about 3.5% pa.

    b. Tables 2 and 3 show that total tourist expenditure in the GBRCA in 2009-10 amounted to $5.9 billion according to Tourism Research Australia (TRA), with the largest proportion (64.5%) coming from domestic overnight visitors followed by international visitors (19.4%) and domestic day visitors (16%). Far North Queensland received a much higher proportion of international visitor spending than the other tourism regions (67.7% of total expenditure in the GBRCA).

c. International holiday visitors not unexpectedly were most prominent in the Whitsundays and Far North Queensland, but even the lowest observation (Mackay) showed that 77% of international visitors were on holidays. The proportions were significantly lower for domestic overnight visitors (Table 4).

d. Table 5 shows that the main experience sought by most domestic overnight visitors were "food and wine" (53%), whereas 93% of international visitors valued the experience of nature as well as food and wine, and significant proportions valued culture and heritage (72%) and the Indigenous component of this (40%).

12. The second group has one table only, showing that tourism has declined in proportion to the total economy in Australia. Since the late 1990s, the gross value of tourism at basic prices (excluding GST and other indirect taxes, less subsidies) has remained fairly constant at around $30 billion at constant 2009-10 prices (Table 6).

13. Thanks to the work of Access Economics (2009), reliable measures exist of the economic contribution of tourism in the GBRCA between 2004-05 and 2006-07 (Tables 7 and 8). At 2009-10 values, the contributions to the GBRCA itself totalled about $3.7 billion ($2.5 billion direct, and $1.2 billion indirect through other industries). The comparable figures for the whole of Queensland were $2.5 billion direct plus $1.5 billion indirect contributions, totalling just over $4 billion. For Australia as a whole, $2.9 billion direct and $2.7 billion indirect contributions added to $5.6 billion for 2006-07.

14. While the Access Economics estimates for the three successive years showed growth in the total economic contribution of tourism (6.2% in 2005-06 followed by 2.4% in 2006-07), further growth is unlikely to have occurred by 2009-10. The Global Financial Crisis (GFC) is likely to have caused a decline, judging from the final statistical evidence presented in Table 9. These statistics, while incomplete, suggest that 2007 was a peak year with just under two million observations of visitors using commercial tour operators to see the reef. This dropped to just over 1.8 million in 2010, down almost 10%. At least temporarily, the economic contribution of GBR tourism may have declined from a peak of $5.6 billion to a level close to $5 billion.

15. This would be attributable to the GFC rather than direct or indirect effects of climate change. The next section, however, should serve as a reminder that climate change remains crucial, notwithstanding the relatively short-term impact of the GFC.

Section 3: Evidence of deteriorating climate change prospects

16. Chapter 2 of the main Florida Keys report (pp 10-17) is headed Global Change. It summarises four background papers associated with the report. This work was carried out to put the base for analysing climate change in the Florida Keys into an up-to-date framework, as distinct from the scenario planning narratives written during the second half of the 1990s that have remained basically unchanged from the IPCC's Third Assessment Report (TAR). In short: "The global

outlook has become more important and more complex over the past decade and has to be the starting point of any analysis of the local impact of climate change." (p 10)

17. This applied to the global assumptions in the Florida Keys project, and it applies equally to the GBR. The first of the background papers, on changing global scenarios, parallels the contents in the scientific expert reports. It shows how the IPCC in its Fourth Assessment Report (Pachauri and Reisinger (2007)) officially recognised that the causes for concern identified in the previous report had become generally more serious. Since then, the threat margin has tightened, preferably setting a target below 350 ppm CO_2 (as discussed in Dr Meinshausen's expert report). NASA's James Hansen was a famous early exponent (see, for instance, Hansen et al. (2008)), but scientific consensus has moved to favour this target. Leading climate change economists including Lord Stern (2006, 2008, 2009), Professor Jeffrey Sachs (2008) and Professor Ross Garnaut (2008, 2011a,b) also find that the need to combat climate change has become increasingly urgent, based on overwhelming scientific evidence that a "business-as-usual" path would most likely prove disastrous.

18. The executive director of the Climate Change Institute of the Australian National University, Professor Will Steffen, has written a report to the Australian Department of Climate Change "to review the science of climate change since the publication of the IPCC's AR4, with an emphasis on areas of science that are changing rapidly and have significant consequences for our understanding and analysis of critical issues for policy and management." (Steffen 2009, p 3) The very first item in his executive summary is (p 1): "The climate system appears to be changing faster than earlier thought likely." This is fully supported by the rest of the points in his executive summary.

19. Probability analysis continues to indicate considerable uncertainty in estimating climatic changes resulting from greenhouse gas emissions, and we are consequently facing increasing risks as atmospheric CO_2 levels rise. Harvard economist Martin Weitzman (2009) warns that the risk of extreme climate-related events has been rising – what he calls the "fat tail" of the probability distribution. Stern (2009) also warns against the rising danger of extreme temperature levels as stabilisation levels for greenhouse gases increase. Garnaut (2008) observes that extreme events have moved closer to the centre of the probability distribution. Many scientists, economists and others make qualitative reference to the grave consequences of persisting on a "business-as-usual" path. An illustrative numerical model of global GDP in another background paper to the Florida Keys study indicates that an unmitigated "business-as-usual" approach could indeed be disastrous, especially if climate change keeps moving towards the centre of the probability distribution, as "worst cases" become more prevalent.

