Development of a Coal to Liquid Transport Fuels Strategy to ensure Sovereign Australian Defence Force Fuel Security

Energy for the Warfighter

“Operational energy equates exactly to operational capability.”


Recommendation:

That given the potential disastrous impact on Australia’s sovereign defence operational capability with disruption of sea oil supply chains the 2015 Defence White Paper should address development of a Coal to Liquid Fuels Strategy to ensure Sovereign Australian Defence Force (ADF) Liquid Transport Fuels Security for Australia’s Defence.

Bede Boyle 27 October 2014

Manufacturship Pty Ltd
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Overview of Submission

This submission will demonstrate that Australia is blessed with abundant coal resources and that a strategic commitment to produce high quality coal-based liquid transport fuels could ensure Sovereign Liquid Fuels Security for Australia’s Defence.

Independent Defence Analysts have highlighted that disruption to oil supply chains will expose ADF to risk of adequate liquid transport fuels to sustain Land, Sea and Air operations beyond several weeks. The Kokoda Foundation recommends that the 2015 Defence White Paper address this strategic imperative. [1]

Michael A. Aimone, the US Air Force assistant deputy chief of staff for logistics, recently commented ‘Our goal is by 2025 to have 70 percent of our aviation fuel coming from coal-based sources’. This is an aggressive but clearly very achievable planning goal. [2]

Departmental advice to Members of Parliament by Dr Julie Styles in December 2008 noted that: Australia is a net importer of crude oil and refined oil products, with domestic production of crude oil and liquefied petroleum gas (LPG) meeting only about 53 per cent of domestic consumption. These factors, together with a desire for increased domestic energy security, and protection from economic instabilities affecting global oil prices and supply, lead to the question of whether Australia should consider developing a coal-derived transport fuel industry to meet domestic demands. [3]

Crude oil benchmarks spiked to ~USD 140/bbl. in 2008 and oil prices are projected by CBA to remain above USD100/bbl. for several years. [4]

Recommendation:

*That given the potential disastrous impact on Australia’s sovereign defence operational capability with disruption of sea oil supply chains the 2015 Defence White Paper should address development of a Coal to Liquid Fuels Strategy to ensure Sovereign ADF Liquid Transport Fuels Security for Australia’s Defence.*

Disclaimer:

The author does not have any pecuniary interest in the Australian Coal Industry nor to any of the Advanced Clean Coal Technology Pathways to Liquid Fuels referenced in this submission.
This submission addresses three Advanced Clean Coal Technology Pathways to Liquid Fuels:

1 **Coal Water Fuels (CWF) as a Strategic Replacement for Heavy Fuel Oil**  
   [Section 3]
   Triggered by the energy crisis of 1973 and 1979 oil importing nations including USA and Japan became aware of their national vulnerability to oil embargoes and escalating prices and initiated research to lessen their dependence on oil. One area of research was CWF as a direct replacement for heavy fuel oil. The strategic intent was to develop a coal-based liquid fuel based on large coal reserves that were disconnected from unstable political environments.

2 **Direct Injection Carbon Engines (DICE)**  
   [Section 4]
   DICE combines the superior thermal efficiency, flexibility and lower capital cost of the diesel engine, with the low cost of coal, and promises an innovative step generation technology and new opportunities for coal in a greenhouse constrained world.

3 **The Fischer-Tropsch Process for Coal-based Synthetic Fuels**  
   [Section 6]
   The Fischer-Tropsch process, with coal as a feedstock is a mature process, which was developed in the 1920s and used by Germany during the Second World War, and has been utilized in South Africa for decades with SASOL producing 195,000 bpd.

