

Dual Gas Demonstration Project

Expert Witness Statement by way of reply

to reports filed by Dual Gas Pty Ltd

by

C.M. (Costa) Tsesmelis

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1 Introduction

1. I have prepared a witness statement in relation to the proceedings currently before the Victorian Civil and Administrative Tribunal relating to the Dual Gas Demonstration Project (“Dual Gas Demonstration Project: Expert evidence in VCAT proceedings” by C.M. (Costa) Tsesmellis dated 8 October 2011) (**Expert Witness Statement**).
2. Corrs Chambers Westgarth has asked me to review the following reports filed by Dual Gas Pty Ltd in relation to the VCAT proceedings:
 - “Dual Gas Demonstration Project”, Statement of David Walton (dated 3 October 2011);
 - “Air Quality Assessment Report” prepared by Dr J T Bellair (dated 22 September 2011); and
 - “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 Expert Witness Statement.
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 abbreviations, acronyms and defined terms in this report as in my Expert Witness Statement.

2 “Summary Document Describing: IDGCC Process Description, Calculation of Greenhouse Emissions and Best Practice” prepared by Alex Blatchford dated 26 September 2011

Section 2.2.4

6. Mr Blatchford states: “Delaying the approval of the second 300 MW 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”.
7. This statement requires clarification. My understanding is that a completely new works approval application would be needed for a second 300 MW train. Approval of the design and the equipment for the second train will be, from my understanding, a totally separate decision by the EPA with a new works approval application being judged on its own merits.
8. I agree with Mr Blatchford’s statement that a 2 x 2 x 1 configuration is a common configuration and is offered by all major suppliers.

Sections 2.5.1 and 2.5.2

9. I do not disagree with this data. There are some minor differences with the data I present in Table 2 of my Expert Witness Statement. For example, the FIFE Electric IGCC reported by GE Power Systems is not included in the DOE data used by Mr Blatchford. Also, my summary Table 2 includes 6 IGCC plants that use Heavy Residue (Petroleum) and Petrocoke whereas Mr Blatchford quotes 11 IGCC plants reported by the DOE that use other fuels ("petroleum, biomass or petcoke").

Section 4.3.4

10. In the last paragraph of this section, Mr Blatchford states: "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)".
11. Given the basis for the comparison, which is a mix of brown coal and natural gas for the DGDP cases, the data presented in Figure 9 of Blatchford's report shows DGDP cases 3,2,1 to be less than Brown Coal SubC and SC emission intensities. However, this does not necessarily mean that the DGDPS's IDGCC technology represents best practice with respect to the use of brown coal for generating electricity. The lack of sulphur recovery facilities and the choice of the second gas turbine that will run 100% on natural gas is not best practice. Further, the choice of gasifier, downstream processes and operating mode, for producing syngas from brown coal may also not represent best practice, as noted in my summary opinion at paragraph 2 of my Expert Witness Statement.

Section 4.4

12. Mr Blatchford states: "As a result of the efficiency gains and the use of natural gas, the sulphur dioxide emissions rate per unit of power generation ($t\ SO_2 / MWh$) will be approximately half that of the existing Latrobe Valley brown coal fired generators".
13. Mr Blatchford's analysis assumes that SO_2 emissions are proportional to the tons of brown coal consumed per MWh of power generated which is a reasonable basis for estimating SO_2 emissions. With the DGDP Cases 3,2,1 a portion of natural gas firing is included which lowers the SO_2 emissions per unit of power generation. I agree that SO_2 emissions for the average of the DGDP Cases 3,2,1 will be about half that of the current Latrobe Valley generators per MWh of power generation.
14. However, I disagree with Mr Blatchford's opinion that "In the context of using low sulphur content fuel, the inherent high process efficiency and the use of natural gas the proposed DGDP represents best practice for coal-based power generation with the lowest rate of SO_2 per MWh". In my opinion, the international benchmark for sulphur reduction best practice is to achieve 85 - 95% sulphur reduction.

