FUTURE DEVELOPMENT OF QUEENSLAND'S CARPENTARIA MINERALS PROVINCE

March 2010

Developing a Resources Corridor – Clean Energy and Minerals

BIS Shrapnel
BUSINESS RESEARCH AND FORECASTING

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EXECUTIVE SUMMARY

An independent review[1], by Rod Sims of Port Jackson Partners Limited, of the supply options for securing power to North West Queensland found that there were a number of credible solutions, but too much uncertainty to accurately determine which would provide the lowest cost outcome for users. The review recommended that the decision over which option should be selected be handed over to the major energy users, a recommendation which the Queensland Government has upheld.

Three options have been put forward for consideration:

- Upgrading the existing baseload gas power station at Mica Creek
- Installing an AC transmission link from Mt Isa to Townsville
- Installing a high voltage DC (HVDC) transmission link from Cloncurry to Stanwell

Modelling undertaken for the Rod Sim's review suggested that the expansion of Mica Creek power station would provide the lowest cost option for energy users in the North West but only at the lower end of a projected range of gas prices and projected levels of future energy demand.

However, uncertainty surrounding the outlook for both demand and future gas prices meant that sufficient confidence could not be placed on a long run contractual arrangement for gas supply being achieved within this lower range of prices and based on the lower level of demand. However, with either a sustained increase in gas price or a growth in energy demand, a transmission solution starts to become the most cost effective energy solution.

A transmission line option would connect the North West to the National Electricity Market (NEM), guaranteeing access to competitively priced energy and mitigating the impact of fluctuations in the price of a single energy source on electricity prices.

The major advantage of using AC technology is the flexibility with which loads and generation along the route can be connected. HVDC technology is mostly used for large point-to-point transmissions and it is costly to build tapping stations.

Connecting the North West to the grid at North Queensland via an AC transmission line would open up significant economic opportunities for North and North West Queensland, which would not be available through either the option of a transmission line to Central Queensland or an upgrade to Mica Creek power station, the former including:

- Renewable energy generation projects under investigation between Mount Isa and Townsville along the so called 'clean energy corridor' could be connected to the electricity grid. This corridor would deliver:
    - An average of around 1,200 full-time equivalent jobs would be created directly as a result of the construction and installation of these projects in the five years to 2014/15 and, similarly, over the five year period to 2019/20.
    - 767 full-time equivalent jobs would be created, directly and indirectly, as a result of the operation of these projects by 2015/16, rising to 1,798 full-time equivalent jobs by 2019/20.
    - The sum of the direct and indirect contribution to the output of the North Queensland economy from the generation of electricity in the clean energy corridor is estimated at $191m (2009/10 prices) by 2015/16, rising to $448m (2009/10 prices) by 2019/20.

- The renewable energy projects would provide economic opportunities for the towns along the clean energy corridor.
- Small mines would be able to access electricity at a lower cost than through their own diesel or gas fired generation which would encourage more investment in the NWMP (North West Minerals Province).
- The co-location of sites suitable for large scale solar, wind and geothermal generation with a grid connection avoids the problem of remoteness associated with many potential renewables sites in inland Australia.
- Once enabled through a transmission line, this 'clean energy corridor' would provide a significant contribution to the Commonwealth Government's renewable energy target and the State Government's emissions reduction target.
- A transmission line to North Queensland would traverse the Northern Galilee Basin, dramatically improving the economics of establishing a baseload power station around Pentland.

Renewable Energy Potential between Mount Isa and Townsville

Three renewable energy projects positioned along the route of the proposed AC transmission line were presented at the North Queensland renewable energy roundtable forum in November 2009:

- Windlab Systems Pty Ltd's proposal for a 600 MW wind farm at Hughenden
- Australian PhytoFuel Company Pty Ltd's proposal for producing biodiesel feedstock and using the waste biomass to generate power around Hughenden/Julia Creek
- Samsung's presentation of a solar/biomass project at Pentland

All three projects require the AC transmission line solution from Mount Isa to Townsville to access the electricity grid. The location of these projects is too far from either the proposed HVDC line to central Queensland or the existing grid in North Queensland to make connection at these points economically feasible.

By 2015/16, there is the potential for up to 900 MW of installed renewable capacity to be connected to the grid through the AC transmission line. 300 MW of this installed capacity would be baseload power – biomass and solar thermal, with a further 600 MW from wind power.

Adjusting for the lower capacity factors for solar and wind power, potential renewable generation of around 400 MW would be available by 2015/16 - equivalent to the projected demand of the North West Minerals Province.

There is a chicken and egg problem for the clean energy corridor. The renewable energy projects along the clean energy corridor cannot proceed without a transmission line. However, the cost competitiveness of a transmission line to Townsville depends on there being sufficient generation in North Queensland to offset the additional load in the North West.

There is a risk that the major users will dismiss the option of transmission line traversing the clean energy corridor on account of it not being the initial lowest cost option. However, by the end of the decade North Queensland could be a net exporter of renewable energy to Central Queensland.

There is currently a major opportunity for North West Queensland's major energy users not only to secure reliable, competitive energy for future use, but also to foster development in both the

North West Minerals Province and along the proposed ‘clean energy corridor’. For the clean energy corridor to proceed, the proposed renewable energy sites will have to be connected to the electricity grid. Only the AC transmission link to North Queensland would be able to connect the majority of the renewables sites currently under investigation and have the additional benefits of providing development opportunities for the towns along the corridor and enabling smaller mining operations to access affordable grid electricity.