According to the International Energy Agency (IEA), Coal to Liquid Fuels (CTL) conversion is viable at oil prices above around US$40/barrel. Studies in the US suggest liquid fuel production from coal in combination with electricity production would be competitive with fuel from oil at oil prices between US$27 and US$45 per barrel, including the costs of incorporating CCS. [3]

Coal-based synthetic transport fuels are cleaner burning than diesel and petrol, with no sulphur emissions, and lower nitrous oxide (NOₓ), particulate matter (PM), hydrocarbon (HC), and carbon monoxide (CO) emissions. [3]

One of the benefits of CTL is that the CO₂ emissions are more readily and cheaply captured from CTL plants than from conventional coal-fired power stations. The captured CO₂ can be transported and injected into underground storage reservoirs (a procedure known as ‘carbon capture and storage’—CCS). [3]

However, it may not be in the best interests of Australia’s Sovereign Fuel Security to constrain the initial development of a CTL Project by bearing the upfront cost of CCS. A CTL Project could be established carbon capture and storage ready with CCS initiated on an agreed timeline.
1 The Strategic Energy Security Issues for Australian Defence

The Kokoda Foundation in a February 2014 report addressed Pressing Issues for the 2015 Defence White Paper (DWP15). “There needs to be an understanding that Australia’s supply chain is long and complex, and reserves are limited. It has been described as ‘fragile’ beyond belief. This raises questions not only about the resilience of not only the ADF and its capacity to sustain operations, but also of the Australian economy and, indeed society in general. This is evident in the lack of depth in areas such as fuel, where local supplies are sufficient to sustain the economy for a few weeks if not replenished. As some suggest, ‘our society is a month deep’. DWP15 would do well to address these aspects.” [1]

The April 2012 Air Power Australia Technical Report by Dr Carlo Copp on The US Air Force Synthetic Fuels Program clearly states the strategic issues for Australia: “The strategic issues for Australia are arguably the very same as they are for the US - security of imported fuel supplies and cost per barrel. Most of the aviation turbine fuel burned in Australia is sourced from domestic refineries, made from imported crude feedstock, while the remainder is imported, mostly from Singapore. Any major disruption to the global supply chain could severely impact Australia’s economy, and the ADF’s capacity to conduct high tempo military operations. With potential ADF fuel burns of thousands of tonnes per day, diesel and aviation kerosene supply is a potential hard bound on ADF capabilities, regardless of the issue of having a proper resupply infrastructure. The latter is an equally neglected issue in Canberra.

In terms of reserves of coal and gas per capita, Australia is actually in a much stronger position than the US is, especially in natural gas where Australia’s recent global ranking of fifteenth is set to with another round of North West Shelf gas discoveries.

Not surprisingly, the synthetic fuels industry in Australia is virtually non-existent. The only effort of significance at this time is Linc Energy’s joint program in Queensland, conducted with US synthetic fuels technology house Syntroleum, to trial synthetic crude manufacture from feedstock gas produced using Linc’s underground coal to gas conversion process. This malaise is despite Australia’s good track record in research, including the successful trials at Monash University many years ago.

Given that energy supply is an issue in the current public debate, it is astonishing that synthetic fuels remain in a policy vacuum, both in the civil and defence sectors. It is not in the national interest for this policy vacuum to persist. This nation has much to gain economically and strategically from self-sufficiency in critical liquid fuels.” [2]
2 What does the Iraq conflict mean for Energy Security and Price of Oil?

“A disruption of Iraq supply would represent a global energy crisis”

John Kilduff, NY, Bloomberg


- In June 2014, a sectarian conflict erupted in Northern Iraq as the Islamic State of Iraq and al-Sham (ISIS), representing the Sunni minority, made a push into Iraq from Syria. Before the conflict began, Iraq produced ~3.3mb/d of crude oil or 3.6% of world crude oil supply. The US Energy Information Agency estimates that one quarter of Iraq’s crude oil output is located in the north of the country where ISIS has penetrated. If we assume this capacity is sidelined, world crude supply would be ~0.8mb/d lower than otherwise.

- World crude oil markets were in a surplus of 1.1mb/d in May (Figure 1). If the conflict reduces, Iraq’s crude oil output by a quarter or ~0.8mb/d, crude oil markets, with all other variables constant, would be in a much smaller surplus of 0.3mb/d. This possibility has supported higher benchmark crude prices, particularly Brent.

