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Introduction to Innovative Energy Australia Pty Ltd

Innovative Energy Australia Pty Ltd ("IEC"), welcomes the opportunity to respond to the Qld Gas Supply & Demand Action Plan Discussion Paper dated November 2016 (the "**Paper**"). IEC has provided commercial, strategic and regulatory consulting services to gas industry clients operating in North America and Australia since the mid 1990's. IEC's clients include various government agencies and departments, industry associations and large companies operating across the value chain from gas production to major gas users. IEC was selected by the Treasury Department of the Qld Government in 1999 as the Gas Industry Specialist and advised the Treasury Department for a number of months regarding due diligence on the proposed PNG to Qld Gas Pipeline Project and all related commercial arrangements proposed by several Qld Government owned companies.

IEC has also held EPM 17010 for the past eight years over a portion of the Boree Salt deposit located in the Adavale Basin, Qld. IEC secured this EPM with the intent of

developing a state-of-the-art world class gas storage facility to service Qld's gas industry. IEC has been pursuing the Qld Department of Natural Resources and Mines (the "DNRM") for the past eight years regarding the need to revise the current Minerals Resources Act to confirm and to accommodate the solution mining process as it pertains to underground salt deposits and that caverns made in salt can be used to cycle and store hydrocarbons in general and gas in particular without complications vis-à-vis the provisions in the Petroleum and Gas Act that apply to gas storage in naturally occurring hydrocarbon bearing reservoirs that have been depleted of those in-situ hydrocarbons. This initiative has been extremely frustrating to IEC for the DNRM has simply procrastinated or outright refused to address this matter. It is rather unreasonable for the resource owner to expect the private sector to continue to invest in developing a resource when such large regulatory omissions and uncertainty exist.

IEC welcomes the opportunity to participate in this process and encourages the DNRM to facilitate the development of salt cavern storage facilities in general and to actively promote the utilisation of the Boree Salt in this regard. IEC has been a commercial advisor to both QGC and GLNG and is fully aware of how a fast cycle high performance gas storage facility would enable the LNG export facilities at Curtis Island and the related CSG supply chain to operate at a much higher efficiency thereby reducing both ongoing capex and opex requirements.

Gas Supply Issues

The current gas supply woes are not new issues to Qld. The SW Qld gas pipeline was built in the mid 1990's because Brisbane and Gladstone were quickly running out of reliable gas supplies from the Surat and Bowen Basins. The Cooper/Eromanga Qld gas centre was soon deemed insufficiently reliable for the future needs of Qld; consequently, the Qld Government elected to sponsor the PNG to Qld gas pipeline project and related long term GSA's with several Government Owned Companies. While CSG resources were being explored for and produced in SE Qld during the 1990's the Qld Government discounted that resource as unreliable until the PNG to Qld project delays forced CSG to

play increasingly larger roles in the supply to new gas fired power generation facilities. Finally, the Qld Government embraced CSG as a reliable alternative to conventional gas supplies and supported the construction of three CSG to LNG export facilities located at Curtis Island. These projects have essentially tripled the eastern Australia gas demand and increased Qld's gas demand six-fold in a very short period thereby reversing the historical over supply/demand imbalance to a very tight if not insufficient gas supply scenario. This exponential growth in gas demand has resulted in the largest gas supply issue since the short-term gas supply outages experienced during the Longford gas plant explosion and the Moomba gas plant unplanned outages experienced in the 1990's. The major difference is the current situation is not a temporary one and therefore requires a new model for eastern Australia's gas industry.

Historically, east coast gas supplies—both proven reserves and production capacity—vastly exceeded what would generally be considered to be cost effective. Gas supplies grew much faster than domestic gas demand over the previous four decades in eastern Australia. The old business formula for the upstream sector will be radically transformed as gas supplies—both producing reserves and pipeline-connected deliverability—will be in demand as never before experienced. Those who resist change will be pushed up to the highest cost quartile, while those who adapt quickly to a new business model will be rewarded with falling gas costs due to better commercial practices and more efficient operations.