Section 4: Consequences for the Great Barrier Reef

20. One limitation of the projections in the GBR report (Hoegh-Guldberg and Hoegh-Guldberg 2004) is that the formal tourism-related projections only covered the period from 2001 to 2020. Having chosen scenario planning as the preferred analytic vehicle, four projections were made, one for each scenario derived from the IPPC's Third Assessment Report (2001). These include a minor element of commercial fishing (5.6% of tourism expenditure in the base year 2001), but the overwhelming contribution is from tourism, including indirect ("multiplier") effects assuming these to be 80% of direct expenditure. The 2004 GBR project had a different brief to that given

to Access Economics, and didn't have the resources to carry out a formal input-output analysis. Appendix D of the 2004 GBR report shows the methodology, which included analysis of all major industries in the GBR catchment area to put tourism and fisheries in perspective.

21. The four scenario storylines adapted for the 2004 report were:

    a. A1 (converging to B1): Driven by strong economic growth and strong global institutions, until constraints on this growth forces a stronger environmental orientation in the second half of the century. (Based on the experience gained since these storylines were adapted as far back as 2002 for the GBR report, convergence between the economic growth dominated A1 scenario and the environmental B1 is no longer seen as an option.)

    b. A2: A world divided into heterogeneous blocks driven by economic growth considerations but without strong unifying forces – identified then as the worst-case scenario.

    c. B1: Global environmental concerns take precedence over economic growth.

    d. B2: A world with strong local community drivers rather than global environmental cooperation.

22. Updated to 2009-10 values by adding 37% to the original estimates (based on the most recent GDP deflator published by the Australian Bureau of Statistics), the A1 scenario implied losses between 2001 and 2020 of $7.7 billion, compared with $11 billion in the worst-case scenario A2, $6.2 billion for B1, and $4.8 billion for B2. (In retrospect, the difference between the B1 and B2 scenarios was based on a bias towards the role of local communities which, while important, probably exaggerated their influence. Clearly, however, either of the environmentally sensitive scenarios are to be preferred.) These values indicate an economic impact on the GBR from climate change in the order of hundreds of millions of dollars per year.

23. The original comment in the report was (p 174): "All four scenarios envisaged a reef significantly damaged by coral bleaching over the coming twenty or thirty years [from 2002], but the longer-term perspective is very different. The worst-case scenario, A2, depicts a world with low economic growth, high population growth and little attempt to divert a rising long-term trend in CO2 emissions, which would spell the end of coral dominated reefs on the Great Barrier Reef for very long periods. The future of coral reefs is also bleak under the global economic growth scenario, A1, even though there will be a trend towards renewable fuels as crude oil reserves dwindle, and this world may develop into an environmental "B1" world in the second half of the century. The best hopes for an ultimate future for coral in Queensland is the development, as soon as possible, of more environmentally sensitive policies in the B1 or B2 worlds to minimise pollution from the mainland and other sources of damage to the Reef. Preserving and even building reef resilience will be critical to how reefs fare under increasing sea temperatures and carbonate alkalinities, especially over the coming quarter century or so."

24. Therefore although the values in the 2004 report remain reasonable up to 2020, the report does not estimate the value of impacts beyond on the GBR 2020. The impacts beyond 2020, outlined

verbally in Chapter 12, are likely to be more severe than the values estimated by the 2004 report.

25. Importantly, two new valuations of the GBR exist. First, the work of Access Economics reported in Section 2 allows an estimate of about $5 billion in 2009-10 to be made of the total economic contribution of GBR tourism to the Australian economy in value-added terms. Assuming that $5 billion per annum remains constant as the economic contribution of GBR tourism to the Australian economy in the absence of climate change effects, the question arises as to what effects future climate change might have. The main signpost is the parallel study carried out in the Florida Keys in 2007-10. Some main assumptions are summarised in the table below.

Main projections, Florida Keys

Scenario	Year	Global warming °C	Global sea-level rise cm	Global ocean acidity pH	Global GDP change % pa	Keys coral cover relative to 2010
A1	2010	0.8	-	8.10	3.0%	100%
	2050	3.0	37	7.90	3.3%	19%
	2100	4.0	80	7.70	0.5%	0%
B1	2010	0.8	-	8.10	3.0%	100%
	2050	2.0	12	8.06	3.0%	72%
	2100	2.5	22	8.00	1.1%	55%
A2	2010	0.8	-	8.10	3.0%	100%
	2050	3.2	16	7.90	1.6%	16%
	2100	4.4	105	7.70	0.3%	0%
B2	2010	0.8	-	8.10	3.0%	100%
	2050	2.2	16	8.00	2.7%	67%
	2100	3.0	37	7.90	0.8%	47%

Source: Hoegh-Guldberg 2010, Chapter 7

26. The four main scenarios were first adapted from their 2000 originals to fit the different world in 2010 (described in Chapter 7 of the Florida Keys report). They were then quantified in terms of global and local indicators. The global indicators are average temperature, sea-level rise, and ocean acidity, and the annual change in world GDP. Locally, there are differences between what is most important in the Florida Keys and what is most important in the GBR. Sea-level rise is relatively more important in the Keys due to their low altitude. In all scenarios, the population will fall in the Keys because of inundation.

27. The tourist-based economies also differ. Coral cover has suffered to a greater extent in the Keys than in the GBR, and is down to 6.4% from much higher levels a few decades ago. This suggests that the GBR has more to lose in the most unfavourable scenarios as the reef currently remains relatively more important. NOAA tourism surveys, reported in the main Florida Keys report (Section 6.4), have already shown a shift away from sea-based activities towards historical and related interests benefiting the main southern city, Key West (see page 92, Table 6.23). The GBR does not have a Key West to retain tourism activity.