INTRODUCTION AND OBJECTIVES

MITEZ has commissioned BIS Shrapnel to investigate the economic benefits of a proposed AC transmission line from the North West Minerals Province to Townsville. The exercise includes three parts:

a. Estimating the level and timing of renewable energy prospects along the route as a result of proceeding with an AC transmission link.

b. Quantifying the direct and indirect economic and financial benefits of renewable energy investment attracted by the installation of an AC link.

c. Providing a qualitative assessment of additional broader regional economic benefits to (a) the greater North West Minerals province and (b) the communities along the route of the transmission line, and (c) the greater Townsville area.

The following report presents the main conclusions from this analysis.

1. BACKGROUND AND OVERVIEW

An independent review, by Rod Sims of Port Jackson Partners Limited, of the supply options for securing power to North West Queensland found that there were a number of credible solutions, but too much uncertainty to accurately determine which would provide the lowest cost outcome for users. The review also noted that consideration would have to be taken into account of the wider economic benefits in comparing the merits of the options.

The review recommended that the decision over which option should be selected be handed over to the major energy users, a recommendation which the Queensland Government has upheld.

Three options have been put forward for consideration:

- Upgrading the existing base load gas power station at Mica Creek
- Installing an AC transmission link from Mt Isa to Townsville
- Installing a DC transmission link from Cloncurry to Stanwell

Modelling undertaken for the review suggested that the expansion of Mica Creek power station would provide the lowest cost option for energy users in the North West but only at the lower end of a projected range of gas prices and projected levels of energy demand. However, uncertainty surrounding the outlook for gas prices meant that sufficient confidence could not be placed on a long run contractual arrangement for gas supply being achieved within this lower range of prices and based on the lower level of demand. The analysis showed that there existed a tipping point, around the mid point of the range of gas price forecasts, where the cost of energy provision through a grid connection became competitive against stand alone gas fired generation at Mica Creek.

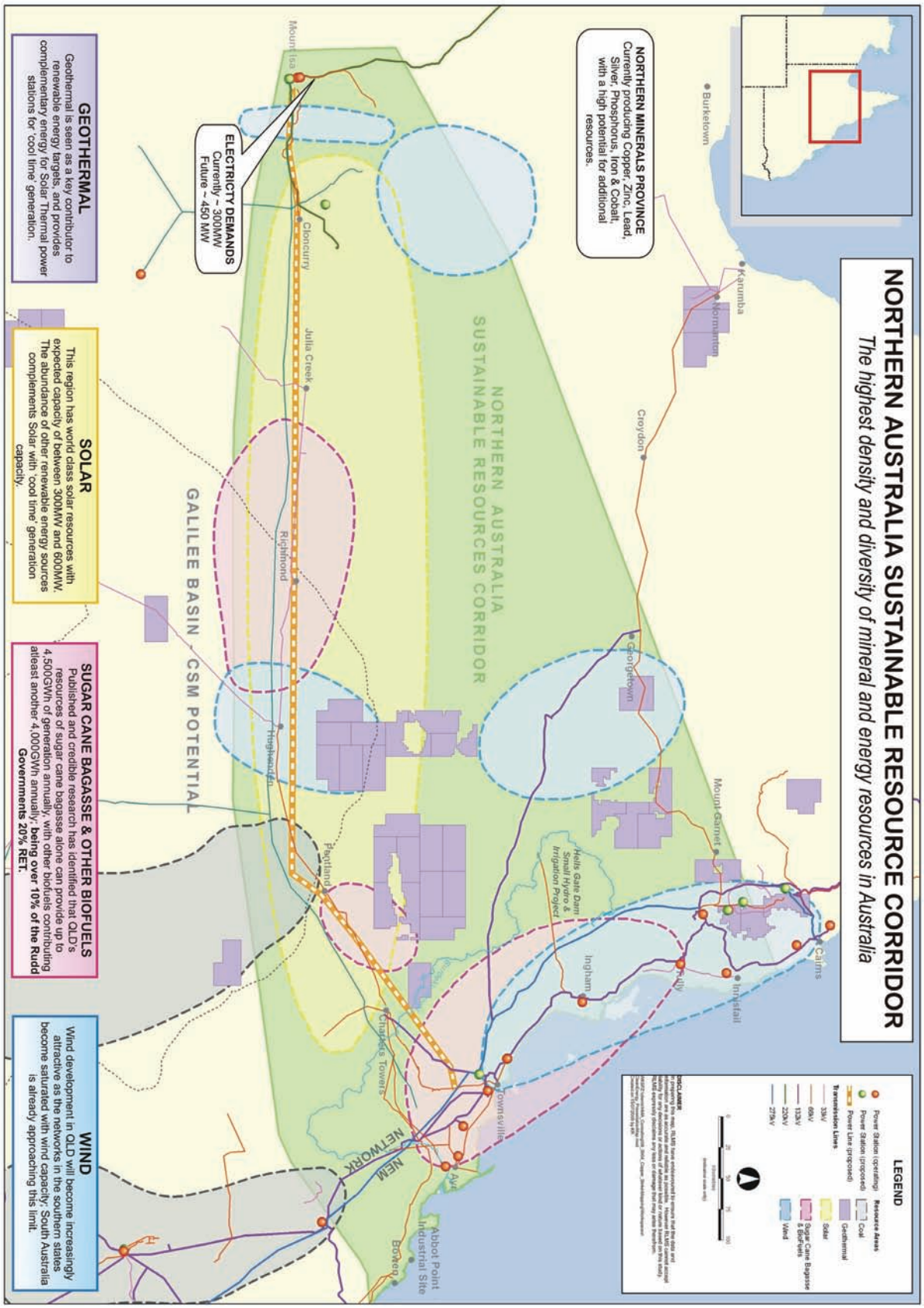
Two alternatives have been proposed for connecting the North West Minerals Province to the National Electricity Market (NEM) via a transmission line. One option proposes using AC technology to connect the region to the grid in North Queensland; the other proposes using HVDC technology and connecting to the grid in Central Queensland.