Section 4.9

15. Mr Blatchford has concluded that it is his belief that “the performance of the DGDP as a whole constitutes best practice in respect of 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 disagree. The lack of sulphur recovery facilities and the choice of the second gas turbine that will run 100% on natural gas do not represent best practice.
16. Also, the gasification of brown coal using the HRL gasifier with air blast may not represent the lowest emissions intensity possible per MWh generated. As noted in paragraph 2 of my Expert Witness Statement, limited technical information was made available to me on the overall Dual Gas project design and the feedstock properties. As a result it was not possible for me to form an opinion on whether the HRL gasifier is the best technology gasifier for generating power from Victorian brown coal with the lowest environmental impacts. Other gasifier options, downstream equipment and operating modes, including entrained-flow gasifiers may be possible.

3 “Air Quality Assessment Report” prepared by Dr J T Bellair dated 22 September 2011

Part II (page 12)

17. Dr Bellair states “Dual Gas proposes to initially install one 300 MW IDGCC “train” and operate the second gas turbine on natural gas, while the second 300 MW IDGCC train will be installed after the technology has been proven at commercial scale. In the unlikely event that the IDGCC technology is not commercially viable, the facility will be operated as a 600 MW natural-gas-fired combined cycle power station”.
18. In my opinion, this indicates that Dual Gas accepts that one 300 MW train is sufficient to prove the IDGCC technology at commercial scale.

Section 3.2.1 (1st bullet point), 7th paragraph on page 15, section 3.5.1 and 1st point on page 24

19. Dr Bellair has taken the relevant “industry sector or activity” for purposes of assessing “best practice” under the provisions of Clause 19(1) of SEPP (AQM) to be “the generation of electricity from brown coal”.
20. A more accurate and specific definition for the “industry sector or activity” concerning the DGDP would be as follows:

“new technology for the generation of electricity from synthesis gas produced from the gasification of brown coal”, and with respect to the second gas turbine, the appropriate definition for “industry sector or activity” would be “the generation of electricity from natural gas”.

Section 3.2.1 (2nd bullet point), section 3.5.1 and 2nd point on page 24

21. Dr Bellair states that the demonstration project should be considered holistically under Clause 19(1), rather than considering each component of the plant individually. I disagree.
22. The starting point in any technology evaluation and best practice assessment is to analyse and consider the individual components and parts that make up the overall process or configuration. This approach helps to identify synergies between components and facilitates a holistic assessment of the overall facility.
23. By considering individual components, alternatives can be considered and the best combination of techniques assessed and evaluated. For example, as noted at paragraph 2 and 65 of my Expert Witness Statement, other gasifier options including entrained-flow gasifiers may be possible as the best technology gasifier for generating power from Victorian brown coal with the lowest environmental impacts. Other gasifier technology and type of blast agent (whether air, O₂ enriched air or pure O₂) and the type of downstream syngas treatment and processes employed, coupled to a CCGT train (or trains) could result in a lower emissions intensity. The resulting overall holistic assessment of an alternative gasifier technology coupled to a CCGT train (or trains), having considered the individual components, could represent better technology than the HRL gasifier coupled to a CCGT train (or trains).

Section 3.2.1 (5th paragraph on page 15)

24. Dr Bellair states "While I understand that technology is available for capturing SO₂ (alone) from syngas (at a substantial cost) this equipment would become redundant if CO₂ (and associated SO₂) capture is implemented as part of the CarbonNet project". I disagree.
25. I do not know which technology Dr Bellair is referring to for capturing SO₂ (alone) from syngas (at a substantial cost). The 1st stage Selexol equipment and a Claus sulphur unit that I suggested in my Expert Witness Statement would not become redundant if CO₂ bulk removal was implemented with a 2nd Stage Selexol at a later date.

Section 3.5.1 (reference to Maarten van der Burgt's conclusion)

26. My opinion is that the quote from Maarten van der Burgt's report has been taken out of context by Dr Bellair.
27. Maarten van der Burgt's advice to the EPA was that: "presently the [Dual Gas] process is the best practice technology for generating power from brown coal with the lowest environmental impact".
28. The conclusion made by Maarten van der Burgt is subject to a number of significant provisos. His conclusion is qualified as follows:

"This conclusion is based on the fact that there are too many uncertainties with both the RWE and an oxygen blown gasifier. Most important uncertainties are that the WTA process required in all alternative processes, and that more information is required on the ash/slag behaviour of the Victorian brown coals".

