

VICTORIAN CIVIL AND ADMINISTRATIVE TRIBUNAL

Applications for Review:

P1816/2011, P1818/2011, P1820/2011 P1822/2011, P1829/2011,
P1846/2011

Dual Gas Demonstration Project

Works Approval WA 67043

Expert Witness Statement by way of reply to
reports filed by Dual Gas Pty Ltd

prepared by Malcolm McIntosh

October 2011

1 Introduction

1 I have prepared an expert report in relation to the Dual Gas Demonstration Project for proceedings that are currently before VCAT (Dual Gas Demonstration Project Works Approval WA 67043 Expert Report prepared by Malcolm McIntosh dated October 2011) (**VCAT Report**).

2 Corrs Chambers Westgarth has asked me to review the following reports filed by Dual Gas Pty Ltd in relation to the VCAT proceedings:

(a) "Dual Gas Demonstration Project", Statement of David Walton (dated 3 October 2011);

(b) "Air Quality Assessment Report" prepared by Dr J T Bellair (dated 22 September 2011); and

(c) "Summary Document Describing: IDGCC Process Description, Calculation of Greenhouse Emissions and Best Practice" prepared by Alex Blatchford (dated 26 September 2011).

3 I have reviewed the statements, opinions and conclusions in those reports that are within the scope of the matters that I have addressed in my VCAT Report.

4 The statements, opinions and conclusions that I materially disagree with or would like to comment on are set out below.

5 I have used the same terms and definitions in this report as in my VCAT Report.

2 Summary Document describing: IDGCC Process Description, Calculation of Greenhouse Emissions and Best Practice, September 2011, Statement by Alex Blatchford (Blatchford Report)

6 The Blatchford Report summarises information included in the Works Approval Application and expands on it to provide a fuller explanation. My comments on the Blatchford Report are set out below.

2.1 Section 2.1 – Introduction to IDGCC

7 This section is consistent with the Works Approval Application.

2.2 Section 2.2.1 – Plant Configuration

8 The description of the major equipment in the proposed plant is consistent with the Works Approval Application.

9 This Section describes the benefits of the combined cycle gas turbine (CCGT) configuration proposed in the Works Approval Application in which electrical power generation is from two gas turbines and a single steam turbine (known as a 2 x 1 multi-shaft configuration). Each gas turbine has a dedicated heat recovery steam generator (HRSG) and the steam generated from these together with the steam generated in the two char boilers is supplied to the single steam turbine. Mr Blatchford claims that a single large steam turbine is cheaper and more efficient than the option of two smaller steam turbines (one steam turbine per CCGT train).

10 Although it may have been considered during the development of the DGDGP (but has not been commented on), an alternative configuration that is often

employed by all gas turbine manufacturers is to use single-shaft CCGTs. In this configuration the gas turbine, steam turbine and generator of each CCGT are installed in a tandem arrangement on a single shaft. In the case of the 600 MW DGDP, this option would have led to the use of two single-shaft CCGTs each with a capacity of 300 MW. According to GE¹, the single shaft arrangement has emerged as a preferred configuration resulting from simplicity of controls and operation, occupies a smaller area, and has a high reliability, better part-load efficiency and a similar cost/kW to that of the 2 x 1 multi-shaft option. This offers the manufacturers the opportunity to develop a standardised CCGT design rather than a more expensive case-by-case design. (The multi-shaft combined cycle system configuration is frequently applied in phased installations in which the gas turbines are installed and operated prior to the steam cycle installation and where it is desired to operate the gas turbines independently of the steam system. According to the Works Approval Application, this mode of operation was not envisaged for the DGDP).