1.1 A Range of Economic Opportunities for North/North West Queensland

Connecting the North West to the grid at North Queensland via an AC transmission line would open up significant economic opportunities for North/North West Queensland, which would not be available through either a transmission line to Central Queensland or an upgrade to Mica Creek power station, the former including:

- Renewable energy generation projects under investigation between Mount Isa and Townsville along the so called ‘clean energy corridor’ could be connected to the electricity grid.
- The renewable energy projects would provide economic opportunities for the towns along the clean energy corridor.
- The increased transmission capacity to the towns would foster industry.
- Small mines would be able to access electricity at a substantially lower cost than through their own diesel or gas fired generation which would encourage more investment in the NWMP (North West Minerals Province).

North Queensland Resource Map and Potential Power Line Route



- The increase in the customer base in the North West through economic development in the towns, the increase in mining operations in the North West Minerals Province and the addition of the renewable energy projects would put downward pressure on the cost of electricity transmission.
- The renewables projects and the reduced requirement for stand alone diesel generation by the mines would help reduce the region's considerable carbon footprint.
- The co-location of sites suitable for large scale solar, wind and geothermal generation with a grid connection avoids the problem of remoteness associated with many potential renewables sites in inland Australia.
- The clean energy corridor would provide a significant contribution to the Commonwealth Government's renewable energy target and the State Government's emissions reduction target.
- The addition of generation along the clean energy corridor would put downward pressure on energy costs in North Queensland by reducing the loss factors associated with transporting energy over long distances.
- Large scale renewable energy generation in North Queensland would mitigate the risks associated with the timing and cost of clean coal baseload generation in Central Queensland. The unit cost of solar and geothermal renewable generation technologies are widely projected to be competitive with, if not cheaper than, clean coal technologies in the medium to long term.

1.2 Renewable Energy Potential between Mount Isa and Townsville

In North/North West Queensland there is a happy coincidence in that many of the prime sites identified as having renewable energy potential would be in range of a transmission line running from North Queensland to Mount Isa. Investigations to uncover the region's renewable potential have shown that it would be a suitable for the establishment of large scale generation capacity using a range of renewable technologies:

- A major geothermal site has been discovered around Julia Creek and drilling exploration is planned. Initial investigations suggest that the site may be as large as the more famous Cooper Basin in South Australia where a demonstration plant is under construction to investigate the commercial viability of 'hot dry rock' geothermal generation.
- Wind mapping of the area around Hughenden and between Mount Isa and Cloncurry suggests that these regions may be suitable for large scale wind generation projects. Windlab are investigating a site for a proposed 600MW wind farm near Hughenden.
- A 10MW solar thermal power plant at Cloncurry is due to be completed in 2010. Sites along and north of the tropic of Capricorn, such as Cloncurry, have ideal solar conditions. Investigations are underway looking into the potential for a large scale solar thermal plant around Mount Isa.
- Phytofuel ltd is investigating the potential for biofuel production/biomass electricity generation between Julia Creek and Hughenden using native Kalpa trees. In the absence of irrigation, limited water access and competition for the available water supplies from agriculture and the local towns is a constraint on the biomass potential of the North West region for all but the hardiest of plantings, such as Kalpa.

The potential for renewables generation exceeds the anticipated load in the North West. The base case scenario for electricity demand in the Sims Review was for a projected peak demand at Mount Isa over a 20 year horizon within the range of 350-400 MW. A high case demand scenario saw peak demand approaching or exceeding 500 MW. Strong growth in electricity demand is also predicted in North and Central Queensland. Powerlink projections suggest that the Queensland network faces a projected shortfall in supply from 2013/14 if no new generation is added to the network, even without the potential addition of load from North West Queensland.

If utility scale solar, wind, biomass and geothermal generation capacity was established in the North West this would significantly increase the level of generation available to customers in North and Central Queensland. The mines in the North West would face strong competition from North and Central Queensland households and businesses for power during the day, but the renewable generation projects would help the network cope with peak demand usage. A grid connection would enable 24 hour mining operations to access cheap off peak electricity from North/North West and Central Queensland.

The addition of renewables generation in North Queensland would put downward pressure on electricity prices for North West customers over the longer term, helping support the competitiveness of the North West Minerals Province in relation to overseas competitors operating without an ETS or equivalent carbon reduction scheme.

1.3 Benefits of Clean Energy Corridor and Grid Energy for Mines

Ergon Energy operates unregulated transmission assets from Mica Creek Power Station to both Century mine in the north and Ernest Henry mine in the east. Ergon Energy also operates a regulated distribution network in Mount Isa, Cloncurry and surrounding areas. Phosphate Hill, Cannington, Eloise and Osbourne mines have on site generation. Xstrata also has its own 30MW gas fired generation plant at Mount Isa.

Despite the scale of the mining operations in the NWMP, the area still has large untapped mineral reserves. Mining in the region has been largely centred on copper/gold and silver/zinc/lead extraction, but the region also has large reserves of phosphate, iron, rare earths and uranium.

There are a number of mining projects under investigation which have a medium to high chance of proceeding in the next 3 to 5 years. These include:

- Legend International Holdings plans for a phosphate rock/fertiliser operation.
- IPL's extension to its fertiliser operations at Phosphate Hill and expansion into the export of phosphate rock.
- Exco Resources, Universal Resources, King Minerals, Cudeco and Ivanhoe copper/gold/ rare earth mines.
- BHP/Breakaway Resources plans to mine the Altia zinc/silver/lead deposits close to the Eloise copper mine.
- Xstrata's conversion of Ernest Henry Mine to an underground operation, with associated iron ore (magnetite) extraction.
- MMG's option of developing its zinc/silver/lead deposits at Dugald River

As electricity can account for up to 40% of total mining costs, the ability to access a reliable and cost effective electricity source is an important consideration in the decision to invest in a mining operation in the NWMP.