28. Bearing in mind that GBR tourism has relatively more to lose than its Florida Keys counterpart, the difference between scenarios that retain significant parts of the coral cover becomes even more important. In short, there is relatively more to gain in the environmentally friendly scenarios (B1 and B2) in the GBR regions. This applies particularly to the main tourism hub, Far North Queensland, and the smaller but almost pure tourism area in the Whitsundays.

29. The indicative change in coral cover, assuming that it deteriorates at the same percentage rates as in the Florida Keys, would be the most important indicator of the future of GBR tourism. Coral cover is itself influenced by the change in sea temperatures and ocean acidity, and at nil cover international tourism would be particularly heavily influenced, especially in the north. Without a comprehensive analysis of annual flows which falls outside the scope of this statement, precise numerical indications cannot be made, one may deduce that tourism, especially in the north, would fall to a fraction in the absence of any coral cover – whereas retaining as much as 55% of the 2010 level by the end of the century, as is projected in the B1 case in Florida, would retain a greater proportion (in excess of 55%) of tourism expenditure. The tourism industry, apart from being resilient, inventive and flexible itself, also has the same advantage as in Florida that the local marine park or sanctuary management is among the strongest in the world. Assuming that global and domestic tourism would otherwise be unaffected by climate change (which is by no means certain), it is possible that the level of tourism would suffer only slightly, or not at all, in an environmentally friendly scenario.

30. Therefore it is reasonable to expect (based on the Florida Keys study and the Oxford Economics Study described below) that the "business-as-usual" (i.e. consistent with the approval of the proposed mine) impact from climate change on reef-based tourism would be a reduction of approximately 65-75% by 2100. Applying this reduction to the $5 billion per annum value added by tourism estimated by Access Economics would yield a value of impacts from climate change on the GBR in the order of $ 3.25 to $3.75 billion per annum by 2100.

31. The upper end of the range of possible losses of tourism expenditure is consistent with the Oxford Economics estimate that the total economic value if the entire reef bleached would be 74% of what it would be if the reef remained intact. The lower value is based on analysis in the 2004 GBR report (pp 142 ff) derived from a principal components study by Pearce, Green and Moscardo (1997). This study made it possible to derive a "reef-interested" component of total GBR tourism which made sense in terms of regional distribution (with Far North Queensland as the largest component followed by the Whitsundays) and relative inbound, interstate and intrastate contributions from tourism. The basic estimate was that 70% of total tourist expenditure could be termed "reef-interested" in the early 2000s (90% in the Far North Queensland region).

32. The 2004 report together with the other studies quoted above indicate that the value of impacts on GBR-related tourism alone are likely to expand from hundreds of million dollars per annum in the next decade to billions per annum as early as the second half of the century under a "business-as-usual" scenario. Both "A" scenarios in the table above show declines in coral cover of at least four-fifths of the 2010 level, over less than four decades to 2050. There is little reason to expect the GBR to fare better than the Florida Keys if warming and acidification rates increase as projected. Both marine parks (sanctuaries) are reputed to be among the best-managed in the world.

Section 5: Total Economic Value

33. The valuation of major ecosystems has become a preoccupation, but going beyond measurable market values is proving elusive. The Florida Keys report discusses it in its Section 6.5 (pp 99-108).

34. Total economic value (TEV) consists of use and non-use values. Direct market-based uses of the GBR can be measured for tourism and fishing and any other industry, provided the appropriate data have been assembled. The focus here is on operating surplus or profit ("producer surplus"). However, use valuation also includes estimating how much more consumers would be willing to pay to experience the reef, giving rise to a "consumer surplus".

35. Indirect use values need to be estimated from elsewhere, including "ecosystem services" such as protecting adjacent coastal areas from storms. This may not be immediately measurable, but the problem is compounded by the non-use values. The bequest value is what members of the current generation place on preserving the GBR for the benefit of future generations. It represents the willingness to pay for future generations to have the opportunity to experience the resource in a certain condition or preserving its existence value, being willing to pay to simply know that a resource will be protected or restored to a certain condition. Existence values, as their name implies, are attached to the existence of the GBR, whether or not the person who makes the valuation ever visits it.

36. Oxford Economics (2009) attempted to put a total economic value on the GBR by identifying the components which are present today, and would be present if the whole reef was bleached and thus becoming unattractive to tourists and other users immediately. The authors identified each component of the TEV, whether use or non-use, and then looked for ways to measure the value of that component. However, they found it impossible to identify even approximately precise values of most components, especially in the non-use categories. For a review of the Oxford Economics research refer Chapter 6.5 of the Florida Keys main report.

37. One weakness of this type of analysis of a major ecosystem is the use of tourist or other consumer survey data on willingness-to-pay. It seems unrealistic to expect a tourist to place a high value on a particular major ecosystem, accounting for all its planet-saving qualities. A report for French President Sarkozy (Stiglitz et al.(2009)) on the shortcomings of GDP statistics agreed that climate change caused by increases in greenhouse gases is a special, truly global issue, going across national boundaries. "Physical indicators of this kind can only be identified with the help of the scientific community." This is discussed in the concluding parts of Section 6.5 of the main Florida Keys report.

