Comments on

The RET Review Issues Paper August 2012

Submitted by

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DUT Pty Ltd is an Australian process design company specialising in the design of ultra-high efficiency coal, gas and methanol-based power systems, capture of CO_2 from flue gases and means to produce and utilise methanol and has collaborated with the University of NSW (UNSW) in developing the DUT UNSW Carbon Capture and Solar Sequestration systems.

The University of NSW (UNSW) is a world-leader in development of advanced and high efficiency photovoltaic systems and photocatlytic materials.

Palcom Pty Ltd is a leading process simulation company, which has been working with BHP, CSIRO and others on advanced processes, including the capture and or reduction of CO2 emissions.

1.0 Introduction

1.1 The question being put to the Climate Change Authority in the Minister's August 2012 letter appears to be- *Is the simple replacement of coal-based electricity by renewable energy the best way for Australia to reach its Renewable Energy Target?.*

1.2 Australia's largest and probably most reliable renewable energy resource is solar energy and this submission outlines why the DUT-UNSW-Palcom solar-based conversion of captured CO_2 into methanol fuel may be the most appropriate strategic and cost-effective way for Australia to reduce its CO_2 emissions and also reduce its growing dependence on imported oil-based fuels.

1.3 The Renewable Energy Target (RET) Review Issues Paper and Renewable Energy (Electricity) Amendment Act 2009 appear to be based on the possibly incorrect assumption that Renewable Energy should mainly be used to directly replace coal-based electricity.

1.4 This DUT-UNSW-Palcom submission outlines a possible optimum way for Australia to radically reduce its CO_2 emissions by the low-cost and potentially profitable capture of coal-sourced CO_2 emissions and the solar-based conversion of CO_2 into methanol. Methanol is a "next generation" ultra-low emission liquid fuel and the solar-based conversion of Australia's CO_2 emissions into methanol can transform and improve the Australian economy in ways that the replacement of coal-based electricity by renewable energy-based energy is not able to.

1.5 The current focus on directly replacing coal-based power with renewable energy-based power, which is the apparent basis for Government plans to meet MRET targets, may be incorrect and the Minister's request for the Climate Change Authority to check current thinking on means to reduce CO2 emissions, as outlined in the Minister's letter, may be appropriate and timely.

1.6 Many regard CO2 as a pollutant. This is incorrect as it is the fundamental building block for all photosynthesis and production of all fossil fuels, biomass and foodstuffs and is a feedstock for production of key chemicals.

2.0 DUT-UNSW Carbon Capture and Solar Sequestration Systems

2.1 The DUT-UNSW Carbon Capture and Solar Sequestration (CCSS) and SS-based schemes use solar energy in a different and novel way to reduce CO_2 emissions by its capture and solar-based conversion into methanol.

2.2 The coal-sourced carbon in this methanol may be exported and or re-cycled and re-used in Australia as a high-value, and low-emission premium liquid fuel. This methanol also reduces the transport sector's dependence on oil-based fuels and can reduce transport-related CO_2 emissions, in addition to the benefit of the initial capture of CO_2 radically reducing coal-based power emissions.

2.3 The CO_2 emission reductions made possible by the use of methanol, which is an inherently superior fuel, compared to oil-based fuels and would be in addition to the initial elimination of CO_2 emissions from the coal-based power plants, for use as feedstock for Solar Sequestration (SS)-based methanol production.

2.4 Australia, China, India, the USA as well as other coal and solar rich countries can also use the DUT-UNSW CCSS and SS-based systems to gain major CO_2 emission reduction benefits and reduce their current oil-based fuel dependence.

2.5 CCSS and SS-based systems are based on industrial-scale solar-based hydrogen production units which are optimally located in desert-like regions, making them ideal for Australian conditions and in most desert-like regions there is sufficient rainfall, if it is captured and stored correctly, for production of the necessary hydrogen.

2.6 Solar energy is Australia's (and many other countries') most abundant source of renewable energy and DUT-UNSW CCSS and SS processes are the optimum way to use this energy to
(a) reduce current CO_2 emissions and
(b) reduce the transportation sector's reliance on oil-based fuels.

3.0 DUT-UNSW CCSS Process

3.1 CCSS is based on the Cummings-Palfreyman (C-P) Carbon Capture (CC) process preferably capturing CO_2 from existing power plants. This process can be simply added to and not require modification of existing power plants and enables CO2 to be captured from power stations, with an allied increase in the net power output from the power stations.