A number of smaller mining operations have previously considered locating in the NWMP, but the lack of access to mains electricity and the high cost of onsite generation undermined the financial feasibility of these projects. The AC transmission line would provide affordable mains electricity within reach of many of these sites. Access to cheaper grid electricity would also improve the chances of profitably extracting a wider range of minerals than currently mined in the NWMP.

The cost of diesel generation will rise once a carbon abatement scheme is introduced. The effective tax on carbon will increase demand for 'clean' energies such as natural gas, which will in turn push up the price of gas fired electricity generation. While the price of electricity sourced through the NEM will also be affected by the carbon abatement scheme, the additional cost will be borne by the whole customer base, rather than just one mine.

If the expansion of the NWMP were accompanied by a proliferation of diesel powered generation this would increase traffic on the road from Mount Isa to Townsville and raise issues of energy security, given that the region is prone to flooding. The trucking of diesel over large distances to these sites would also have the perverse result of adding to these mines carbon footprint, and their cost of production.

If the mines were connected to the NEM they would benefit from the impact of renewable energy additions to the grid. In the medium to long term the unit cost of these technologies are expected to fall to levels comparable with, or even below, those of conventional energy sources and the overall price of energy will ultimately start to fall beyond 2020.

The existing gas fired power station at Mica Creek and the associated gas pipeline infrastructure would continue to provide energy to the North West Minerals Province even if a transmission line option were chosen. Mica Creek power station could potentially be used as a standby capacity which would increase the security and stability of energy delivered in the North West. There is also an option for Mica Creek to operate as a peaking plant during the day when there will be strong competition for energy from households and businesses in North and Central Queensland.

The mines will benefit from economic development in the North West associated with a transmission line as it will encourage investment in other areas of infrastructure. The cost of investing in infrastructure in the North West is high because of its remoteness. While the mines are heavy users of electricity and transport, there are not many of them and their operations run for a finite period. The level of their operations is volatile, depending on world demand and supply conditions. On the other hand, infrastructure is financed over a long time horizon, usually a minimum of 20 years. This has given rise to a mismatch between demand and supply.

1.4 Economic Development Benefits of Clean Energy Corridor and Grid Connection

The expansion of the North West Minerals Province is a key part of the Northern Economic Triangle (NET) 'a commitment by the Queensland Government to foster sustainable economic, social and community growth through the emergence of Mount Isa, Townsville and Bowen as a triangle of mineral processing and industrial development.'

An AC link between Townsville and Mount Isa would have the additional benefits of opening up opportunities for regional development in the towns between Mount Isa and Townsville and

thereby extending economic benefits beyond the towns that make up the three corners of the so called NET.

Industrial land has been set aside around Mount Isa to promote industrial development. Grid electricity at the mines would provide the opportunity for more value added activity to be performed at Mount Isa/Cloncurry rather than at the coast, interstate or overseas. Refining more of the minerals extracted at Mount Isa rather than shipping large amounts of concentrate by rail to the refineries around Stuart would take pressure off the Mount Isa to Townsville rail link as well as providing additional economic opportunities for these towns.

Cloncurry and Mount Isa are the bases for the mines in the North West Minerals Province; the economies of the towns further east are built on a mix of agriculture, tourism and mining. The mix and level of agricultural production which is sustainable in the towns depends on the availability of water, as well as local infrastructure capabilities. Richmond Shire and Flinders Shire have both put forward proposals to increase their respective water storage facilities to harness the average annual strong flows of the Flinders River. Proposals to increase the area of land under irrigation around Charters Towers and Pentland are also under consideration. The combination of a more reliable water supply and grid electricity would enable the towns to broaden the mix of agriculture, increase production and diversify into value added food manufacturing.

The renewable energy projects would be an ideal way of promoting economic development within these towns. There will be employment opportunities for the towns, particularly in the maintenance of the assets and the sites, as well as providing services to the site workforces during both the construction and operational phases.

If the towns had grid electricity it would also provide the towns with the opportunity to leverage off mining activity in the North West and associated growth in the populations of Mount Isa and Cloncurry.

A high voltage mains connection would also open up opportunities for the towns to develop industry. The current transmission line used to distribute energy to the towns between Townsville and Mount Isa, particularly between Julia Creek and Richmond, has reliability issues and a significant load could not be added to the current low voltage network. The transmission line would also close the missing link in the transmission network between Julia Creek and Cloncurry.

While the risk of supply interruptions associated with long transmission lines will remain, distributed renewable generation and the possible use of Mica Creek Power station as standby capacity would reduce the risk of a total loss of power if these generation assets can run in isolation from the grid. Ergon energy intends on applying for an injection point into the high voltage network at a bulk supply point. The reduced distances between the bulk supply point and the towns would improve the reliability, and reduce the cost, of transmission to the towns.

1.5 Economic Development Benefits of AC Transmission Line for North Queensland

The users of the regulated transmission system in North and North West Queensland are not faced with the same high cost of electricity as the mines because the Queensland Government subsidises their electricity by paying Ergon Energy a Community Service Obligation (CSO) to cover the additional cost of transmission.

The location of renewable energy generation projects close to the major loads would reduce the cost of energy transmission. Assuming the reduced cost of energy outweighs the increase in

transmission cost from accessing the new infrastructure, this would reduce the CSO obligation of the Queensland Government.

The cost of energy delivered to Mount Isa along a transmission line connected to the NEM would depend on the NEM price, the cost of transmission including losses, the transmission use of system charge (TUOS) at the NEM connection point and the marginal loss factor at the NEM connection node.