Gas production facilities are capital intensive, and their utilisation rate could be vastly improved upon on Australia's east coast. Unit production costs decrease as volume or throughput increases. The variable costs of processing gas are generally not that significant. In North America, gas processing plants, gas wells and gas gathering systems are pushed each and every day in order to maximise throughput subject to good production practice constraints. By comparison, east coast Australia's gas production facilities generally idle their way through each year. For example, the multibillion dollar Bass Strait facility has been operating at less than a 60 per cent annual utilisation rate with respect to the gas component of that operation for many decades.

The entire cycle time between any future gas discovery and first commercial production will soon be reduced significantly from historical Australian averages. For example, gas discoveries in Alberta, Canada or in the Gulf Coast region of the U.S. are typically producing within months of discovery. Most of this gas has access to existing gas processing facilities that are owned either by other gas producers keen to create a win/win or increasingly by midstream operators who aggressively solicit business from anyone and everyone. The old game of vertical integration and the creation of barriers to entry will soon become counter-productive. Winners in this brave new world will focus on well-established overseas models that allow the efficient management of a very tight gas supply/demand environment.

Gas producers on the east coast will soon have the opportunity to lower their reserves to production (R/P) ratios and increase gas production utilisation rates to levels consistent with other overseas regions such as Canada and the United States. Finding gas reserves is expensive and the acquisition of in-situ proven gas reserve is typically even more so. A reasonable inventory of proven producing gas reserves in order to avoid frequent gas supply shortages is required. This prudent level is now considered to be an R/P ratio of less than 10 years. North America has been running very smoothly on an R/P ratio of around 8 years over the past few decades. “Just-in-time” is a common business principle that avoids excessive inventory costs.

Eastern Australia has historically exhibited a low turnover of exploration land and poor third party access to existing gas plants on commercially attractive terms. This has not been an issue in the past because of the abundance of stranded gas in virtually every producing basin. As the inventory of producing proven gas reserves evaporates over the next decade opportunities to reduce costs by efficiency gains will be abundant. Necessity is not only the mother of invention; it is also the mother of change. Tools such as underground gas storage facilities will start to play a dominant role in Australia’s east coast gas supply chain.

The plan going forward should be one of much more co-operation toward increased efficiency and lower gas supply costs. This requires a completely different business model than what has been in operation historically in Australia; one that has been operating for several decades across North America and that has and continues to evolve. The east coast is just beginning to experience for the first time the proverbial gas supply replacement treadmill and that is a new paradigm for both Government and industry operating in Australia. This scenario requires revolutionary thinking and action by both Government and industry in order to unlock the considerable amount of latent undeveloped recoverable gas resources remaining in Qld.

Gas Pipeline Issue

Access to low cost pipeline infrastructure on a non-discriminatory basis and fees for service that reflect the value of that service is the hallmark of an efficient, competitive, vibrant domestic gas industry. The gas pipeline tariffs in Qld are far from world's best practice and reflect unchecked monopoly pricing. This scenario is unsustainable for it discourages new remote gas supplies, competition from existing gas supplies, gas storage development and true gas trading hub development.

The gas pipeline sector in the east coast of Australia has not served the gas industry very well to date in terms of providing good services at fair and reasonable tariffs on a non-discriminatory basis to all market participants and prospective users. This has resulted in inflated delivered gas costs, a lessoning of competition, inefficiencies throughout the value chain, and an extremely slow development of underground gas storage facilities and a meaningful short term trading market. The current model is out dated and needs to be drastically altered in order to accommodate the future ongoing needs of the much larger east coast gas industry that involves large gas exports at Gladstone and the production of higher cost unconventional gas resources. The challenges facing eastern Australia's gas industry at the moment are unprecedented and successfully meeting those challenges will require the adoption of much more efficient models and practices from overseas, including those pertaining to the gas pipeline sector.