- 11 Multiple single-shaft CCGTs have been offered both for natural gas and IGCC plants. Of the IGCC plants currently in operation as listed in Table 2 of my VCAT Report, the following plants have single-shaft CCGTs installed: Nuon in The Netherlands (one Siemens CCGT), Tampa in USA (one GE CCGT), and Sarlux in Italy (3 GE CCGTs). In most cases the IGCC plants have only a single gas turbine and single steam turbine in a multi-shaft arrangement although at the ISAB plant in Italy there are two multi-shaft CCGTs in a 1 x 1 configuration, ie there are two gas turbines and two steam turbines. The proposed Magnum IGCC plant is also to have three single-shaft MHI CCGTs (refer Section 2.5.2).
- 12 The single-shaft CCGTs will have a slightly lower efficiency than a 2 x 1 multi-shaft CCGT with a single large steam turbine because of the lower efficiency of the smaller steam turbine. GE estimates that the efficiency of a single-shaft configuration will be reduced slightly by about 0.3% relative to that of a multi-shaft arrangement with a single steam turbine (which is consistent with the estimate given in the Walton Report). This reduction in efficiency is small when compared with, for example, the inefficiency introduced by steam injection for control of NOX emissions when operated on natural gas alone. The part load performance of the single-shaft configuration will be superior although this is not relevant for the base-load mode of operation proposed by Dual Gas.
- 2.3 Sections 2.2.2 and 2.2.3 – Construction Timing and Plant Location**
- 13 These sections are consistent with the Works Approval Application.
- 2.4 Section 2.2.4 - Technical Differences between a 300MW and a 600MW Plant**
- 14 There is an assumption that the impact of the EPA assessment will be to delay the second 300MW unit. The report states “Delaying the approval of the second 300MW unit will require changes to the design of the plant including the use of two smaller steam turbines, two circulating water systems and two ACCs”. A table is shown listing the differences. The Walton Report made a similar assumption.

¹ Tomlinson L, McCullough S
3767c

Single-shaft combined Cycle Power Generation System, GE publication GER-

- 15 The project as approved under the Works Approval is for a 300 MW plant – there is no mention of a second stage in the approval.
- 16 Generally a larger plant does lead to economies of scale as described in this section. The economies of scale apply here only to the steam turbine and its associated equipment –refer to the comments on Section 2.2.1 above.
- 17 The 2 x 1 multi-shaft arrangement is a common CCGT configuration but the multiple single-shaft configuration is also common – refer to the comments on Section 2.2.1 above.
- 2.5 Sections 2.3 and 2.4 – IDGCC Development History and Australian and Victorian Government Support for DGDP**
- 18 These sections are consistent with the Works Approval Application.
- 2.6 Section 2.5 - Existing and Planned IGCC and Gasification Plants Worldwide**
- 19 Refer to Table 2 of my VCAT Report for a fuller list of existing IGCC plants.
- 20 In section 2.5.2, Mr Blatchford states that there is a strong growth in gasification based projects including IGCC power plants. There are issues, however, that are curtailing development and a number of projects have been cancelled. These issues include the high cost of IGCC plants and the policy and regulatory shortcomings associated with IGCC in terms of a price on CO₂, the infrastructure requirements for transport of CO₂, and the validation, acceptance and regulatory requirements for CO₂ storage that have yet to be determined. It should be noted also that gasification for the production of chemicals and liquid fuels would involve oxygen-blown rather than air-blown gasification (as proposed for the DGDP).
- 21 I agree with the conclusions in section 2.5.3 of the Blatchford Report, apart from the cost effectiveness of the DGDP. I do not have sufficient information to provide comments on the costs. However, because the DGDP does not require either an air separation plant or a high pressure/temperature syngas cooler, there is potential for cost savings relative to a conventional entrained flow gasifier IGCC plant. For completeness it should be noted that the MHI gasifiers, which are used in the Negishi and Nakoso IGCCs, and the TRIG gasifier, which is to be used in the Kemper County IGCC are both air blown and claim the efficiency and cost advantages of not having an air separation plant.
- 2.7 Section 3 - Calculation of Greenhouse Gas Emissions**
- 22 Sections 3.1 to 3.9 provide a comprehensive explanation of the methods, bases and references for the greenhouse gas calculations used in the Works Approval Application.
- 23 I agree with the methods that were used to calculate the greenhouse gas emissions from the DGDP.
- 24 It is not clear why in Dual Gas's Case 4 operational scenario the natural gas usage and the electrical power generated fall from 2027 onwards to less than half of the values in the preceding period.
- 25 In Section 3.10.1, Mr Blatchford compares the State and Federal emission standards. He refers to the proposed State target of 0.8 tCO₂-e/MWh and states that the DGDP complies with this benchmark. However, the previous

Victorian State Government's Victorian Climate Change White Paper did not define whether the target of 0.8 tCO₂-e/MWh was to be determined using electrical power on an as generated or sent out basis. The difference between the generated and sent-out electrical power is the electrical power used within the plant (auxiliary power consumption). Dual Gas has chosen to calculate GEI on a generated electrical power basis which, for the same plant, has a lower value than the GEI calculated on a sent-out electrical power basis.