29. It is difficult for me to comment further on Maarten van der Burgt's conclusion given that I was not provided with the same technical information on the overall Dual Gas project design and the feedstock properties as Mr van der Burgt, as noted at paragraph 2 of my Expert Witness Statement.

Section 3.5.2

30. Dr Bellair has stated that "I have not reviewed the complex technical and economic issues involved in this assessment, but understand that these issues extend well beyond a simple comparison of the relative energy efficiencies of Class E and F gas turbines".
31. It is not clear to me which assessment is being referred to by Dr Bellair. If the assessment is a comparison of best practice technology for gas turbines, then a key factor for determining best practice would be their relative energy efficiencies. I also disagree that F Class gas turbines cannot operate on syngas. Please see paragraphs 81 and 85 of my Expert Witness Statement.

Part IV - Conclusions

32. Dr Bellair has stated that "the demonstration project clearly involves the application of 'best practice' in the relevant 'industry sector or activity' in terms of minimising emissions". I disagree that the demonstration project *clearly* (my italics) involves the application of "best practice". Please also see my responses at paragraphs 14, 15 and 16 above.
33. Dr Bellair has stated that "assessment of the demonstration project in terms of the local control provisions of SEPP (AQM) provides no justification for requiring the application of SO₂ removal technology at this stage (particularly in light of the likely closure of nearby Hazelwood and Energy Brix power stations)". I disagree. European & US standards are for a 85 - 95% sulphur recovery requirement. This constitutes international Western world "best practice" and is inclusive of considerations such as "*technical, logistical and financial considerations*" referred to in the SEPP (AQM) and the Protocol for Environmental Management. (The EPA works approval requires 90% reduction of uncontrolled emissions based on the average sulphur level in the coal feedstock).

4 “Dual Gas Demonstration Project” Statement of David Walton dated 3 October 2011

Sections 2.1 and 3.1

34. I agree there are additional efficiency and operational (maintenance) benefits for a “2 plus 1” vs a “1 plus 1” configuration.
35. I am not able to comment on the increased unit cost presented (12 - 20%) since no basis of calculations or estimates is presented.
36. I discuss the additional cost of sulphur reduction at paragraphs 55, 56 and 57 below. With respect to the sulphur capture figures presented by Mr Walton I do not know the basis of the calculation for the 30% estimate, however I disagree with the substantial increase presented, (12 - 20%) increasing to “in excess of 30%” due to the sulphur recovery facilities.

Section 3.3 (2nd paragraph)

37. Mr Walton states: “The DGDP requires GT(s) capable of burning syngas derived from brown coal which has a completely different constitution and different characteristics to natural gas and to other sources of syngas. Important differences include energy content and water content. These differences affect the resulting volume throughputs to a GT”.
38. While I agree that the HRL gasifier brown coal syngas as applied in the IDGCC plant will have a lower energy content and higher water content compared to brown coal syngas produced by other gasifiers, I disagree that it has a “completely different” constitution to other syngas sources.
39. The HRL gasifier syngas as applied in the IDGCC plant will still contain a large percentage of CO and H₂ just like brown coal syngas produced in any other type of gasifier. What is unique about the HRL gasifier syngas as applied in the IDGCC plant is the high water content in the syngas fired in the gas turbine.
40. The HRL patent describing its gasifier technology as applied to a combined cycle gas turbine states a moisture content of 32% in the syngas feed to the gas turbine. It is unlikely that this will in fact be the actual level of moisture in the operating plant, with some water removal likely to be needed to adjust the water content to ensure combustion stability. However the moisture content may be still be between 10 - 20%. There was no information provided by DG on this figure in their application or in the correspondence with the EPA that the EPA was entitled to provide to me.
41. If the syngas fuel to a gas turbine did contain a level of about 10 - 20% moisture this would in my opinion certainly constitute a different quality syngas for gas turbine vendors to

consider, but I still disagree that “syngas derived from brown coal...has a completely different constitution... to other sources of syngas”.