Gas Storage Issues

A structural issue that prohibits efficient use of Qld's gas resources is the lack of adequate underground gas storage facilities in eastern Australia generally, but in SE Qld in particular. Although Qld currently has four gas storage facilities, none of these facilities, to our knowledge, are open access facilities in that they do not offer storage services of any kind to gas market participants. Furthermore, these facilities are not high performance gas storage facilities and in fact are quite the opposite. The poor quality naturally occurring reservoirs in the Surat and Bowen Basins do not qualify for high performance gas storage operations. The Cooper/Eromanga Basin is rather isolated and it is dominated by one gas producing joint venture that does not appear interested in developing an open access gas storage facility.

Salt Cavern Storage Facilities

Salt is an ideal material for storage. Although salt can be dissolved by water, it cannot be dissolved by hydrocarbons. Salt, especially under pressure, has a high level of plasticity, meaning that if a crack or fissure appears in the salt, the salt will "heal" itself. This plasticity also allows for the cavern to slightly expand and contract depending upon the pressures within the cavern while in use. As a result, once a cavern is properly created in a salt formation, it is impermeable and will not leak or be contaminated by an outside source. These factors make salt an ideal medium for storing crude oil, LPG, propane, ethane, butane, or other natural gas liquids.

Rock salt (halite) exhibits unique physical properties and mechanical behaviour and may exist in two forms: 'thin bedded' salt beds and, due to their rheological and deformation mechanisms, 'massive' salt domes (up to 1.6 km in diameter and anywhere between 5 and 9 km in height) formed by halokinetic movements. Underground salt formations, therefore, offer another option for the storage of hydrocarbon products (including liquefied petroleum gas (LPG) and gas), with salt cavities excavated in bedded salt layers or in

halokinetic structures (salt pillows, diapirs, domes, walls etc.). Salt caverns should be spherical or cylindrical in shape with domed roofs and with a grid spacing related to their size (diameter). While bedded salt deposits have been frequently used for liquid hydrocarbon storage, halokinetic salt structures are necessary for gas storage facilities since caverns need to be of significant size for salt cavern gas storage facilities to be economically developed. The Boree Salt deposit in the Adavale Basin meets this important criterion.

Caverns are created in salt formations using a technique called “solution mining” whereby a well is drilled into the salt, fresh water is injected into the well dissolving the salt and the salt-saturated water, “brine”, is then pumped out of the well in a circulation process creating a cavern space in the salt formation. The salt mineral is recovered at the surface by recrystallization or alternatively the saturated brine is disposed of either in the ocean or injected into deep saline aquifers. With a controlled solution mining process the shape and size of a cavern can be carefully constructed to create a cavern that is suitable for storage of hydrocarbons. Salt caverns created for hydrocarbon storage and waste management are located deep within the salt formation to maintain their integrity, with the ceiling of a cavern located 175m to 200m below the top of the salt and the cavern walls at least 175 meters for the sides of the salt formation. Salt caverns are generally cylindrical in shape with a diameter of about 75 meters and total height in the range of 500-800m.

Storage of both liquids and gases in solution mined salt caverns was reportedly first conceived in Canada in the early 1940’s, during World War II. Storage of liquid petroleum gas (LPG), and other “light hydrocarbons” spread rapidly in the early 1950’s in North America and several European countries. Storage of crude oil reportedly occurred first in England, also in the early 1950’s, during the “Suez Crisis”. Gas storage utilising salt caverns followed storage of liquid hydrocarbons by about a decade in the U.S. and Canada. Currently, over 2,000 mined and solution-mined caverns in salt formations are in use for the storage of hydrocarbons (natural gas, crude oil, LPG and other petroleum products) in 27 of the 50 U.S. states, Mexico, Canada, England, France, Germany,

Holland, Sweden, Norway, Finland, Denmark, South Africa, and several other countries throughout the world.

The U.S. Department of Energy's Strategic Petroleum Reserve has approximately 800 million barrels of crude oil storage capacity in salt caverns in Texas and Louisiana. PEMEX currently stores 12 million barrels of crude oil at its storage facility in Coatzacoalcos, Mexico. At the Barbers Hill salt dome located at Mont Belvieu, Texas three companies operate more than 150 caverns with a storage capacity of over 175 million barrels storing primarily LPG. In addition, over 300 PJ's gas can be stored in over 150 salt caverns associated with 50 UGS facilities dispersed across the U.S. and Canada, and over 100 PJ's of working gas capacity is associated with 53 UGS facilities utilising 250 caverns in northern Europe.