3.2 The captured CO_2 is then converted to methanol by reacting it with hydrogen, which has been split from water by photovoltaic means.

3.4 The CCSS process has the potential to cost-effectively solve CO_2 emission problems and the produced methanol would have a predictable cost and be able to replace oil-based fuels to reduce and possibly solve the major problems associated with crude oil's supply and price uncertainties.

3.5 The solar-based conversion of captured CO_2 into methanol gives CO_2 a commercial value and demonstrates that it is not necessarily a pollutant.

3.6 The CCSS process can enable major reductions in CO_2 emissions whilst leaving current coal-fired power plants in normal operation and it would be logical for the SS component of CCSS to be a component of Australia's Mandatory Renewable Energy Target (MRET).

3.7 For rapid commercialisation Phase-1 developments would be based on current PV cell designs with phase 2 focussed on development of systems for the direct photolysis of water.

4.0 Methanol (CH_3OH)

4.1 Methanol can be made from hydrogen and carbon dioxide by the following, commercially-proven reaction;

$$\mathbf{CO_2 + 3H_2 \rightarrow CH_3OH}$$

4.2 Methanol is a high-grade multi-functional liquid fuel and valuable chemical and its use as a high-grade and high-efficiency automotive liquid fuel could help eliminate the transportation sector's almost total dependence on oil-based fuels.

4.5 Methanol sales revenue would compensate for the CCSS system's capital and operating costs.

5.0 Replacement of Oil-based Fuels by SS-based methanol

5.1 Conversion of the captured CO_2 into methanol by reacting it with hydrogen, which has been produced by photovoltaic means, is termed Solar Sequestration (SS).

5.2 CCSS and other Solar Sequestration applications provide the means whereby the World's huge demand for oil-based liquid fuels can be met by methanol made from solar energy and captured CO_2.

5.3 Crude oil-based fuels and chemicals have been a key factor in industrial growth in the 20th Century and oil-based (not coal-based) CO_2 emissions are currently the World's dominant source of CO_2 emissions.

5.4 It will be essential for Australia to ensure that MRET rules do not penalise and impede the use of Solar Sequestration as a possible simple, novel and cost-effective means to make major reductions in Australia's CO_2 emissions.

6.0 Potential World-wide Impact of CCSS and SS-based Developments

6.1 "Fossil fuel and solar-poor" countries importing coal and SS-sourced methanol would regard SS-sourced methanol as a high-grade liquid fuel, superior to oil-based fuels and LNG. This could make SS-souced methanol a logical fuel of choice for such countries.

6.2 Countries such as Korea and Japan, if importing this methanol, could have an assured supply of predictable cost fuel to replace potentially unreliable oil-based fuels. An assured supply of methanol would also assist a growth in the manufacture of methanol-fuelled vehicles and the emergence of "next generation" ultra-high efficiency and ultra-low emission methanol-based power systems, such as the DUT SOFC-GT-D power systems.

6.3 The DUT-UNSW Solar Sequestration systems are possibly the optimum means to develop the Galilee Basin's coal and solar assets.

6.4 The production of coal and solar-based methanol from CO_2 captured from existing coal-fired power plants and directly producing coal-based methanol in coal and solar-rich regions, such as the Galilee Basin, could have assured access to high-grade liquid fuel on a scale commensurate with the large 20th Century Middle East (i.e. Iraq) oil discoveries.

6.5 Proper planning of such developments in Australia will require a degree of large-scale rigorous and coordinated planning, similar to Norway's planning of development of its North Sea oil assets and not seen in Australia since the planning of the Snowy Mountains Power and Irrigation Schemes.

6.6 DUT-UNSW systems have the potential to provide major energy, security and environmental benefits to coal and solar-rich economies such as Australia, China, India, South Africa and the USA and change current plans based on simply exporting coal from coal-rich regions and converting it to power elsewhere.

6.7 DUT-UNSW systems can radically increase the amount of end-use energy which can be provided from Australian coal by either capturing CO_2 from existing coal-based industries or capturing CO_2 from coal-based methanol production and converting it into high-value methanol fuel.

6.8 Large and economically viable DUT-UNSW CCSS-based methanol production plants would significantly reduce Australia's CO_2 emissions. Similar plants in China, India, the USA elsewhere could significantly reduce the World's CO_2 emissions and the co-produced methanol would reduce the World's current dependence on crude oil-based fuels and eliminate major problems caused by this dependence.