But if the violence spreads to the south of Iraq, and threatens all of Iraq’s crude production, crude oil prices would likely spike significantly higher as the market adjusts to a deficit of 2.2mb/d. Crude oil benchmarks spiked to ~USD 140/bbl in 2008 when world markets averaged a ~1.3mb/d deficit for nearly two years. [4]

The Australian Financial Review 21-22 June 2014, reported that Iraq’s main Baiji oil refinery north of Bagdad has been shut down because of rebel activity, and further north the pipeline connecting the Turkish Mediterranean part of Ceyhan has not operated since March 2014 for the same reasons. Iraq accounts for 10% of OPEC which supplies 40% of the world’s requirements.
3 Coal Water Fuels (CWF) as a Strategic Replacement for Heavy Fuel Oil

Triggered by the energy crisis of 1973 and 1979 oil importing nations including USA and Japan became aware of their national vulnerability to oil embargoes and escalating prices and initiated research to lessen their dependence on oil.

One area of research was CWF as a direct replacement for heavy fuel oil. The strategic intent was to develop a coal-based liquid fuel based on large coal reserves that were disconnected from unstable political environments.

CWF is a thick, low-viscosity, highly stable liquid with a heating value of 4,800kcal/kg consisting of:
- 70 – 75% pulverised coal
- 24 – 29% water, and
- 1% chemical additives to improve flow and stability
CWF replaces No 6 heavy fuel grade oil, and similar to heavy oil CWF can be stored in tanks, transported on land and sea by long distance pipelines and tankers, atomised and burned in boilers for thermal electricity generation and heating.

US Army - With about 50% of their petroleum consumed in fixed boiler plants at its base facilities the US Army Construction Engineering and Research Laboratories (ASA – CERL) at the direction of US Congress researched CWF as an alternative to heavy fuel oil. [5]

Japan – UBE Industries and Nissho Iwai (now Sojitz) developed a CWF test and demonstration Plant in the late 1980s which supplied CWF to an industrial boiler for testing and subsequently to 500MW and 1000MW Power Plants. [6]

Japan – Australia UBE Industries and Nissho Iwai were shareholders in Coal & Allied Industries Limited who with large coal reserves supplied coal to Japan with UBE as a large customer. Coal & Allied and UBE joint Feasibility Study in early 1990s was to establish a CWF Plant at the Port of Newcastle. The strategic intent was to estimate the project CAPEX and OPEX to determine the financial viability of exporting CWF to Japanese Power Utilities and Industrial Complexes compared to imported oil. [6]

China – China produces an estimated 100Mtpa of CWF for industrial boilers and for coal gasification. China also conducted research to replace oil in Diesel Locomotives.
CWF Technical Viability is proven as a replacement for heavy fuel oil in:

- Fixed boilers for energy and heating,
- Thermal Electric Power Stations,
- Blast furnace injection (BHP research),
- Direct Injection Coal Engines, [Section 4] and
- most importantly, CWF is a proven Feedstock for Coal Gasification which is a Clean Coal Technology pathway to produce Hydrogen, Electricity, Chemicals and Liquid Transport Fuels [Sections 5 & 6]

4 Direct Injection Carbon Engines (DICE)

DICE – The Best Option for Coal? …*combining the superior thermal efficiency, flexibility and lower capital cost of the diesel engine, with the low cost of coal, promises an innovative step generation technology and new opportunities for coal in a greenhouse constrained world.*” Dr Louis Wibberley, CSIRO 18 May 2014 [7]

DICE require cost-effective production of micronized ultra-low ash water based slurry fuel called Micronized Refined Carbons (MRC). The earlier US Department of Energy (USDOE) work concluded that coal with 2–3% ash was suitable for DICE.

It is generally accepted that lower speed diesel engines are most suitable: the low-speed two-stroke marine-type engines (10–100 MW at 90–120 rpm) and largest four-stroke medium-speed engines (20 MW at 400-500 rpm). This is due to their low maintenance, longevity and tolerance to current lower quality fuels. The choice of engine will be site and application dependent: the low-speed engine has slightly higher efficiency and lower maintenance costs but the cost is $1.8 M/MW compared to $1.2 M/MW for medium-speed engines.

Research & Development

1978-92 The USDOE carried out a large development program focussed on the use of coal water mixtures. The program was very successful, and defined economic and technical conditions under which direct injection carbon engines could be commercialised. The program was terminated when crude oil costs plummeted.