Growing load demand in North Queensland has seen rising marginal loss factors at the North Queensland connection. In the absence of new generation in North Queensland the marginal loss factors will continue to rise as growth in the Northern Economic Triangle draws increasing transfers of energy from Central Queensland to North Queensland.

The increase in demand from the NWMP would improve the economics of electricity generation in North Queensland. A transmission line to North Queensland would traverse the Northern Galilee Basin opening up the option of a clean coal baseload power around Pentland. Alternatively, a baseload power station could be located on the east coast.

The addition of baseload power in North Queensland would put downward pressure on marginal loss factors at the North Queensland connection. Lower loss factors at North Queensland would translate into lower subsidy payments to Ergon Energy and lower costs for electricity users in North and Central Queensland.

1.6 Existing Renewable Energy Proposals

Three renewable energy projects positioned along the route of the proposed AC transmission line were presented at the North Queensland Renewable Energy Roundtable forum in November 2009:

- Windlab Systems Pty Ltd's proposal for a 600 MW wind farm at Hughenden
- Australian PhytoFuel Company Pty Ltd's proposal for producing biodiesel feedstock and using the waste biomass to generate power around Hughenden/Julia Creek
- Samsung's presentation of a solar/biomass project at Pentland

All three projects require the AC transmission line solution from Mount Isa to Townsville to access the electricity grid. The location of these projects is too far from either the proposed HVDC line to central Queensland or the existing grid in North Queensland to make connection at these points economically feasible.

The Windlab project at Hughenden is still in the early stages of development, but Windlab has a successful track record of developing wind energy sites in Australia and overseas. A wind monitoring tower is scheduled to be installed on the site in 2010. Windlab estimates it will take 5 to 7 years to develop and construct the wind farm if the project proceeds. Based on that time frame the wind farm would not be connected to the grid before 2015/16.

The PhytoFuel project is primarily focused on the growing of native trees (Kalpa tree) for the production of biodiesel feedstock (vegetable oil) with the biomass waste either used for electricity generation or biodiesel production, depending on whether the AC link proceeds. The biofuel project has a long gestation period. The full implementation of the program will take up to 12 years and allowing for the maturity of the trees it would take at least 20 years for the full potential to be realised. A feasibility study is underway supported by BP Australia.

Full implementation of the project would see the establishment of 25 production units each with a 16MW gasification plant and the potential to generate 150 GWh of electricity a year. PhytoFuel is proposing to remove prickly acacia as part of a land access deal and utilise the biomass in the gasification system proposed for the processing of Kalpa shells while the trees are maturing. The cost of clearing the prickly acacia, determined by the intensity and spread of the weed, will influence how much electricity will be generated while the plantings are maturing. It takes 5 to 7 years for the trees to mature. There is potential for 100 MW of generation capacity to be installed by 2015/16, rising to 400 MW early next decade if all 25 units proceed.

The solar biofuels project at Pentland received considerable publicity in North Queensland after it was revealed that Korean electronics giant Samsung was assessing the plans. Samsung presented a proposal for the scheme at the North Queensland renewable energy roundtable forum in November 2009. However, the project does not yet have official confirmation of funding.

The Pentland scheme would be capable of providing 400 MW of base load power and an estimated 1,000 megalitres a year of ethanol. It would require the construction of a dam on the upper Burdekin River at Hell's Gate which will also be used to generate a further 100 MW of hydro electricity. Water released from the dam will then be diverted some 150 km to flat arable land south east of Pentland to irrigate 120,000 ha of sugar cane. Two large scale ethanol plants will then turn the cane into 1,000 mega litres of ethanol and the left over sugar cane fibre will fuel steam electricity generators producing 400 megawatts of electricity for 16 hours a day. A 400 megawatt solar concentrator will be installed to produce steam to run the generators for another 8 hours a day.

The timing of the project as it stands would depend on the construction of the dam at Hell's Gate. This major water project has been under consideration for a number of years as one of a number of options looking to develop agriculture in North Queensland through increasing the area of land under irrigation. The project would be in competition for funds with a proposed upgrade to the Burdekin Falls dam and other major water programs in Queensland. A feasibility study into a 30 MW hydro power station at the Burdekin Falls dam is also underway. The earliest date at which construction of a dam at Hell's Gate would realistically proceed would be early next decade.

Funding for a 150 MW solar power station, potentially around Hughenden, has been lodged under the Commonwealth's solar flagship program. The project would require the AC transmission line to proceed. The Commonwealth Government's solar flagship program will provide funding assistance of $1.365 billion for solar power projects. The program proposes to have 400 MW up and running by 2015 and targets capacity of 1000 MW by 2020. Solar projects are very expensive, but they have relatively short construction time frames. If a solar project along the Mount Isa to Townsville clean energy corridor was selected under the first round of the solar flagship program, construction could be underway in 2012/13 and connection to the grid could come as early as 2014/15.

1.7 Future Renewables Generation Potential

There are a number of other sites with renewable energy potential being explored. One option under consideration is for a utility scale solar thermal power station to be built near Mount Isa. The clean energy corridor traverses the region north of the tropic of Capricorn providing ideal solar conditions, particularly at Mount Isa and Cloncurry. There is also abundant land along the clean energy corridor, a requirement for large scale solar and wind generation facilities. A 10 MW demonstration solar thermal power station is under construction at Cloncurry to test the

commercial viability of large scale solar thermal generation. The combination of ideal solar conditions and a grid connection would make the region an ideal candidate for funding from the solar flagship program.

Generous government subsidies in Germany, the US and Spain have fuelled a boom in solar technology development, which has seen the long run marginal cost of both solar photovoltaic and solar thermal fall sharply in the past few years. Both solar photovoltaic and solar thermal would be suitable for North/North West Queensland depending on access to water.