6.9 In Australia these CO_2 emission reduction and methanol production facilities would be part of a completely new, manufacturing industry, This new liquid fuel manufacturing industry would be Australia's largest manufacturing industry with an associated large number of permanent employment positions, which would be sited in inland locations.

6.10 CCSS and SS-based resource processing developments would help Australia compensate for the recent loss of labour intensive manufacturing jobs, which were created in the 20th Century.

6.11 When the advantages of converting coal and solar energy into methanol are understood, it is probable that energy importing countries will start to have a preference for importing this form of methanol.

6.12 SS methanol produced by the conversion of Queensland, NSW and Victorian power plants into ultra-low emission plants, if used in current diesel and gasoline engines, would be equivalent to producing and displacing about 2 million bbl/day of oil-based refined gasoline and diesel fuel. This would change Australia from being a net importer of liquid automotive fuels, into a major exporter of such fuels.

6.15 If this methanol was used in next generation fuel cell-based power plant systems it would be equivalent to displacing about twice this amount of gasoline and diesel fuel.

6.16 Coal's key role in industrial development is not finished, but the simple 20th Century means of utilising and generating power from coal, should be.

7.0 Development of New Coal Regions

7.1 The availability of the above systems can radically change how to best develop coal resources in high solar flux regions, such as the Galilee Basin.

7.2 Present plans for Galilee Basin coal are based on its coal being railed to Abbott Point for shipment through the Great Barrier Reef to deep water ports in China and India for ultimate use in conventional coal-fired power plants.

7.3 DUT-UNSW Solar Sequestration and advanced fuel cell-based systems would enable full processing of Galilee Basin coal and the supply of about 2.5 times more end-use power from Galilee Basin coal than is possible by its conversion to power by currently proposed means.

7.4 This major coal-to-end use energy advantage would be in addition to eliminating the need to rail unprocessed coal to Abbott Point and having to ship it through the Great Barrier Reef.

7.5 This alternative development option for Galilee Basin coal would also put long-life coal and ultra-long life solar-based industrial manufacturing plants and associated permanent employment in Queensland's Gulf regions and provide a basis for further new and major industries based on processing nearby bauxite and copper mineral deposits.

8.0 New Coal-based Power Developments

8.1 Australia and some other countries have large coal deposits and massive solar energy potentials. The DUT-UNSW coal + solar energy-to-methanol-to-power system enables optimum use of such coal and solar assets.

8.2 Up until now the generally accepted means for Australian coal to supply power in overseas countries has been to export coal and have it converted into power in that country.

8.3 In this alternative 21st Century coal utilisation system, all the carbon in the coal is converted into methanol with the resultant methanol having a higher energy content than the original coal and also being in the form of a high value, easily transported, stored and utilised liquid fuel.

8.4 Advanced UNSW low-cost photovoltaic systems and DUT-UNSW SS and SOFC-GT-D systems can-
(a) Convert the coal to methanol and
(b) Solar Sequester the released CO_2 to produce additional methanol
(c) Convert the methanol at where the end-use power is required and, with the possible use of ultra-high conversion efficiency DUT SOFC-GT-D (Solid Oxide Fuel Cell-Gas Turbine-Dissociator) systems, convert coal and SS-sourced methanol into ultra-low emission power for base-load, peak-power or transportation power needs**.**

8.5 With DUT-UNSW solar-assisted coal-to-methanol-to-power systems about 2.4 times more end use power can be supplied from a given amount of coal, than can be supplied by current means.

9.0 Conversion of Methanol to Power via the DUT SOFC-GT-D System

9.1 An optimum way to convert methanol to power is via the ultra-high conversion efficiency DUT SOFC-GT-D (Solid Oxide Fuel Cell-Gas Turbine-Dissociator) system which-

- Converts methanol to power at up to 90% efficiency.
- Can be very compact
- Has an emission rating of <0.3 T CO_2/MWh

- Has no associated noxious emissions
- Does not require cooling water

9.2 Methanol-fuelled SOFC-GT-D systems will be able to supply ultra-low emission base-load power, peak-load power or transportation power needs. These systems will be superior to and able to displace gasoline and diesel engines, enabling coal and solar-based energy, in the form of methanol, to displace oil-based energy.