Minerals Act Regulations Issue

Neither the Minerals Resources Act 1989 nor the Petroleum and Gas Act 2004 begin to address the following:

1. The solution mining process of dissolving the mineral halite using wellbores;
2. The use of a man-made underground salt cavern for hydrocarbon storage and cycling purposes; and
3. The ownership rights of a void (cavern) located in a salt structure.

The *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) sets out the regulatory framework for the storage of petroleum products in natural underground reservoirs. The major features of the regulatory framework are as follows:

- Separate storage tenure does not exist.
- Authorities to Prospect (ATPs) include the right to explore for underground reservoirs suitable for storage (s32(1)(d)).
    - Depleted reservoirs are the main source of underground storage under an ATP.

- A Petroleum Lease (PL) authorises underground storage of petroleum (s109(1)(d)) and allows access to that storage facility by third parties (s205).

- The allocation procedure for PLs associated with storage activities is the same as for petroleum production (s109(1)).

- Royalties are payable when the gas is sold, and the point of sale determines whether they are paid before or after storage (s590 of the P&G Act and R147 of the P&G Regulations). Section 591 of the P&G Act exempts petroleum royalties from being paid more than once. It also exempts royalties being paid for petroleum produced outside the State and injected or re-injected into a natural underground reservoir in the State.

- A petroleum leaseholder must negotiate in good faith with a third party that proposes to use available capacity (s209(2) P&G Act).

- Owners of stored petroleum can claim the petroleum at the end of the lease (s213).

- PLs that are granted under the *P&G Act* are subject to a maximum of 30 years (s123(2)(b)).

The P&G Act does not allow for the storage of petroleum in artificially created caverns and petroleum safety provisions also do not consider artificially created underground cavern storage.

Legislative barriers to the development of a salt cavern gas storage facilities

Given that the salt deposit must be secured and that occurs under the Mineral Resources Act 1989 (MRA), it would seem logical for salt cavern development and use to be addressed in the MRA (which is precisely what is commonly done overseas).

Ownership rights for a created underground salt cavern storage facility are not explicitly defined in the Queensland petroleum legislation or the Mineral Resources Act 1989 (MRA). However, s8 of the MRA asserts the Crown's property in minerals and s10 states that the granting of a Mining Lease (ML) does not create an estate or interest in land.

A freehold landowner reserves ownership rights to an underground cavern (unless the land is unallocated State land, whereby the State retains ownership), except in relation to greenhouse gas storage reservoirs (s27 of the Greenhouse Gas Storage Act 2008 asserts the State's ownership of these storage reservoirs).

While a salt cavern storage proponent may mine the salt under a ML to create a cavern suitable for storage, the ML holder has no ownership rights to the cavern and cannot operate the cavern for petroleum storage purposes.

The right of the developer to inject, store and withdraw stored hydrocarbons:

Rights to mine salt and create a cavern are currently allocated separately to the rights to conduct gas storage activities. At present, an ML allocated under the MRA would be required to mine the salt, but a ML does not permit storage operations.

The P&G Act authorises storage operations to be conducted under a PL as described above. However, there is no scope to transition from a ML to a PL under either Act.

The lack of a clear transition from the development of a cavern to its operation as a storage facility is unacceptable for salt cavern storage proponents and developers. They are unable to invest in mining salt without some assurance that they will be able to operate the resultant cavern as a storage facility.

A further issue is that the P&G Act only refers to storage in 'natural' reservoirs, not created caverns.

Other Issues

It may be necessary to ensure that salt cavern storage is exempt from the need for development approval for a material change of use of premises per s3.2.1 of the Integrated Planning Act 1997 (Qld) (Schedule 9 exemption).