38. Meanwhile, Oxford Economics (2009) has provided what can only be a minimum estimate of the total discounted value of GBR tourism ($51 billion), and the loss from total bleaching ($37.7 billion or 74% of the total value). The Oxford Economics report states that this is roughly equivalent to a constant $1.08 billion per annum over the course of a century. While the loss of $37.7 billion appears "big", should it really be $50 billion, or $100 billion, or $500 billion? Based on what? The way forward would be to take a radically new look at the nonmarket values of preserving the ecosystems intact for this and coming generations across the planet (existence

and bequest values). The assessment would replace what users say they would be willing to pay with what would be needed to preserve the ecosystems. It is safe to predict that the present value of the GBR ecosystem would be much higher than those based on consumers' willingness to pay to preserve the ecosystems, and much higher than the estimates in Oxford Economics (2009). It would also be higher based on the aggravated impact of climate change both in terms of global warming and other impacts which have become significantly more prominent in the past four to five years, notably sea-level change and ocean acidification. The impact is compounded by the growing realisation that ecosystems are interlinked, not only locally (like between coastal mangrove areas, seagrass areas and reefs) but also what may be potentially ocean-wide, especially through ocean acidification (for example see Veron et al. 2009).

39. Consequently the impact from bleaching of roughly $1 billion per annum over the next century must be regarded as an absolutely minimal estimate of the total impact from climate change on GBR tourism in a "business-as-usual" scenario.

Section 6: Impact of proposed mining project

40. The proposed mine would accelerate the destruction of tourism in the GBR that is already seeing the impact of climate change, due to the sensitivity of the coral reef to increasing sea temperatures, acidification and other impacts (see the report to this Court by Professor Ove Hoegh-Guldberg).

41. Specifically, the impact of the project is global, not confined to a particular country or region. In relation to the GBR, a "business-as-usual" scenario approximated by A1 will substantially (by an estimated 80% or more) obliterate the coral cover by mid-century and thus most of the tourist value of the reef whether or not a particular mine goes ahead (the mine will accelerate the process). It would also damage the situation under an environmentally friendly scenario (B1 or B2) before the scenario becomes operational, after which such a scenario would not include the opening of new coal mines.

42. The underlying analysis in my research has not specifically measured the impact of any one mining or other project in terms of atmospheric pollution but has noted that its prevention is vital for the well-being of the planet, as measured by the overall pollution of the atmosphere. The economic impact of the mine on GBR tourism relates to the science-based analysis which has been carried out by Dr Meinshausen and others. I have read his expert report carefully and concur with his general approach and conclusions. I note in particular his statement that 99% of emissions would result from burning the coal by the end user, and that the ultimately induced emissions might be up to twice as high compared with a medium carbon content assumption.

43. A second important point is that supply shortfalls and the increasing competitiveness of alternative energy sources for power production would probably prevent other similar sources from filling the gap if the Wandoan coal is not extracted.

Section 7: Likelihood of substitution of coal from elsewhere

44. Several lines of evidence suggest that it would be unlikely that a large share, if any, of Wandoan coal would be compensated by increased production from other coal mines, in the case that the Wandoan mine does not go into operation.

45. The reason is threefold:

(a) Firstly, a shortfall of supply. The international seaborne coal market, particular in the Asian region, is currently restricted by a shortfall of supply, not demand. For example, for the 2010 global coal market, Xstrata states in their 2010 Annual Report:

> "While an additional 41 million tonnes of supply was added to global seaborne supply, this fell short of global demand by some 15 million tonnes. High levels of consumer inventory moderated the supply shortfall throughout most of the year. However, by year's end the gap between supply and demand became more pronounced."

Likewise, the outlook for the 2011 coal market assumes a continuing shortfall of supply (ibid.):

> "For the balance of 2011, the seaborne thermal market is expected to remain moderately undersupplied. Supply growth, including a significant quantity of sub-bituminous coal from Indonesia, is not expected to satisfy projected demand. Supply shortfalls should maintain high pricing levels and lead to increased price volatility in response to any further disruptions."

Thus, even under a current supply shortfall, other mines across Indonesia, South Africa, Brazil and elsewhere are not meeting the demand, despite potentially considerable profits and high market prices. Thus, a further restriction of supply (or non-increase of supply) due to the non-operation of the Wandoan coal mine is unlikely to be fully compensated by additional production.

(b) Secondly, induced price increases of coal. The non-operation of the Wandoan coal mine might lead to comparatively slightly higher world coal market prices, probably inducing a small share of extra coal production (small price elasticity of supply), if any, which would however not be able to make up for the lesser Wandoan coal supply given the supply shortfalls already. Thus, this small price elasticity of supply would induce a small price increase on the world's coal markets in the case of the Wandoan mine not going into operation – compared to the scenario that the additional 30 Mt p.a. of Wandoan coal which would not be produced.

The price effect due to the shortfall of supply is stated by Xstrata as (ibid.):

> "The tightening global supply-demand balance during 2010 resulted in strengthening thermal coal prices in the second half of 2010 in both the Pacific and Atlantic markets, as well as the Chinese domestic market."

(c) Thirdly, price elasticity of demand. Following from point (1), an important effect of slightly higher coal prices would be an increasing competitiveness of alternative, lower carbon

sources for electricity production as already observed in Europe and elsewhere. In economic terms, the price elasticity of demand is increasing in the presence of alternatives. For example, Xstrata indicate that the reason for lower absolute coal demand in some regions, particularly the UK, is related to an increasing competitiveness of gas (ibid.):

> "The weakness in the Atlantic seaborne thermal coal market was primarily due to decreased demand from the UK, Spain and the US, with UK demand falling by 45% as low gas prices at the beginning of 2010 favoured gas burn over coal and record coal stocks, equating to nearly six months supply, suppressed imports."