42. Mr Walton seems to imply that it is the brown coal that creates a “completely different” syngas. In Section 6 he states: “HRL has developed the unique technology specifically around brown coal as compared to other gasification technologies which operate on oil, pet-coke and black coal sources.” This statement suggests that other gasifier technologies do not operate on brown coal. This is not the case. Once the moisture in brown coal has been reduced in an external dryer, and it has been milled and prepared to suitable particle size, the brown coal can also be fed to other types of gasifiers as well to produce syngas for any of its many applications.
43. While the syngas produced from air blast gasification has a significantly lower calorific value than syngas produced from oxygen blast gasification, the variation in calorific value is likely to be handled by the diffusion-type burners that are used with syngas capable machines.
44. What is different with the HRL gasifier brown coal syngas as applied in the IDGCC plant is that the presence of perhaps 10 - 20% moisture will further reduce the calorific value - although again this additional reduction in calorific value may not necessarily be the major concern for gas turbine vendors who have developed syngas-capable machines.
45. What is potentially more significant is the impact of high water content on the combustion properties of the syngas and potentially the materials of construction in the gas turbine itself. I mentioned in paragraph 77 of my Expert Witness Statement it is known that water content in the syngas picks up heat as it passes through the combustor and that this potentially causes additional uncertainty concerning the combustion properties of syngas with high levels of inerts (N₂, CO₂, and H₂O).
46. This phenomenon with water may also impact the materials of construction of the gas turbine. In paragraph 66 of my Expert Witness Statement I describe the components of a gas turbine, and the key third section which is the turbine where the main work of energy conversion takes place. An area of concern for gas turbine vendors could be how different materials of construction of the blades will stand up to the high moisture content over time. This could be one reason why there were no guarantees offered other than from one vendor given these estimated levels of perhaps 10 - 20% water in the syngas.
47. I would also like to comment that the lower calorific value of the HRL gasifier syngas as applied in the IDGCC plant is also due to the presence of nitrogen in the syngas, due to the use of air blast, as well as the high water content. If oxygen or oxygen enriched air was used (as with other gasifiers and also possible with the HRL gasifier) – then the energy

content of the brown coal syngas produced by the HRL gasifier as applied in the IDGCC plant would be higher.

48. In fact, once the brown coal has had its high moisture level reduced, gasification can also take place with other gasifiers using O₂ blast for an IGCC operation. As noted in paragraphs 2 and 65 of my Expert Witness Statement, there was insufficient information including the ash/slag behaviour of Morwell and Yallourn brown coals, for me to form an opinion on what the best technology gasifier would be for generating power from brown coal with the lowest environmental impact.
49. Mr Walton also states that “Accordingly, a GT capable of burning syngas requires considerable re-design. Dual Gas was ultimately offered redesign and subsequent performance guarantees only in respect of an E Class turbine”.
50. I was not aware that a “redesign” was required for the syngas-capable E Class turbine reported for the DG project. There was no material or correspondence provided by DG to the EPA (that the EPA was entitled to provide to me) which described what constituted this turbine “redesign” in order for guarantees to be provided.

Section 3.3 (3rd and 4th paragraphs)

51. Mr Walton implies that F Class GTs are not currently available for operation on low energy syngas. I disagree. GE and MHI already have available F Class GTs operating on low calorific value (energy) syngas and they have “already moved into this area for F Class GTs”. The syngas used in these F Class GTs and the expected HRL gasifier syngas quality have been discussed at paragraphs 43 and 44 above. Although there is only one 50 Hz syngas F Class machine operating, there are other 60 Hz syngas F Class machines operating in the USA.
52. No information has been provided to the EPA (that the EPA was entitled to provide to me) on what is involved or required for “GT fuel and handling and combustion modifications for low energy syngas from low rank coal”.
53. Given an E Class syngas machine was selected for the approved 300 MW train, at Section 3.3 page 9 Mr Walton describes the difficulties of adopting a more efficient GT for a future second stage of development for the DGDP.
54. I agree that there would be some operational and maintenance difficulties with the mismatch of GTs as well as revised integration design and gasifier sizing required for such a second stage development.