26 I agree with Mr Blatchford's statements in section 3.10.2. Generated output was the basis for the Australian Government's election commitment which had as a starting point for negotiations a GEI of 0.86 T/MWh gen. There was also a requirement that plant should be capable of retrofitting CCS technologies which would require installation within an appropriate time frame, once commercially available.

27 In section 3.12, Mr Blatchford comments on the potential for carbon capture and storage (CCS). I agree that a future retrofit of CCS to the DGDP (if commercially viable) is expected to reduce the GEI to approximately 0.26 T/MWh. To provide a basis for comparison, the air-blown Kemper County IGCC proposes to capture 65% of the CO₂. A GEI of 0.8 T/MWh should on that basis be reduced to 0.28 T/MWh.

28 There is a question about what constitutes commercial viability for CCS to be undertaken. The Interdepartmental Task Group discussion paper referred to in Section 3.10.2 of the Blatchford Report has addressed this issue as follows:

To determine whether CCS is considered commercially available the Australian Government, in consultation with bodies such as the Global CCS Institute and IEA, would undertake a review process every two years. The review would consider:

- *the technical viability of CCS, and whether retrofitting a plant is both operable from an engineering perspective and of a comparable scale (an indicative scale-up will be advised at a future date);*
- *the operational viability of each element of the technology in conjunction with other elements (i.e. carbon capture along with CO₂ transport and storage); and*
- *Australia-specific factors affecting the commercial availability of CCS.*

Further, the Australian Government would define commercial availability as:

- *integration of carbon capture, transport and storage has been proven at a comparable scale and technology in several demonstration plants worldwide;*
- *the systems comprising CCS are readily attainable; and*
- *safety and environmental risks of CCS have been minimised (e.g. the potential for carbon leakage from storage sites).*

If the report positively assesses that CCS is commercially available, the Minister for Resources and Energy may make a declaration that a retrofit must occur. Due to the costs and planning involved with CCS being retrofitted to power generators, it is proposed that it will be mandatory to

implement the planned CCS retrofit within four years and complete the retrofit within seven years of it being declared. This may allow the CCS retrofit to be implemented in a graduated manner.

29 The statements in section 3.12.1 of the Blatchford Report are consistent with the Works Approval Application.

2.8 Section 4 - DGGP Best Practice

Section 4.2

30 I broadly agree with the statements in Section 4.2.1 of the Blatchford Report, particularly as they relate to the advantages of the IDGCC technology. However, it should be noted that materials capable of operation at temperatures of 700°C and pressures of 35 MPa are being developed for boiler plant which would enable very high efficiencies to be achieved that are competitive with those from IGCC. Developments in post combustion carbon capture or the further development and demonstration of oxyfuel combustion could then be applied to these technologies to achieve carbon capture – refer Section 2 of my EPA Report.

31 In section 4.2.2, Mr Blatchford compares the efficiency of combined cycle with conventional thermal power plants. I agree that the average efficiency of the DGGP for Cases 1-3 is 39.4%, HHV although the range I calculated was from 38.8% to 41.2%, HHV (not to 42.2%, HHV). I agree that the efficiency improvement over the existing Latrobe Valley power station generators is as shown in Table 9 of the Blatchford Report.

32 The DGGP efficiency does, however, include a benefit from the use of natural gas. As noted in paragraph 57(b) of my VCAT Report, on average approximately 21% of the energy to the DGGP must be supplied by natural gas to achieve an average GEI of 0.8 T/MWh gen. For the purpose of benchmarking the DGGP relative to other brown coal fired plant, I compared the CO₂ emissions for operation on coal alone. For operation at base-load on syngas, the only natural gas used is for pre-drying and air preheating. In this case, for syngas from Morwell coal, about 7% of the energy input is supplied by natural gas. The base-load case therefore gives a reasonable, albeit low, estimate of GEI for the DGGP of 0.87 T/MWh generated (refer to my VCAT report, paragraphs 63 and 64(a)) and the efficiency is 37.8% gen, HHV.