The combination of increasing competitiveness of new gas-powered power plants, in combination with governments' introduction of economic incentives and hence increased competitiveness of renewable energies, primarily wind and solar power, will cause the induced comparative price increase in coal (due to the non-operation of the Wandoan coal mine) to cause comparatively more investments in the gas and renewable sectors.

46. In summary, the existing supply shortfall in the world's coal markets and the increasing competitiveness of alternative sources for electricity production will be the reason why the Wandoan coal would not be fully replaced by increased coal production elsewhere. Quite the contrary, the economics of the international energy market rather suggest that a shortfall of coal supply would be primarily offset by increased demand for gas or alternative power sources. Or in other words, the price elasticity of demand can be assumed to be greater than that of supply – particularly at times when governments around the world increase the competitiveness of low or zero carbon forms of energy production with economic incentives.

Section 8: Summary of conclusions

47. Approval of the proposed mine would be consistent with a "business-as-usual" global greenhouse gas emission scenario, which includes the continued extraction and burning of fossil fuels.

48. "Business-as-usual" greenhouse gas emissions would result in economic impacts on the Australian economy from lost Great Barrier Reef tourism in the order of hundreds of millions of dollars by the end of the decade, rising to billions of dollars as soon as the middle of the century. The economic loss from impacts on the Great Barrier Reef from coral bleaching due to climate change would be at the very least one billion dollars per annum over the next century. The total economic impacts flowing from climate change impacts on the Great Barrier Reef is likely to be much higher than these estimates.

49. Other reports to this Court have concluded that the contribution of the proposed mine to climate change and ocean acidification is significant (see the reports of Professor Ove Hoegh-Guldberg and Dr Malte Meinshausen). If the mine were to proceed it would accelerate the destruction of tourism under the "business-as-usual" scenario and would also damage tourism under even in the most optimistic emission scenario. Therefore, the proposed mine would make a substantial contribution to the economic impacts of climate change on the Great Barrier Reef.

DECLARATION

In accordance with rule 428 of the *Uniform Civil Procedure Rules* 1999 (Qld), I confirm that:

(a) the factual matters stated in this report are, as far as I know, true; and

(b) I have made all enquiries considered appropriate; and

(c) there are no readily ascertainable additional facts that would assist me in reaching more reliable conclusions; and

(d) the opinions stated in this report are genuinely held by me; and

(e) this report contains reference to all matters I consider significant; and

(f) I understand that my duty is to assist the Court and that it overrides any obligation I may have to any party to the proceeding or to any person who is liable for my fees or expenses; and

(g) I have complied with my duty to assist the Court.

Signed: 

Date: **04.08.2011**

Address: **Economic Strategies Pty Ltd, 55 Whiteley Road, Oberon, NSW 2787**

APPENDIX 1 - Curriculum Vitae

Hans Hoegh-Guldberg graduated from Copenhagen University, Denmark, in 1958 with a First Class degree in economics. He migrated with his Australian wife and small daughter late in the same year and settled in Sydney. During the ensuing 25 years he worked as a consulting economist in Sydney for three major management/economic consulting firms: W D Scott & Co (1959-64), Philip Shrapnel & Co (as co-founder and director, 1964-73), and PA Management (1973-76). He then worked for eight years to late 1984 in CSR Limited where he was employed in new business research and as strategic planning manager in the company's sugar division.

He founded Economic Strategies Pty Ltd as a corporate vehicle for his professional consulting activities in December 1984, and initially specialised in culture and arts related economic research (most of which is published). While continuing his involvement in the cultural sector he became involved in scenario planning in 1998 and then from 2000 in the economics of climate change.

Selected references relating to climate change research

Hoegh-Guldberg, H. (2010), *Climate Change and the Florida Keys*, and four background papers: (1) *Changing Global Scenarios*, (2) *Limits to Economic Growth*, (3) *The Changing Economic Paradigm*, and (4) *Technology and Climate Change.* For NOAA and the Florida Keys National Marine Sanctuary. http://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/climate_change/welcome.html.

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Note: Data tables (shown in Appendix 3) derived from Tourism Research Australia, Australian Bureau of Statistics, Office of Economic and Statistical Research (Queensland Treasury), Great Barrier Reef Marine Park Authority, and Access Economics Pty Ltd (2009). Sources are detailed below statistical tables appended to the statement.

APPENDIX 3 - Statistics

Four groups of updated tourism data have been tabulated here:

1 Regional population statistics for Queensland (Table 1)

2 Tourism data from Tourism Research Australia (Tables 2 to 5)

3 Economic analysis, mainly by Access Economics (Tables 6 to 8)

4 A long-term series (1994 to 2010) showing visitors to the GBR using commercial tourist operators (Table 9). These statistics do not show total visitors.

All expenditure and other value measures have been converted to 2009-10 values using the implicit GDP deflator published in the National Accounts by the Australian Bureau of Statistics.

REGIONAL POPULATION STATISTICS

Table 1 shows updated population data in each Statistical Division in Queensland. The state is shown in three parts: the GBR Catchment Area (GBRCA), metropolitan areas including the Gold and Sunshine Coasts, and the west dominated by Darling Downs.