2007-present CSIRO reassessed the use of coal in diesel engines with new drivers and technology, leading to test programs with UCC Energy, Exergen, Newcrest, BCIA and then Xstrata
CSIRO and its industry partners plan to conduct a A$1 million trial of the DICE with the aim of reducing emissions from brown coal-generated electricity by 50 per cent compared to current technology.

Using Ignite Resources' high calorific value coal in advanced power technologies such as the DICE generator, can result in a substantial improvement in energy efficiency and a reduction carbon dioxide (CO₂) emissions. A DICE generator, is estimated to reduce CO₂-equivalent emissions by 43.5% in comparison to the average for grid power in Victoria, Australia.
5 The US DoD Coal-based Synthetic Fuels Program

The U.S. Department of Defense requested the Western governors to consider the development of local synthetic fuel refineries: “The Department of Defense (DoD) is working to produce synthetic fuels from coal, biomass, and oil shale. Given the West's vast reserves of these natural resources, DoD would like to open a dialogue with Western governors on the opportunities to the West that such an effort presents.” [8]

Background to US DoD Coal-based Synthetic Fuels Program

The ever increasing reliance on foreign supplies of energy, in particular crude oil and finished transportation fuels (such as military jet fuel), imported from some of the most unstable regions of the world is a growing concern for the DoD. In addition, the increasing use of the finite quantities of crude oil by rapidly developing nations, such as China, India, and other Asian nations, puts strain on the supply-demand balance and has contributed to the rapidly increasing cost of fuels for the military. Significant risky investment is going to be required to meet the world’s energy requirements with the bulk of this investment currently slated for these unstable regions. Regional instability and competition for energy by developing nations could significantly influence the ability of the military to respond to worldwide situations.

The U.S. military currently utilizes approximately 300,000 barrels per day of transportation fuels with 75% produced in domestic refineries. The vast majority of these refineries are clustered in mega refining centers along the coasts with a significant presence in the Gulf Coast region. Although the current system of supply, refining, and finished product distribution is very efficient and cost effective in meeting the military and commercial sector needs, inherent risks and vulnerabilities are present. One such case was demonstrated by the disruptions caused by hurricane Ivan which hit the Gulf Coast in 2004. In addition, the past two decades have shown a significant decrease in the number of US refineries with the mega refineries being expanded to make up for lost US capacity. As a result the overall fuel supply diversity has diminished and supply-demand imbalance situations can occur when unplanned shutdowns happen.

The DoD has been working towards a more universal (single battlefield) fuel that can be utilized in current and legacy system as well as enable the next generations of hybrid propulsion, fuel cells, and hypersonic vehicles. The U.S. Congress has supported one such program for Ultra-Clean fuel via funding the research and production of Fischer-Tropsch (also known as Gas-to-Liquids) jet fuels. Clean jet fuels produced under the Department of Energy’s Clean Fuels Program in conjunction with Syntroleum Corporation (Tulsa, OK) have been evaluated by the U.S. Air Force, Army, and Navy and show promise in meeting the requirements of the military while reducing overall tailpipe emissions.
The United States has approximately 25% of the world’s coal reserves and approximately 1 trillion barrels of unconventional oil in oil shale. In particular, the western United States contains vast resources of coal and oil shale that could be used to provide secure supplies of fuel to the military, local first providers (fire departments, police, ambulances etc), and the commercial sector. Secure, diverse fuel supplies would provide security and could provide a steady supply of fuel during a crisis situation. Clean jet fuels can be produced via the Fischer Tropsch process from domestic coal, petroleum coke, natural gas and biomass. Secure domestic shale oil can also be refined into clean transportation fuels.

The DoD is working jointly with the Department of Energy (DOE) to develop a national initiative to develop, test, certify, and use jet fuels produced from these alternative energy resources. As the western states hold large supplies of domestic resources, we are interested in coordinating at the state level to help catalyse the development of these resources, which could provide for supply security and diversity, facilitate job and economic growth, and provide more environmentally friendly transportation fuels.