A seismic study in 2008 uncovered significant hot dry rock (geothermal) potential centred on Julia Creek. It is conjectured that that 'Millungera basin' could rival the Cooper basin in South Australia for geothermal potential.

Hot dry rock technology is not yet commercially viable. A Government funded 25 MW demonstration project is under construction in the Cooper basin to gauge the cost effectiveness of the technology on a commercial scale. This is the largest hot dry rock project in the world and is scheduled for commissioning in 2013.

The Millungera basin would have a considerable cost advantage over the Cooper basin if the AC transmission link were to proceed. The Millungera Basin underlies almost three quarters of the McKinlay Shire and is centred under the town of Julia Creek past which the AC link would travel. In contrast, the Geodynamics site near Innamincka in the Cooper basin is about 490 kilometres from the nearest grid connection. New high-voltage transmission lines cost between $1 million and $2 million per kilometre[2].

If the Cooper Basin demonstration plant is successful then it is possible that a large scale geothermal power station could be under construction in Australia over the second half of the decade. If the AC transmission link was already running through Julia Creek then the Millungera Basin could present a lower cost geothermal option than the Cooper Basin, depending on the success of the drilling exploration program at the Millungera Basin. Economies of scale favour the construction of a base load power station of at least 200 MWh.

The cost of conventional geothermal technologies has also been falling. Enhanced Geothermal Systems (EGS), or hot dry rock technologies, are yet to be used on a commercial basis. The technology is comparatively new and technical hurdles remain, but public funding for EGS has received a significant boost in the past few years, with projects now underway in France, Germany, the US and Australia. Assuming that the technical difficulties can be overcome in the medium term, the cost of drilling is expected to fall sharply by the end of the decade.

Given the recent pace of innovation and falling costs for solar and geothermal technologies, many renewable energy analysts are now predicting that hot dry rock generation and solar thermal generation, both of which are capable of providing baseload power, will be competitive with, if not cheaper than, clean coal generation by the time clean coal technologies become commercially available, which is estimated to be at least 10 years away.

1.8 Risk of Short-Sighted Cost Assessment of Energy Delivery

While there is significant potential for the addition of base load, peak and intermittent generation capacity in North Queensland this decade, the commissioning of this generation will not coincide with the completion of the transmission link in 2013. Modelling undertaken by Roam Consulting[3] suggests that if there were no generation in North Queensland to offset the load at the NWMP the price of electricity under the AC link option from North Queensland would

be higher than if energy was provided from Central Queensland or generated at Mica Creek Power Station.

However, by 2015/16 there is the potential for around 900 MW of installed renewable capacity to be connected to the grid through the AC transmission line. 300 MW of this installed capacity would be baseload power – biomass and solar thermal – with a further 600 MW from wind power. Adjusting for the lower capacity factors for solar and wind power, potential renewable generation of around 400 MW would be available by 2015/16 - equivalent to the projected demand of the North West Minerals Province.

There has been a classic chicken and egg problem in the provision of infrastructure in North West Queensland. The Mount Isa to Townsville rail link (which is operated by QR Network) and Mica Creek Power station (operated by CS Energy) have both run up against capacity constraints. For CS Energy and QR Network to justify major capital expenditure on infrastructure they need a guarantee that there will be sufficient long term load to recover the cost of investment. However, the existence of capacity constraints and the high cost of infrastructure will discourage the minerals investment that is required to justify the infrastructure investment. The result is a stand off, with a sub-optimal outcome. The Queensland Government has moved to break the energy stand off and is following the recommendations of the Sims Review in allowing the major users to decide the best solution for securing power to the region.

However, there is also a chicken and egg problem for the clean energy corridor. The renewable energy projects along the clean energy corridor cannot proceed without a transmission line. However, the initial cost competitiveness of a transmission line to Townsville depends on there being sufficient generation in North Queensland. Best estimates show that sufficient generation capacity will be installed by 2015/16, two years after the commissioning of the transmission line. There is a risk that the major users will dismiss the option of transmission line through the clean corridor on account of it not being the initial low cost option. However, by the end of the decade North Queensland could become an exporter of energy to Central Queensland, which would reduce the cost of electricity to the North West and to the major users, the mines.

2. ECONOMIC BENEFITS OF THE CLEAN ENERGY CORRIDOR

The case for the clean energy corridor is compelling. The Commonwealth Government's renewable energy target is for 45,850 GWh of renewable energy generation by 2020, equivalent to 20% of projected energy generation. If the AC transmission line were to proceed, based on an assessment of the current projects under investigation, the clean energy corridor could be providing annual output in excess of 3,750GWh, or 8% of the total renewable energy target, by 2015/16. By 2020, this figure could be potentially as high as 20% of the total Australian target.

Table 2.1 lists those projects which are currently under investigation along the clean energy corridor. The information is based on existing proposals as well as expression of interest to the councils along the clean energy corridor.

Table 2.1: Renewables Generation Project List

Project Name	Renewable Source	Installed Capacity	Potential Grid Connection
Phytofuel	biomass	48 - 400	2013 - 2022
Kennedy Windfarm	wind	600	2015/16
Hughenden solar project	solar thermal	150	2014/15
Pentland Project	hydro	100	2020 +
Pentland Project	solar thermal	400	2020 +
Pentland Project	biomass	400	2020 +
Mt Isa solar project	solar thermal	300	late decade
Geothermal	geothermal	200	late decade
Mount Isa wind farm	wind	200	late decade

Information on the proposed capacity and timing of the Phytofuel biomass project, Windlab Systems Kennedy Windfarm and the Hughenden solar project is available. The Pentland solar-biofuels proposal is for 400MW of installed solar/biofuels capacity, with a 100MW hydro plant at Hell's Gate on the upper Burdekin River.