1: Average annual residential population change, 2001-2009

Statistical Division	Resident population		Average increase	
	2001	2009 (p)	Number	Per cent
Far North	224,163	269,650	5,686	2.34%
Northern	190,266	227,340	4,634	2.25%
Mackay	137,539	172,735	4,400	2.89%
Fitzroy	186,527	220,714	4,273	2.13%
Wide Bay-Burnett	232,008	287,425	6,927	2.71%
Total GBRCA	970,503	1,177,864	25,920	2.45%
Brisbane	1,663,120	2,004,262	42,643	2.36%
Gold Coast	387,102	515,157	16,007	3.64%
Sunshine Coast	247,167	323,423	9,532	3.42%
West Moreton	77,217	94,660	2,180	2.58%
Total metropolitan	2,374,606	2,937,502	70,362	2.69%
Darling Downs	208,961	237,211	3,531	1.60%
South West	27,002	26,277	- 91	-0.34%
Central West	13,591	12,270	- 165	-1.27%
North West	34,283	33,979	- 38	-0.11%
Total western	283,837	309,737	3,238	1.10%
Queensland	3,628,946	4,425,103	99,520	2.51%

Based on preliminary data for 2009. Figures are subject to change as part of OESR's ongoing program of updating and refinement. No responsibility taken for decisions or actions taken as a result of the data.

Source: *Population growth highlights and trends 2010* , Office of Economic and Statistical Research, Queensland Treasury, and ABS 3218.0, *Regional Population Growth, Australia* , 2008-09

In 2009, there were 1.18 million residents in the GBRCA, up from just over 970,000 in 2001. The annual growth rate was 2.45%, marginally lower than the state average but exceeding the national population growth of 1.5% pa. The Mackay SD showed the highest annual growth rate of almost 2.9%. It includes one of the main tourist areas on the GBR, the Whitsundays, but also have a large non-tourism industry sector.

The other Statistical Division in the GBRCA

with above average population growth between 2001 and 2009 was Wide Bay-Burnett at the southern end of the Marine Park, and the least "reef-oriented" of these regions.

TOURISM DATA FROM TOURISM RESEARCH AUSTRALIA (TRA)

Table 2 shows the most recent annual tourism statistics from the TRA. While most visitors don't stay overnight (day visitors), the vital measure of expenditure is highest for domestic overnight visitors ($3.8 billion in 2009-10), with smaller contributions from international visitors (1.145 billion) and day visitors ($945 million). The average expenditure per trip, however, was highest for international visitors ($936) followed by domestic overnight visitors ($771) and day visitors ($128).

2: Summary tourism data, 2009-10

Region	Expenditure $million	Visitors Thousand	Nights Thousand	Average stay Nights	Average expenditure Per trip	Average expenditure Per night
Domestic day visitors						
Far North Queensland	209	2,035	-	-	103	-
Northern	184	1,248	-	-	147	-
Whitsundays	*34*	*261*	-	-	*132*	-
Mackay	147	862	-	-	171	-
Central Queensland	249	2,096	-	-	119	-
Bundaberg	122	900	-	-	136	-
Total GBRCA	945	7,402	-	-	128	-
Domestic overnight visitors						
Far North Queensland	1,654	1,435	8,657	6.0	1,153	191
Northern	504	787	3,332	4.2	640	151
Whitsundays	538	463	2,131	4.6	1,162	252
Mackay	343	597	2,367	4.0	575	145
Central Queensland	589	1,128	4,908	4.4	522	120
Bundaberg	175	524	1,959	3.7	334	89
Total GBRCA	3,803	4,934	23,354	4.7	771	163
International visitors						
Far North Queensland	775	654	6,091	9.3	1,185	127
Northern	120	138	1,421	10.3	870	84
Whitsundays	160	213	1,153	5.4	751	139
Mackay	*16*	52	409	7.9	*315*	*40*
Central Queensland	53	125	1,111	8.9	424	48
Bundaberg	21	42	646	15.4	500	33
Total GBRCA	1,145	1,224	10,831	8.8	936	106

Note: GBRCA (catchment area): Terminology adopted from Access Economics 2009 report
Source: Tourism Research Australia (figures in italics are estimated)

Far North Queensland attracted the highest expenditure: $1.65 billion from domestic overnight visitors, $775 million from international visitors, and $209 million from day visitors. As shown in Table 3, the total for the Far North ($2.6 billion) represented 45% of the total expenditure by visitors to the GRB catchment area in 2009-10.

While the expenditure of international visitors was heavily concentrated in the northern half (67.7% in Far North Queensland, 14% in the Whitsundays, and 10.5 % in the Northern district centred on Townsville), total visitors were more evenly spread with the largest categories after the Far North in Central Queensland (equalling the former Fitzroy region less the former Jericho Shire in the inland), Northern, and Whitsundays.