33 On a coal alone basis, the efficiency improvement of the DGGP over the existing Latrobe Valley station generators is reduced to a still substantial 37.5% higher than the average of the current generators, 27.7% higher than the most efficient generator Loy Yang A and 11.2% higher than the AGO's new power plant standard (NPS) for power generation from brown coal fired boiler plant.

34 I calculated the efficiency and GEI of the RWE Niederaussem K power plant in Germany if it was to be fuelled with Morwell coal and obtained a higher efficiency than stated by Dual Gas. However, I concluded that the IDGCC was competitive with the Niederaussem plant (on a coal alone basis), particularly as there is currently no commitment to a plant incorporating coal pre-drying.

35 It should be noted that I expect that the current Latrobe Valley power stations have a limited capability of being fired partially on natural gas as a means of reducing their GEI – see comments on Section 4.3.2 below. However, this might be a consideration if/when there is an impost on CO₂ emissions.

Section 4.3

- 36 Section 4.3.1 of the Blatchford Report is consistent with the Works Approval Application.
- 37 In section 4.3.2, Mr Blatchford states that the DGDP has a lower GEI than any of the existing black coal fired power stations which I accept. (I have not checked the GEI values for the black coal fired power stations but they are in the range that I would expect). Again, as was the case for existing brown coal fired boiler plant, the comparison is not on the same basis as there is no natural gas firing of these boilers. In the case of black coal fired boilers, however, it is possible to dual fire with natural gas to a significant extent and, as with the DGDP, the GEI will be dependent on the proportion of energy supplied by the natural gas.
- 38 Liddell power station in NSW has recently received approval for the supply of mine waste methane gas as a supplementary fuel. This will be the first known large scale implementation of supplementary methane gas fuel in an Australian coal-fired power station. Also, Bayswater B power station has been granted concept approval for a "dual fuel" power station development, which allows potential developers to choose whether the power station will be coal or gas-fired.
- 39 In section 4.3.3, Mr Blatchford benchmarks the DGDP against existing gas fired power stations and highlights that the DGDP will have a lower GEI than the existing gas fired power plants in Victoria (when the DGDP is operated on natural gas alone).
- 40 It would be expected that the DGDP would have a higher efficiency than the open cycle gas turbine plants that are currently used in Victoria to meet peak load demands. Many of the gas turbine plants used for this purpose have quite low efficiencies but these plants are used for only short periods each year.
- 41 Best practice for a natural gas CCGT would be consistent with the GEI obtained from the Tallawarra (and Swanbank E) F class equivalent, single-shaft CCGTs with an estimated GEI of 0.34 T/MWh gen. (I have confirmed this efficiency).
- 42 In section 4.3.4, Mr Blatchford refers to the New Plant Standards (NPS). In determining the NPS, the performance of super critical boiler plant fuelled with brown and black coal and gas turbine plant in combined cycle and open cycle has been calculated using commercial software. The plant conditions and equipment required to meet the NPS reflect Best Available Technology (BAT) when operated under Australian conditions using Australian fuels.
- 43 Mr Blatchford compared the performance of the DGDP to plant having the AGO's NPS. The same comments apply as made in respect of section 4.3.2 above, that the comparison, particularly with black coals, is not on the same basis because the DGDP utilises natural gas to reduce the GEI.
- 44 I have commented on the performance of the RWE plant in paragraph 34 above.
- 45 The GEI of the open cycle and CCGT plant having the AGO's NPS is 0.55 and 0.35 T/MWh gen, respectively. This compares with 0.45 T/MWh gen for the DGDP when operated as a CCGT on gas alone.