The capacity of the remaining projects is based on BIS Shrapnel's assessment of the optimum level of generation for these projects. The timing of these projects depends on a number of factors, including:

- the future regulatory framework — the projected cost of carbon
- the price of renewable energy certificates
- the level of industry assistance
- the long run marginal cost of renewable energy technologies

It is assumed that the proposed projects will be economically feasible over the forecast horizon based on these assumptions.

It is also assumed that hot dry rock geothermal technology will be commercially viable by the second half of the decade. The Department of Climate Changes modelling predicts that geothermal will account for 25% of the RET by 2020. However, this depends on the technical hurdles how long it takes for the technical hurdles to be overcome and whether there is a sufficiently high REC price and government commitment to funding.

Table 2.2, below, shows the potential energy output from these projects. The capacity factors for the Pentland, Phytofuel and Windlab projects are based on published estimates. The capacity factors for the other projects are based on average capacity factors for those technologies.

Table 2.2: Installed Capacity and Energy Output of Renewables Projects

Project	Technology	Capacity Factor	Installed Capacity MW	Gwh/year
Pentland	Biomass	67%	400	2348
Phytofuel	Biomass	85%	400	2978
Julia Creek	Geothermal	90%	200	1577
Hell's Dam	Hydro	55%	100	482
Hughenden	Solar Thermal	60%	150	788
Pentland	Solar Thermal	33%	400	1156
Mount Isa	Solar Thermal	60%	300	1577
Windlab	Wind	35%	600	1840
Mount Isa	Wind	35%	200	613

A recent paper by Wei, Patdia and Kammen (2010)[4], published in the *Journal of Energy Policy*, looked at the job creation potential of the clean energy industry. The authors reviewed 15 studies and found the results suggested that renewable energy created more jobs per unit of energy delivered than conventional fossil fuel-based sectors, for all renewable technologies studied.

Table 2.3 below shows the multipliers for each technology type (sum of construction and operational phases) calculated by the authors based on the studies reviewed. The multipliers for some technology types are derived from multiple studies; others are based on the results of a single study.

Table 2.3: Renewable Energy Employment Multipliers

Total Job Years per GWh			
Technology	**Direct**	**Indirect**	**Total**
Biomass	0.21	0.19	0.40
Carbon Capture and Storage	0.18	0.16	0.34
Conventional Hydropower	0.15	0.14	0.29
Geothermal	0.25	0.23	0.48
Hydro (Small)	0.27	0.24	0.51
Municipal Solid Waste	0.15	0.14	0.29
Nuclear	0.14	0.13	0.27
Solar PV	0.87	0.78	1.65
Solar Thermal	0.23	0.21	0.44
Wind	0.17	0.15	0.32
Coal	0.11	0.10	0.21
Natural Gas	0.11	0.10	0.21

Source: M.Wei et al./ Energy Policy 38 (2010) 919-931

Average employment for different technologies normalised to the anount of energy produced. All renewable energy sources produce more jobs than coal and natural gas

Table 2.4 shows the employment benefits derived for the clean energy corridor projects based on the multipliers in Table 2.3. The average number of construction, installation and manufacturing jobs (CIM) is calculated as the number of job years diving by the estimated length of the construction phase, including the design phase.

Table 2.4: Estimates of Employment Benefits of Clean Energy Corridor

		Number of Jobs - Full Time Equivalent Employment	
Project	**Energy Technology**	**Average CIM jobs over construction period**	**O&M and fuel processing**
Pentland	Biomass	365	432
Phytofuel	Biomass	128	548
Julia Creek	Geothermal	372	344
Hell's Gate Dam	Hydro	114	114
Hughenden	Solar Thermal	257	120
Mount Isa	Solar Thermal	513	240
Pentland	Solar Thermal	684	176
Mount Isa	Wind	348	48
Windlab	Wind	836	145

O&M - operation and maintenance

CIM - construction, installation and manufacturing, also includes design and management

The analysis suggest that if all the projects currently under investigation were to proceed 2,169 permanent jobs would be created in the operation and maintenance of the generation sites, including some fuel processing jobs at the biomass sites.

The job creation studies reviewed in the M. Wei et al. paper were a combination of spreadsheet based analytical models (“bottom-up”) and input-output models (“top-down”). Input-output models analyse the interaction of goods and services between the various industrial sectors and consumers in an economy. They capture the impact of shifts between sectors.

Given that the results of the M. Wei et al. study suggests that the potential direct and indirect employment multipliers for renewable energies are comparable with those for conventional energies, we believe using existing input-output multipliers can provide a reasonable guide to the potential economic benefits of the addition of generation output (MWh) along the clean energy corridor.

The 1996-97 Queensland and Regional Queensland input-output tables, produced by the Queensland Government’s Office of Government Statistician, were used to assess the economic impact of the renewable energy projects to North Queensland during their construction and operational phases. The regional impact was measured as that experienced in the Northern, Mackay and North West statistical divisions, hereafter referred to as the ‘NET region’

The direct, indirect and induced impact of the construction and operation of the proposed renewable energy projects can be traced through the economy using the input-output multipliers. Multipliers provide an estimate of the ‘gross’ activity generated for some given impact on the economy. The concept of gross effects occurs because I-O multipliers do not account for potential crowding out of one activity by another.

The impact of the stimulus can be traced through the system in three different ways:

- The direct effects on final demand measure the requirements of the industry experiencing the initial impact to produce a stated amount of additional output.
- The indirect effects on final demand measure the additional output required from other industries in the economy needed to supply the additional demand of the industry receiving the initial impact.
- The induced effects on final demand measure the changes in consumption by the household sector in response to income changes resulting from the change in output. These effects tend to be overstated because the multiplier implicitly assumes that new employees were unemployed and consuming nothing.