Section 4.2 – Capital Costs

55. Mr Walton states “The installation of an integrated system is only \$20m greater than installing carbon capture by itself (that is, excluding the plant and equipment required for integrated sulphur capture). Engineering, design and construction of a system exclusively for sulphur capture is estimated at \$120m for a 300MW facility and at \$195 for a 600MW facility”. I disagree that a system exclusively for sulphur capture if designed and installed from Day 1 for a 300 MW facility would cost \$120 million.
56. At paragraph 129 in section 30 of my Expert Witness Statement, I suggested that a single stage Selexol unit be initially installed without the added costs of a 2-stage Selexol system that requires refrigeration and additional equipment. For selective removal of H₂S, without the need for bulk CO₂ removal, an absorber, a flash vessel and a steam stripper (regenerator) may be all that is required for the 1st stage Selexol.
57. Since a two stage process is not necessary from Day 1 where only H₂S is removed, the necessary tie-ins could however be installed for the future 2nd stage Selexol equipment, for future CO₂ removal as well. My +/- 40% estimate of a single stage Selexol with a suitably sized small Claus unit for sulphur recovery is \$20 million. Some pre-investment in the sizing of the H₂S absorber may be needed and the impact of the Shift Reactor unit that will be added when the future CO₂ removal is implemented will need to be taken into account for the 1st stage Selexol design – however Selexol can definitely remove H₂S selectively from Day 1 without expensive refrigeration and without the need to build the CO₂ removal facility from Day 1 either.
58. My indicative cost estimate consequently did not include the cost of pre-heat for the Shift Reaction unit, nor the likely twin reactor configuration plus their catalysts for the Shift Reaction unit, nor the gas condensate separation at the Shift Reaction unit outlet nor any reheat/humidification facility that might be needed for the Shifted syngas, nor the drying and compression of the CO₂ for pipeline transport. All of these items would be part of the capital cost for the future carbon removal stage when the 2nd stage Selexol with the required new Selexol CO₂ absorber/stripper system would also be added.
59. There are many options that exist for AGR design and the equipment required. These options depend on the untreated syngas flowrate, its composition, its pressure and temperature, the amount of H₂S and CO₂ removal required, and whether or not H₂S and CO₂ will be removed in two separate stages or both at the same time.
60. Mr Walton does not provide the basis for his estimate which may be for an integrated MDEA, Selexol or Rectisol facility together with a Shift Reaction unit from Day 1 for the 300 MW train. This different basis may explain the large discrepancy between my

indicative estimate described above and the \$120m for a 300MW facility according to Mr Walton.

61. On page 11, Mr Walton states: "The difference in cost between installing an integrated carbon and sulphur capture system, and installing separate carbon and separate sulphur capture plant, is estimated to be \$100m". No explanation is provided concerning the proposed systems and no explanation is provided for the basis of the \$100m figure.
62. He then states "The comparative differential in cost is due to the cooling, de-humidification, capture volumes and re-humidification of the syngas and relative actual volumes of sulphur and carbon content of syngas". It is not clear to me which comparative differential cost is being referred to. As mentioned previously, there are many options that exist for AGR design and the equipment required. These options depend on the untreated syngas flowrate, its composition, its pressure and temperature, the amount of H₂S and CO₂ removal required, and whether or not H₂S and CO₂ will be removed in two separate stages or both at the same time.
63. I have addressed the staged removal of sulphur followed by future carbon capture in my previous commentary at paragraphs 55, 56 and 57 above, and at section 30 of my Expert Witness Statement. It is not possible for me to comment further on Mr Walton's figures given the limited information available to me on the DGDP design. The discussion on costs presented by Mr Walton is particularly confusing because: "The exact costs of an integrated sulphur and carbon capture plant is commercially sensitive and Dual Gas is not willing to disclose this figure".

Section 4.2 – Operating Costs and Demonstration of IDG technology

64. I agree there will be increased operating costs to operate the sulphur recovery facilities. I also agree that these will involve parasitic load, consumables and maintenance, and since there will be extra energy consumption required, there will be increased CO₂ emissions. Should there be a carbon price applied, there would also be added carbon costs. I cannot comment on the estimated opex figures presented since I do not have design data nor do I know what facility is proposed.
65. The HRL gasifier has a high likelihood of success. I do not agree that installing sulphur removal facilities is premature. It would not be international best practice to allow a plant to operate without sulphur emission controls on the basis that it might shut down at some point in the future.

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.

C. Tsesmelis

C.M. (Costa) Tsesmelis

Date: *18/10/11.*