46 On page 28, Mr Blatchford has stated that “Inspection of Figure 9 indicates that, clearly, the DGDPS’s IDGCC technology represents best practice with respect to the use of brown coal (noting that the operating DGDPS will always use a combination of NG and syngas)”. I agree that the integrated gasifier and drier together with the E class CCGT proposed for the DGDP is currently best practice when fuelled with coal and supported by natural gas to achieve the desired GEI. The use of an E class CCGT fuelled only with natural gas is, however, not best practice.

47 Section 4.3.5 of the Blatchford Report is a summary of Section 4.3 and repeats various-issues on which I have commented on in relation to Sections 4.3.2, 4.3.3, and 4.3.4. My summary is:

- (a) I agree that the DGDP is significantly more efficient and has a lower GEI than existing brown coal plant in the Latrobe Valley and the current plant operating in Germany even when compared on a coal alone basis. The plant can be operated with natural gas for part of each year to reduce the GEI. For Morwell coal, approximately 21% of the energy would need to be provided from natural gas to achieve a GEI of 0.8 T/MWh gen.
- (b) I consider that the comparison of efficiency and GEI with black coal boiler plant is extraneous as these plants could also be operated with a significant portion of the energy input provided by natural gas.
- (c) The performance of the DGDP on natural gas has a GEI of 0.45 T/MWh gen, which is higher than obtained from more advanced F class equivalent CCGTs currently being used in Australia which, assuming the efficiency for the NPS, have a GEI of 0.35 T/MWh gen. The efficiencies corresponding to these GEIs are 41.0% and 52.8%, respectively on a generated, HHV basis.

2.9 Section 4.8 – Water Consumption

48 I agree with the statements in this section.

2.10 Section 4.9 – Best Practice Conclusion

49 Mr Blatchford states that the DGDP has been assessed on the basis that the relevant industry sector is the brown coal fired electricity generation sector.

50 However, if a CCGT is to be operated on natural gas alone , then the relevant industry sector is electricity from natural gas.

51 Efficiency – The DGDP has a substantially higher efficiency than the existing Latrobe Valley generators or a plant based on the AGO’s NPS for power generation from brown coal whether based on a coal alone basis or with support from natural gas to achieve a desired GEI.

52 Greenhouse Emissions – DGDP’s range of GEI from 0.73 to 0.78 T/MWh gen is lower than the previous Government’s proposed standard of 0.80 T/MWh assuming that this is on a generated basis. The previous Government left this undefined.

53 To achieve these emissions targets natural gas must provide between approximately 22% and 28% of the input energy to the plant.

54 I accept that the GEI when operating on natural gas is lower than the other natural gas fired plants in Victoria which apart from the Newport gas fired power station are open cycle gas turbines. However, there are several F class CCGTs in Australia which have significantly lower GEIs, and correspondingly higher efficiencies, than the DGDP would have when operated on natural gas.

55 On page 38, Mr Blatchford states that "Having regard to the overall performance of the plant, it is the author's belief that the performance of the DGDP as a whole constitutes best practice in respect to the sector or activity of power generation from brown coal, and meets the definitions of best practice as set out in the SEPP(AQM). I agree that the integrated gasifier and drier together with the E class CCGT proposed for the DGDP is currently best practice when fuelled with coal and supported by natural gas to achieve the desired GEI. The use of an E class CCGT fuelled only with natural gas is, however, not best practice.

3 Dual Gas Demonstration Project - Statement of David Walton dated 3 October 2011 (Walton Report)

3.1 Section 3.1 - The Proposed and Approved CCGT Modular Configuration

56 The DGDP as approved under the Works Approval will likely be a single train comprising a gas turbine, HRSG and single steam turbine sized appropriately for the gas turbine. As indicated in the Works Approval Application, the DGDP plant is expected ultimately to have an availability of 85% for the IDGCC technology based on the performance of other IGCC plants. Also, if the gasification system is unavailable it would be able to operate on natural gas with an expected reliability of greater than 95%.

57 Mr Walton has stated that "The generally accepted most beneficial application of gas turbine combined cycle power generation is in the modular form described as "2 plus 1" being two of the same gas turbines ("GT") into one steam turbine ("ST")."

58 This is not necessarily the case. Refer to my comments on the Blatchford Report on a single-shaft CCGT option (paragraphs 9 to 12 above). There is greater operational flexibility with two single shaft CCGTs than offered by the 2 x 1 CCGT option as proposed.