3: Regional distribution of total tourism expenditure, 2009-10

Region	Visitor category			
	Domestic day	Domestic overnight	International	Total visitors
Far North Queensland	22.1%	43.5%	67.7%	44.8%
Northern	19.5%	13.3%	10.5%	13.7%
Whitsundays	3.6%	14.1%	14.0%	12.4%
Mackay	15.5%	9.0%	1.4%	8.6%
Central Queensland	26.3%	15.5%	4.6%	15.1%
Bundaberg	12.9%	4.6%	1.8%	5.4%
Total GBRCA	100.0%	100.0%	100.0%	100.0%
$ million	945	3,803	1,145	5,894
Proportions	16.0%	64.5%	19.4%	100.0%

Source: Tourism Research Australia

Overnight visitors and international visitors are categorised according to purpose of visit (holiday, business, education, visiting friends and relatives), as shown in Table 4. Holiday visitors in 2009-10 accounted for 42% of visits and 48% of nights spent by 2.08 million domestic overnight visitors to the GBR Catchment Area spending 10.7 million nights. Far North Queensland attracted 794,000 domestic overnight holiday visitors (38% of the GBRCA total), but the proportion of holiday visitors in this category was higher in the Whitsundays, reflecting its purer status as a holiday area.

Of international visitors, 595,000 of a total 1,095,000 visited Far North Queensland on holidays (54%). Again the actual share of holiday visitors was highest in the Whitsundays.

The share of holiday visits was 89% overall for international visitors to the GBRCA, ranging from 97% in the Whitsundays and 91% in Far North Queensland to 81% in the Northern region and 77% in Mackay. The share of total nights spent was lower, reflecting different average lengths of stay.

Finally, Table 5 shows that international and domestic overnight visitors seek different experiences. Domestic visitors are not very interested in culture, heritage or the Indigenous component of these. Their main interest appears to be food and wine (53% of all domestic overnight visitors), followed by an experience of nature (in which 24% expressed interest).

4: Holiday visitors to GBR regions 2009-10 (excluding day visitors)

Region	Visitors Thousand	Nights Thousand	Share of visits %	Share of nights %	Average nights
Overnight domestic visitors					
Far North Queensland	794	5,169	55%	60%	6.5
Northern	244	1,138	31%	34%	4.7
Whitsundays	315	1,430	68%	67%	4.5
Mackay	144	507	24%	34%	3.5
Central Queensland	416	1,741	37%	35%	4.2
Bundaberg	167	728	32%	37%	4.4
Total GBRCA	2,080	10,713	42%	48%	5.2
International visitors					
Far North Queensland	595	4,669	91%	77%	7.8
Northern	111	578	81%	41%	5.2
Whitsundays	206	959	97%	83%	4.7
Mackay	40	157	77%	38%	3.9
Central Queensland	108	580	86%	52%	5.4
Bundaberg	35	468	82%	72%	13.4
Total GBRCA	1,095	7,411	89%	69%	6.8

Source: Tourism Research Australia

5: Main visitor experiences (relative to total visitors)

Region	Culture/ heritage	Nature based	Food and wine	Indigenous
Overnight domestic visitors				
Far North Queensland	12%	37%	60%	np
Northern	6%	14%	54%	np
Whitsundays	np	32%	57%	np
Mackay	np	13%	45%	np
Central Queensland	5%	14%	51%	np
Bundaberg	np	27%	45%	np
Total GBRCA	na	24%	53%	na
International visitors				
Far North Queensland	70%	93%	92%	39%
Northern	75%	93%	93%	42%
Whitsundays	76%	97%	95%	42%
Mackay	67%	87%	94%	33%
Central Queensland	76%	90%	95%	41%
Bundaberg	74%	90%	95%	31%
Total GBRCA	72%	93%	93%	40%

Source: Tourism Research Australia

The situation was different for international visitors. An overwhelming proportion of 93% expressed an interest in experiencing Australian food and wine, and the same proportion sought a nature-based experience. Almost three-quarters of international visitors was interested in culture and heritage, and 40% in the Indigenous component.

ECONOMIC ANALYSIS TABLES

Table 6 provides an overall Australian perspective, based on the Tourism Satellite Accounts developed on an annual basis by the Australian Bureau of Statistics as a supplement to the standard National Accounts. The best overall measure of the contribution of tourism to the economy is the value-added figure in the left-hand column of Table 6. It differs from the overall GDP statistic by excluding indirect taxes less subsidies, which as shown by the second column was significantly distorted when the GST was introduced in 2000.

6: Tourism Satellite Account and GDP, Australia

Year	Direct tourism ($m at 2009-10 prices)			Total GDP	Tourism share	
	Gross value added at basic prices	Plus tourism net taxes on products	Equals direct tourism GDP		of GVA	of GDP
1997-98	27,294	- 321	26,974	869,868	3.1%	3.1%
1998-99	29,207	- 308	28,900	913,293	3.2%	3.2%
1999-00	29,493	- 323	29,170	949,317	3.1%	3.1%
2000-01	30,205	2,930	33,134	970,125	3.1%	3.4%
2001-02	30,359	2,890	33,248	1,008,005	3.0%	3.3%
2002-03	31,068	2,924	33,992	1,041,115	3.0%	3.3%
2003-04	30,345	2,896	33,242	1,082,942	2.8%	3.1%
2004-05	29,942	2,883	32,824	1,116,201	2.7%	2.9%
2005-06	29,984	2,809	32,793	1,150,419	2.6%	2.9%
2006-07	30,887	2,890	33,777	1,193,042	2.6%	2.8%
2007-08	31,256	2,995	34,250	1,238,048	2.5%	2.8%
2008-09	30,008	2,836	32,844	1,255,241	2.4%	2.6%
2009-10	30,929	2,915	33,844	1,283,066	2.4%	2.6%

Source: ABS Tourism Satellite Accounts 2009-10, using implicit GDP deflator from ABS 5206.0 Table 5

Tourism according to the satellite accounts has lost share of the total gross value added (GVA) to the economy. It hovered around 3.1% until 2000-01 but had since fallen to 2.4%. This is the relevant measure rather than tourism's share of GDP which is distorted by the inclusion of GST and other indirect taxes.