U.S. Department of Defense - Clean Fuels Initiative “intends to catalyse the commercial industry to produce clean fuels for the military from secure domestic resources using environmentally sensitive processes that create jobs and wealth in the United States.” [8]

Declaration of Policy – Congress declares that it is the policy of the United States that:
(1) United States oil shale, tar sands, and other unconventional fuels are strategically important domestic resources that should be developed to reduce the growing dependence of the United States on politically and economically unstable sources of foreign oil imports

(2) The development of oil shale, tar sands, and other strategic unconventional fuels, for research and commercial development, should be conducted in an environmentally sound manner, using practices that minimize impacts: and

(3) Development of those strategic unconventional fuels should occur, with an emphasis on sustainability, to benefit the United States while taking into account affected States and communities
The April 2012 Air Power Australia Technical Report by Dr Carlo Copp on *The US Air Force Synthetic Fuels Program* states that: Late in 2007 the US Air Force released the final test report covering flight trials of a synthetic aviation kerosene, flown over a year using a service B-52H bomber. This is first step in a carefully planned long term effort which is intended to wean the US military machine off imported petroleum products, the aim being eventual replacement of crude oil based fuels with products made from natural gas and coal, where possible sourced within the US.

There are two central imperatives for this change in US strategic policy. The first imperative is simply cost, since at this time synthetic crude oil based fuels cost around half of natural crude oil based fuels, per barrel. Given the enormous fuel burn of the US military machine, of which the US Air Force consumes the lion's share, there is a huge fiscal incentive to abandon legacy crude oil based products.

The second imperative is no less important. Its aim is to reduce dependency on foreign imports in a volatile global market. Many major crude oil producers, such as Iran and Venezuela, are intensely hostile to the US. Other producers will play political games to extract favours and concessions over access and pricing of crude oil.

The stark reality is that access and pricing of crude oil can be used as a political and strategic weapon, something the US has become acutely sensitive to in recent times. Since the 1973 oil embargo over the Yom Kippur war, major oil producers have well understood the strategic dependency of the US and EU, and the political power this provides them with.

The U.S. military currently utilizes approximately 300,000 barrels per day of transportation fuels with 75% produced in domestic refineries. The US Air Force alone utilises around 3 billion gallons of aviation kerosene annually, which is more than half the consumption of the whole US military.

Michael A. Aimone, the US Air Force assistant deputy chief of staff for logistics, recently commented *‘Our goal is by 2025 to have 70 percent of our aviation fuel coming from coal-based sources’*. This is an aggressive but clearly very achievable planning goal. [2].
6 The Fischer-Tropsch Process for Coal-based Synthetic Fuels

The Fischer-Tropsch process, with coal as a feedstock, is a mature process, which was developed in the 1920s and used by Germany during the Second World War, and has been utilized in South Africa for decades with SASOL producing 195,000 bpd.

During Second World War, because of limited access to natural crude oil, Germany built synthetic fuel plants to power its war efforts, based on coal which was its most readily available carbon-based fuel source.

The Fischer-Tropsch Technology Roadmap from Coal to Transportation Fuels

The Fischer-Tropsch process converts the feed gas into liquid organic compounds, carbon dioxide, and water. The conversion takes place in the presence of a catalyst, usually iron or cobalt. The temperature, pressure, and catalyst determine whether a light or heavy syncrude is produced. For example, at 330°C mostly gasoline and olefins are produced whereas at 180 to 250°C mostly diesel and waxes are produced. Since there is often a surplus of hydrogen from the syngas process, the economics of the process are assisted if this can be used in a petroleum refinery or for the manufacture of ammonia in an adjoining plant.

The coal to liquid conversion using the Fischer-Tropsch process has quite high capital, operating, and maintenance costs, but recent refinements that tailor the products and reduce costs have made it commercially competitive in very large plants which enjoy significant economies of scale. However, free capital markets...
have been reluctant to invest the enormous multi-billion dollar costs for these plants faced with volatile crude oil prices and uncertainty about future CO₂ emissions costs. The main disadvantage of coal to liquids processes are the high capital and operating costs which have kept the technology economically uncompetitive. Those situations where it has been implemented have been driven by strategic considerations (Germany, South Africa), centrally controlled economies or with government underwriting or subsidy.