We note that the impact of costs and prices cannot be modelled in a static setting. A fall in the long run marginal cost of renewable generation, a rise in the price of renewable electricity certificates and a rising carbon price would increase renewable energy revenues and profits. While it is assumed that the projects are running at capacity and cannot readily increase output in response to price, it would be expected that the rise in incomes would flow back into the economy through increase consumption and investment. However, as noted earlier, IO multipliers do not account for potential crowding out. The introduction of a carbon abatement scheme would have wide ranging impact for economic activity across the economy, possibly leading to a contraction in some high emitting industries.

Constant prices and costs were therefore assumed and the analysis was restricted to the impact of the establishment of the individual projects, and their nominated capacity, on employment and output in the North Queensland economy. Therefore the analysis is comparable with the M. Wei at al. analysis in that it looks at the benefits per output of energy.

The costs used were based on estimates provided for the Federal Treasury[5] and Department of Climate Change[6], adjusted for the estimated the fall in the price of technologies through 2009[7]. Phytofuel Ltd. and Windlab Systems Ltd. provided information on the composition of capital expenditure for their proposed projects. Estimates of the value of capital expenditure that leaked into imports for the other projects were based on analysis of capital expenditure by Concept Economics[8].

The price used was the estimated average wholesale NEM price for 2009/10 of $40/MWh. The renewable energy generators are also able to sell renewable energy certificates for each MWh of electricity generated at a market determined price. However, this is a subsidy to renewable energy producers, which is necessary as the long run marginal cost of renewable electricity generation currently exceeds the NEM price.

The base case investment scenario used in this analysis does not include construction of the Pentland project in the forecast horizon to 2020. The other projects listed in Table 2.1 are assumed to proceed and are estimated to be completed in line with their projected grid connection date provided in Table 2.1.

Table 2.5 below provides the breakdown of the average number of construction jobs in the two five year intervals to 2019/20 based on the grid connection timings given in Table 2.1. The number of operation and maintenance jobs expected in 2015/16, when the Kennedy Windfarm is expected to connect to the grid, and in 2019/20, when the second round of projects are expected to connect to the grid, are also provided. It is assumed that 8 of the 25 Phytofuel Regional Product Units (each with a generation capacity of 16MW) are operational by 2015/16. In fact, Phytofuel estimates that each RPU would employ up to 40 full time personal, which

would provide a figure of maximum of 1000 operation and maintenance workers when fully implemented, considerably higher than the 548 workers estimated in Table 2.4.

Table 2.5: Five Year Estimates of Employment Impacts – Construction and Operation

	Number of Jobs - Full Time Equivalent Employment	
Period	**Average CIM jobs over construction period**	**O & M and fuel processing as at end of period**
2009/10 - 2015/16	1220	448
2015/16 - 2019/20	1234	1445

O&M - operation and maintenance

CIM - construction, installation and manufacturing, also includes design and management

Table 2.6 and Table 2.7 provide estimates of the economic benefits of the renewable energy projects during the construction and operational phases.

Table 2.6 lists the average impact on employment and output anticipated in the five year period to 2014/15 and the subsequent five year period to 2019/20. The direct employment benefits are higher than those estimated in Table 2.5 using the M. Wei et al. multipliers for the second five year period and are likely to be an overestimation of the potential maximum employment impact. The level of construction activity, as implied by the M. Wei et al. research, is likely to vary between the types of renewable generation projects and, with the exception of hydro power, renewable generation projects are not likely to be as labour intensive as the other types of infrastructure construction and the non-dwelling building categories on whose activity the input-output multipliers are primarily based.

Table 2.6: Estimated Economic Impact from Construction of Renewables Projects

Measurement	Impact	Annual Average 2010/11 - 2014/15	Annual Average 2015/16 - 2019/20
Output	Direct	136	185
($m) (2009/10 prices)	Indirect	46	63
	Induced	41	56
	Total	223	304
Employment	Direct	1208	1648
(FTE)	Indirect	286	391
	Induced	330	451
	Total	1825	2489

The economic impacts estimated during the operational phase using the electricity, gas and water industry multipliers are provided in Table 2.7.

M. Wei et al. assumed an indirect multiplier of 0.9 times the number of direct jobs (sum of construction and operation job years per GWh) for all technologies. This estimate was taken as the average of the indirect multipliers sourced from three of the studies reviewed. However, the M. Wei et al. study did not consider local vs. regional employment effects and a significant

proportion of the indirect impact of the clean energy corridor would be felt outside the NET region. The NET regional multipliers based on the interaction of industries in 1996-97 had a low indirect employment multiplier, because the NET region did not manufacture inputs to the electricity, gas and water sector.

However, the scale of indirect employment benefits of the renewable energy projects depends to a large degree on whether investment in the clean energy corridor can also attract investment in the development and manufacture of renewable technologies to the Northern Economic Triangle. If successful, as has been the case with the minerals corridor, then the indirect benefits could be higher than implied in Table 2.7.

Table 2.7: Estimated Economic Impact during Operational Phase of Renewables Projects

Measurement	Impact	Year end 2015/16	Year end 2019/20
Output	Direct	150	352
($m) (2009/10 prices)	Indirect	41	96
	Induced	31	74
	Total	223	522
Employment	Direct	525	1231
(FTE)	Indirect	242	567
	Induced	255	598
	Total	1022	2396

The input-output analysis suggests the addition of generation capacity to North Queensland along the clean energy corridor to the volume of output in the North Queensland economy, excluding the construction impact, would be the following:

- directly, $150m (2009/10 prices) by the end of 2015/16
- directly, $352m (2009/10 prices) by the end of the decade
- indirectly, $41m (2009/10 prices) by the end of 2015/16
- indirectly, $96m (2009/10 prices) by the end of the decade

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