9.3 With modern, conventional coal-fired power systems each 100 GJ of coal can enable the supply of up to about 50 GJ of end-use power with the distributed power having a CO_2 emission rating of about 0.7 T of CO_2/MWh, in addition to noxious emissions, such as SOX, NOX and particulates

9.4 If the same 100 GJ of coal, with solar enhancement, is converted to methanol and the methanol used as feedstock for a “next generation Solid Oxide Fuel Cell-Gas Turbine-Dissociator (SOFC-GT-D) based power generation systems, about 120 GJ of ultra-low emission (<0.3 T CO2/MWh) end-use power can be delivered.

9.5 Further major advantages of the SOFC-GT-D systems are that, in addition to having a very high potential (>90%) efficiencies, they do not require large cooling systems and any surplus heat is lost in relatively cool exhaust gases. SOFC-GT-D systems will be able to power stationary and mobile (locomotive, earth moving, bus, truck, commercial vehicle and automobile) power plants.

9.6 At present, Australia (Ceramic Fuel Cells Ltd) has a lead position in Solid Oxide Fuel Cell development and commercialisation.

10.0 DUT-UNSW CCSS and SS Process Detail

10.1 The information in this document will, with its release, be in “The Public Domain”.

10.2 This information is based on detailed process assessments and, where necessary, recognised computer-based modelling of the proposed systems. Some key aspects of process designs have been cross-checked, under suitable non-disclosure agreement conditions where necessary, with leading, international power station and process plant designer/contracting groups and during development of the processes referred to in this document, contact and discussions with major power generation plant constructors has been a feature of the development of DUT-UNSW CCSS and SS systems.

10.3 Patent coverage has been and will be applied for, for key aspects of DUT-UNSW systems and access to this and other key, confidential data would require special and specific clearance.

Past DRC/DUT Management/Senior Designer experience relating to CCSS Concept

CO2 Separation and Purification

- 1968 20 TPD CIG (BOC)-operated food-grade CO_2 Plant (NSW)
- 1969 Kwinana Nickel Refinery CO_2 plant (WA)
- 1970 Mount Morgan CO_2 / Cl_2 Separation Plant (Qld)
- 1989 DUT/BHP design of Mega tonnage CO_2 separation plant (NSW)
- 1992 DUT/SECV design of coal to syngas plant with mega tonnage CO_2 separation
- 1992 DUT/CCE/BOC study of Liddell-located Coal-to-Methanol facility
- 2005 Design of prototype large-scale CO_2 post capture plant for the CRC-SD
- 2007 Development of C-P CO_2 Post-capture system (NSW)

Methanol Production

- 1972 Design of World-scale Methanol and Hydrogen Facilities (NW Shelf)
- 1973 Initial design of World-scale Methanol and Hydrogen Facilities (Saudi Arabia)
- 1989 DUT/BHP study of oxygen-blown blast furnace plus methanol production
- 1987 Victorian Brown Coal Council/DUT/Fluor study of brown coal-fired reformer
- 1992 SECV/DUT Study IDG brown coal to methanol process (Vic)
- 1992 DUT/CCE/BOC study of reacting solar hydrogen with CO_2 to produce methanol
- 2006 75% efficient/zero CO_2 emission methane to methanol process (NSW)
- 2008 Initial design of DUT-UNSW Captured CO_2 and SWS-based methanol plant

DRC/DUT Management/Senior Designer experience relating to CCSS Concept

Coal to Power Systems

- 1978 Designs for IEA 90 MW PFB system (Grimesthorp UK)
- 1983 Design of combined PF and waste coal FBC fired power station boilers
- 1991 Design and co-invention of brown coal IDGCC system (Vic)
- 1995 Development and patenting of AIDG brown or black coal process (NSW)

Methanol Utilisation

- 1974 2 Tonne truck methanol fuelling demonstration Burmah Castrol (UK)
- 1974 Truck Diesel methanol fuelling tests Ricardo Engineering (UK)
- 1976 Dissociated methanol-fired gas turbine systems (UK)
- 1980 GM EMD Locomotive diesel test engine methanol fuelling tests (USA)
- 1990 90% efficient methanol dissociator/SOFC/GT system design (UK & NSW)

Hydrogen Production and Purification

- 1958 Design of commercial cryogenic deuterium separation plant (UK).
- 1968 Kwinana Nickel Refinery Hydrogen Plant (WA)
- 1969 CIG-operated Nitrogen-Hydrogen facility for BHP annealing plant (Vic)
- 1973 Initial Design for Al Jubail hydrogen intensive refinery (Saudi Arabia)
- 2008 Collaboration in development of UNSW Solar Water Splitting technology