It appears that for salt cavern storage of gas to work, a framework would have to be developed to provide for all of the following:

- the development of a site into a cavern (i.e. mining);
- a clear definition of what is a created cavern (as opposed to natural reservoir);
- a legal mechanism allowing for the operation of the site for the purpose of storage; and
- certainty over which workplace health and safety regime would apply (at present, there is potential conflict over whether the safety provisions of the P&G Act apply, the Mining and Quarry Safety and Health Act 1999, or the Workplace Health and Safety Act 1995).

Gas Liquidity Factor

According to all generally accepted criteria, there is no meaningful liquidity in Qld's STTM. While the objective of creating the Wallumbilla gas hub remains a good one that will someday enhance Qld's gas industry, we are far from meeting that objective. Consequently, we will have to rely on gas storage facilities to balance out any and all variations in gas production and gas consumption or else simply accept a very inefficient gas supply chain. The latter is not acceptable given investment in an inefficient gas supply chain is waning across Australia. Gas pipeline line pack storage receives a lot of attention in Australia and yet this type of gas storage is generally considered to be only reliable for a few hours.

Furthermore, it has been the experience in North America and Europe that gas storage facilities are a pre-requisite to the development of meaningful STTM liquidity. Overall, more than two-thirds of the gas hubs in North America have access to some form of underground gas storage (refer to following Table). The total working gas capacity of accessible gas storage at gas hubs in North America exceeds 1,420 PJ's or about 36% and 79% of all the working gas capacity in the United States and Canada respectively. Expressed in terms of daily deliverability, this represents 31 PJ/d, or 35% of North American underground storage capability. Practically all the U.S. salt gas storage sites are accessible to gas trading hubs.

UGS Facilities @ 4 Major North American Gas Hubs

Hub	Commencement	# Intersecting Pipelines	# Connected UGS Facilities	UGS WGV (Bcf)
Henry, La, US	1988	12	3	130
AECO, AB, Canada	1990	N/A	10	365
Chicago, IL, US	1993	5	8	145
Leidy, Pa, US	1993	14	11	104

Source: Innovative Energy Consulting Various Sources

Wallumbilla is the logical major gas trading point in eastern Australia but it is doubtful that it will ever become a relevant gas pricing point without connecting to a number of high deliverability multiple cycle (HDMC) reservoir gas storage facilities or to a large state-of-the-art salt cavern gas storage facility. While multiple gas pipeline connections are necessary, that feature alone does not result in a truly bona fide gas trading hub that has a high churn rate and essentially provides a reliable STTM gas price upon which the gas industry can be confident that it is reliable and accurately reflects the current supply/demand balance. Wallumbilla currently has no open access high performance gas storage facilities connected to it.

Conclusion

The efficient recovery and the monetisation of Qld's resources in a manner commensurate with its endowment of each resource is also vital to wealth creation and has and continues to contribute to a large degree to the general economic and social wellbeing of all Queenslanders. This includes the development of export and domestic markets for Qld's gas and the attraction of capital to the upstream petroleum industry as

the cumulative gas production from Qld's vast and prospective geological basins remains relatively small compared to the in-situ hydrocarbon resources.

The lack of high performance (HDMC) open access underground gas storage capacity in Qld is a major deficiency in Qld's gas industry. The best option for such a capacity appears to be a gas storage facility that uses solution mined salt caverns like the ones that have been operating in Europe and North America for several decades. Studies performed by North American experts on the Boree Salt located in the Adavale Basin have confirmed that this salt is world class in every regard. Qld's regulations do not currently support such an activity for they create many barriers and much uncertainty.

The structure of Qld's gas industry at the moment is not conducive to a competitive healthy gas supply chain. Inefficiencies discourage unconventional gas exploration, development and production operations regardless of how attractive the geology and the prospective in-situ resources may be. The lack of liquidity in the STTM means that industry participants must rely exclusively on gas storage in order to balance mismatches between gas production and gas consumption or else simply endure the inefficient use of capital and intermittent operations. Addressing gas pipeline market power and abuse related thereto is also a pre-requisite for a vibrant gas storage sector in Qld.

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