Variants of the technology have been developed by a number of companies and the process may be adjusted to produce the most desired products: petrol, diesel, aviation fuels or waxes. Amongst the major companies that market Fischer-Tropsch processes are Exxon Mobile Sasol-Chevron, Shell and Statoil.

In Australia there have been a number of proposals for coal syngas to liquids proposals cancelled, including the Monash Energy Project based on Victorian lignite, proposed by Anglo American Plc and Royal Dutch Shell Plc. The cancellation of the project in December 2008 cited rising costs. “Monash Energy and its owners Shell and Anglo American believe that, in the long term, coal-to-liquids may provide an opportunity for Victoria to provide domestically produced clean liquid fuels for Australia and international markets. However, at this stage, critical requirements for the project are not yet in place.”

Many studies (eg The “Future of Coal” study by Massachusetts Institute of Technology) suggest that the technology should be competitive when the oil price is above about US$50/bbl. While this may seem attractive, the extreme volatility of oil prices have made investors very wary, since multi-billion dollar investments in capital plant may be stranded for extended periods if the oil price dips. [9]

Brown Coal Innovation Australia has ongoing research programs including coal gasification. [10]
7 Ignite Resources’ Lignite to Syncrude Technology

Ignite Resources (‘IR’) has the rights within Victoria to a unique technology, the Cat-HTR process, which can convert low-cost lignite into synthetic crude oil (‘Syncrude’). IR also has a 16.4 billion tonne (‘Bt’) lignite resource within the Latrobe Valley of Victoria, one of the world’s premier lignite-producing regions. IR is part of Ignite Energy Resources Limited (‘IER’), an Australian unlisted public natural resource and energy technology development company. www.igniteer.com [11]

IR has a unique combination of tier-1 lignite resources and an advanced-stage lignite to syncrude technology. It is possible to upgrade IR’s Syncrude into finished ‘drop-in’ fuels by utilising existing, conventional refineries.

Economic modelling by the University of Sydney Engineering Department, based on the results of test runs at IER’s Large Pilot Plant (LPP), indicates that at a commercial scale the Cat-HTR technology can upgrade lignite into Syncrude, at costs that are competitive with existing conventional crude oil producers (see yellow area in chart below). If proven at a commercial scale, therefore, the Cat-HTR process has the potential to significantly uplift the value of IR’s and Victoria’s vast lignite resources.

![Oil production costs for various resource categories](source: International Energy Agency, World Energy Outlook 2013)

**Clear pathway to commercialisation**

In just over five years the Cat-HTR technology has been brought from lab scale, to Small Pilot Plant (‘SPP’) scale and Large Pilot Plant (‘LPP’); the LPP was officially opened in December 2011. The next step is the completion of a comprehensive feasibility study for a commercial plant and the construction of a commercial-scale Cat-HTR reactor. To co-fund this process, IR has been short listed under the A$90m Advanced Lignite Demonstration Program (‘ALDP’), a federal Australian and Victorian government initiative.
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Manufacturship
27 October 2014
Innovation with Strategic Intent

Professional Engineering, Research and Development Experience Relevant to Submission

Bede is a mechanical design and product development engineer (BEng UNSW) with extensive innovative engineering design and applied research and development experience.

- Manager Technical Services Coal and Allied Pty Ltd
  Led a joint Japanese – Australia Feasibility Study with UBE Industries and Coal & Allied to establish a Coal Water Fuel Plant at the Port of Newcastle.
- Coal & Allied’s representative on Australian Coal Association Research Committee Research into suitability of Australian coals for Coal Water Fuel and Coal Gasification
- Private development of patented dense phase Coal Water Fuel technology acquired by ASEA.

Manufacturship was founded by Jason Furness who has extensive engineering and executive experience with General Motors and Electrolux in new product design, rapid prototyping and manufacture to business critical cost and timelines.

Manufacturship is a member of HunterNet engineering cooperative and Hunter Defence Forum.

Bede is the leader of the Hunter Defence Land Systems – LAND 400 Task Force whose strategic intent is to leverage regional integrated engineering capability to provide Australian Content to support International Primes for Army Land System Programs and specifically LAND 400.