59 The Walton Report discussed the flexibility of operation and maintenance that is achievable from having two gas turbines. However, I expect that because of the high reliability of the plant and a knowledge of when the plant would likely be idle, eg during known periods during the year of reduced demand, maintenance would be scheduled accordingly.

3.2 Section 3.3 – E Class v F Class Turbines

60 The composition of the syngas obtained from the DGDP would be expected to influence the decision on the choice of gas turbine mainly because of its high moisture content. This is more important than the type of coal that is used assuming it is dried beforehand. As noted in my EPA Report, the specific energy (SE) of the syngas in the Nuon IGCC plant at Buggenum is significantly lower (4.3 MJ/kg, LHV) than proposed for the DGDP as a result of the nitrogen from the ASU being admitted into the syngas upstream of the combustor. This was done to reduce the combustion temperature and hence NOX emissions.

The diluted syngas is also able to be introduced into the gas turbine combustor at a relatively high temperature of 310°C.

61 Mr Walton implies that F class gas turbines are not currently available for operation on syngas.

62 I disagree. As stated in my VCAT Report there are a number of F class turbines currently being used in 60 Hz IGCC applications and there are currently two F class gas turbines being used in 50 Hz IGCC applications. Also, Siemens has more recently offered two 60 Hz F class gas turbines for the Kemper County IGCC in the USA where apparently a market is seen. The issue I believe relates very much to syngas gas composition and the perceived market.

63 I agree that it is likely that an F class gas turbine if offered by Siemens would have approximately twice the output of the E class gas turbine (nominally 292 MW compared with 168 MW). However, I disagree that this is an impediment to the adoption of anything other than an E class gas turbine for any second stage of development contemplated with respect to the DGDP (as stated by Mr Walton on page 8). In this case, two gasifiers might be used to supply a single CCGT train.

3.3 Section 3.4 – Alteration of the Approved Configuration

64 I agree that the plant, as approved under the Works Approval, would need to be constructed in a “1 plus 1” configuration. See my comments in paragraphs 9 to 12 above.

3.4 Section 6 – IDGCC Potential in Australia and Globally

65 I agree that air blown gasification offers efficiency and potential cost advantages for IGCC, particularly for coals that do not require very high gasification temperatures, because an ASU is not required.

66 However, for the production of liquid fuels and chemicals, oxygen-blown gasification would be used to maximise the product yield.

4 Proposed Dual Gas Demonstration Project, Morwell – Air Quality Assessment prepared by Dr Bellair dated 22 September 2011 (Bellair Report)

67 I agree with the description of the DGDP proposal set out on page 12 of the Bellair Report.

68 On page 14, Dr Bellair states that the relevant industry sector or activity is the generation of electricity from brown coal. If however a CCGT is to operate on natural gas alone then the relevant industry sector for assessment of best practice is the generation of electricity from natural gas. This comment also applies in relation to point 1 on page 24 of the Bellair Report.

69 On page 15, Dr Bellair states that the DGDP is at least 30% better than the existing brown coal fired boiler plant in the Latrobe Valley (not world-wide). I have commented on this in paragraphs 31 to 35 above.

70 On page 15, Dr Bellair states that in his opinion “the technology to be employed in DG’s demonstration project clearly represents “best practice” in the relevant “industry sector or activity” (the generation of electricity from brown coal) in terms of minimisation of emissions”. I agree that the integrated

gasifier and drier together with the E class CCGT proposed for the DGDGP is currently best practice when fuelled with coal and supported by natural gas to achieve the desired GEI. The use of an E class CCGT fuelled only with natural gas is, however, not best practice. This comment also applies in relation to points 3 and 9 on page 24 of the Bellair Report.

- 71 There is an emphasis on CCS which, although important in the assessment of the proposal in terms of future requirements, is only one of the factors to be considered.
- 72 Dual Gas has not undertaken a detailed assessment of the GEI of the plant after carbon capture has been made. However, I compared the claim with that expected elsewhere and I consider that it is feasible.

Declaration

I declare that I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Tribunal.



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Malcolm McIntosh

19 October 2011