Table 7 reproduces the valuable analysis by Access Economics (2009) of the economic contribution of GBRCA tourism. The figures relate to 2006-07 and the methodology (with which I can find no flaw) is explained in detail in the Access Economics publication. It shows the direct and indirect contribution of this tourism on (a) the area itself, (b) Queensland and (c) Australia.

The indirect contributions are estimated through linkages with other industries analysed in input-output tables and creating multiplier effects on top of the direct contributions. The larger the

geographic area for which the total contributions are estimated, the larger the influence of the indirect contributions adding to already increased direct contributions.

Updated to 2009-10 values, the total contribution to the GBRCA economy in 2006-07 was $3.7 billion, including 33% indirect contributions. For the whole of Queensland, the total contribution was $4.1 billion (including 38% indirect), and for the nation as a whole $5.6 billion including 48% indirect contributions.

The best estimate available for the economic contribution of GBR tourism therefore relates to 2006-07. However, it is legitimate to extend this estimate to 2009-10 as shown in Section 2 of this statement.

7: Economic contribution of GBRCA tourism (2006-07 in 2009-10 $m values)

Contribution by visitors	GBRCA	Queensland	Australia
Direct contributions			
Visitors from GBRCA	555	555	629
From rest of Queensland	410	460	504
From interstate visitors	861	861	1,057
From international visitors	645	657	744
GBRCA total tourism	2,471	2,532	2,935
Indirect contributions			
Visitors from GBRCA	282	352	607
From rest of Queensland	195	278	453
From interstate visitors	406	515	940
From international visitors	307	395	664
GBRCA total tourism	1,191	1,541	2,665
Total direct and indirect contributions			
Visitors from GBRCA	837	907	1,237
From rest of Queensland	605	738	957
From interstate visitors	1,267	1,377	1,997
From international visitors	952	1,052	1,408
GBRCA total tourism	3,661	4,073	5,599

Source: Access Economics 2009, Table 4.2, and GDP implicit deflator (+9.4% up between 2006-07 and 2009-10

Table 8 shows summary estimates for all three years covered by Access Economics analysis. The figures for 2006-07 are identical with those in Table 7 except for rounding errors.

8: Updated estimates of GBRCA total tourism contribution, 2004-05 to 2006-07

$million at 2009-10 values	2004-05	2005-06	2006-07
GBRCA			
Direct contributions	2,273	2,416	2,471
Indirect contributions	1,091	1,162	1,191
Total contributions	3,365	3,578	3,662
Change on previous year		6.3%	2.4%
Queensland			
Direct contributions	2,335	2,478	2,532
Indirect contributions	1,416	1,506	1,541
Total contributions	3,751	3,983	4,073
Change on previous year		6.2%	2.3%
Australia			
Direct contributions	2,708	2,872	2,935
Indirect contributions	2,448	2,603	2,665
Total contributions	5,156	5,475	5,600
Change on previous year		6.2%	2.3%

Source: Access Economics 2009 Table 7.6, and GDP implicit deflator

GBR VISITORS USING COMMERCIAL TOUR OPERATORS

GBRMPA since 1993 has compiled monthly statistics of passenger days for people visiting the reef. While they are need to be supplemented by information on vessels, trip types and points of departure (as well as values) they do represent the longest data series available for the GBR, covering each of four GBRMPA Management Areas: Far Northern (extending not quite down to Cooktown), Cairns/Cooktown covering the area from north of Cooktown to Mission Beach, Northern/Whitsundays, and Mackay/Capricorn.

Tourist numbers in the Far Northern Management Area are negligible, at least in relative terms. The main areas are clearly Cairns/Cooktown and Northern/Whitsundays, with the latter gaining significantly on the former during the years covered by the statistics – especially during the 1990s.

Table 9 shows the figures, supplemented by a graphical representation.

9: Visitors to the Great Barrier Reef using commercial tourist operators

Year	GBRMPA Management Areas (thousand visitors)				
	Far Northern	Cairns/ Cooktown	Townsville/ Whitsunday	Mackay/ Capricorn	Sum of four areas as shown
1994	5.7	876.9	529.0	105.5	1,517.1
1995	4.7	951.8	581.9	121.1	1,659.5
1996	4.9	964.2	597.4	97.0	1,663.4
1997	5.1	998.3	533.4	99.0	1,635.8
1998	5.0	821.4	590.4	119.0	1,535.8
1999	7.6	839.9	704.9	120.2	1,672.6
2000	9.6	836.7	730.4	100.9	1,677.5
2001	5.7	884.8	819.4	137.7	1,847.6
2002	5.8	916.4	846.1	157.6	1,926.0
2003	5.6	909.1	874.4	142.9	1,932.0
2004	7.0	950.0	879.9	141.0	1,977.9
2005	8.9	948.1	883.7	150.2	1,990.9
2006	13.9	860.3	853.4	155.8	1,883.4
2007	10.1	948.0	885.8	151.6	1,995.5
2008	5.9	802.6	869.7	147.8	1,826.0
2009	6.0	812.2	879.3	150.7	1,848.2
2010	5.6	868.2	806.2	123.9	1,803.9

Source: GBRMPA (http://www.gbrmpa.gov.au/corp_site/key_issues/tourism/management/gbr_visitation/numbers)