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PRELIMINARY CONCEPTUAL MODELLING & ECONOMIC ANALYSIS OF THE HAZER PROCESS

- **Process modelling and comparative economic analysis of input and output commodities indicates that the Hazer Process has significant potential as a low cost, low emission hydrogen production process**
- **Potential 75% net commodity cost reduction compared to Steam Methane Reforming (SMR) process**
- **Significant (around 70%) reduction in CO_2 emissions relative to SMR**
- **Opportunity to produce hydrogen with near zero CO_2 emissions using renewable energy at an approximate 6x production rate compared to electrolysis-based systems**
- **Potential commodity cost savings for low emission hydrogen production compared to electrolysis-based systems**
- **Results are conceptual in nature and subject to the qualification as described in the final section of this release**
- **Supports the principle that Hazer could potentially have a significant competitive advantage in the global industrial hydrogen market, as well as providing cost effective solutions for clean energy applications.**

PERTH, AUSTRALIA; 28th FEBRUARY 2018: Hazer Group Ltd ("Hazer" or "the Company") (ASX:HZR, HZRO) is pleased to announce that preliminary process modelling and commodity cost analysis indicates Hazer offers a potentially significant competitive advantage in the global industrial hydrogen market, as well as providing cost effective solutions for clean energy applications.

OVERVIEW

Hazer has undertaken preliminary process modelling to simulate the potential application of the Hazer Process to produce hydrogen and graphite, and compared it to hydrogen production by competing processes Steam Methane Reforming (SMR) and electrolysis. SMR is currently viewed as the most commonly used and cost effective conventional hydrogen production process. Electrolysis is an alternative hydrogen production process that can use renewable energy for process energy requirements and produce hydrogen with near zero CO_2 emissions.

The purpose of this process modelling is to predict the performance of the Hazer Process and analyse the costs of commodity consumption required for hydrogen production.

The process modelling and analysis of the Hazer Process compared to SMR indicate that the Hazer Process has the potential for:

- the costs of commodity inputs (offset by revenue/credits from commodity outputs) required for hydrogen production to be around 75% lower than the equivalent costs associated with commodity inputs for hydrogen production using SMR.

- significant (around 70%) reduction in CO_2 emissions relative to SMR.

The process modelling and analysis of the Hazer Process compared to electrolysis-based systems indicate that the Hazer Process has the potential for:

- approximately 6x hydrogen production (per renewable energy unit) compared to electrolysis-based systems, while maintaining the same near-zero CO_2 footprint.

- the costs of commodity inputs required for hydrogen production to be potentially significantly lower than the equivalent costs associated with commodity inputs for hydrogen production using electrolysis-based systems.

The process modelling undertaken by the Company compares the costs of commodity inputs for hydrogen production using the Hazer Process, SMR and electrolysis systems. Credit or revenue from commodity outputs (graphite and a fuel gas product) associated with the Hazer Process have been included when comparing the costs of the Hazer Process against SMR and electrolysis systems. The process modelling does not include any other costs such as ancillary operating costs, incidental consumables and maintenance, labour and capital expenditure that would be incurred for any of these processes. As such the actual costs of hydrogen production for each process will be different to that indicated by the modelling.

PROCESS MODELLING ASSUMPTIONS AND PRODUCTS

The process modelling was developed based on the initial results obtained from research and development activities currently undertaken by the Company, and standard engineering and process design methodologies. Modelling scenarios assumed 50% conversion of methane feedstock into hydrogen and graphite on single pass basis, with further process modelling based on recirculation of unreacted natural gas to achieve 70% or 90% conversion of the methane feedstock.

In all scenarios, the Hazer Process is assumed to produce a graphite product of 85-90% purity, in line with observed production purities from the Company's reactor systems. The primary product from the Hazer Process is hydrogen, with secondary products of graphite concentrate, plus a "Fuel Gas" product consisting of unreacted natural gas (methane), and also some residual hydrogen

HAZER PROCESS VS. STEAM METHANE REFORMING

Most hydrogen produced today (95%) is made from fossil fuel-based production methods, which are mature and low cost, but environmentally damaging processes in which high temperatures are used to produce hydrogen from a hydrocarbon feedstock, with concomitant production of CO_2 in significant quantities. Steam Methane Reforming, the most commonly used fossil fuel reforming process using natural gas, typically produces 10-12 tonnes of CO_2 for every tonne of hydrogen produced.

To model comparison of the Hazer Process to SMR, a conceptual process flowsheet was developed as shown in Figure 1 below and a computer-based process model was developed to simulate potential process performance.

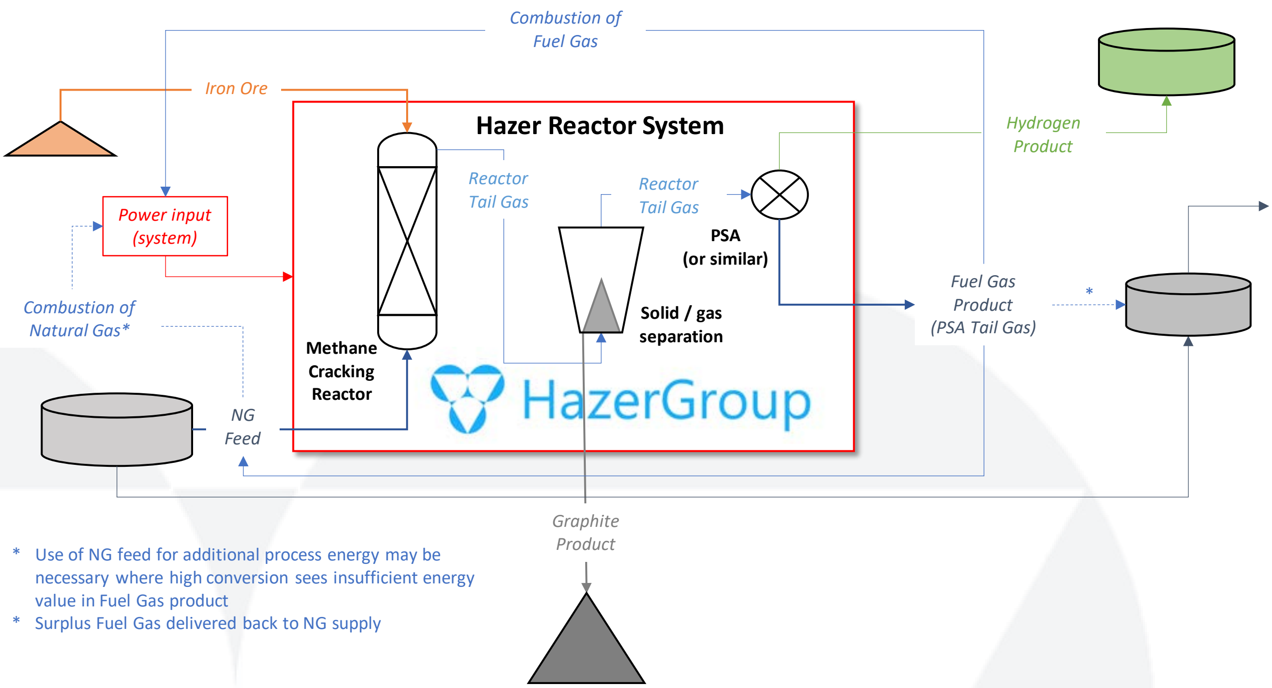

Figure 1: Conceptual process flowsheet for the Hazer Process simulation utilising Fuel Gas based energy for low cost H_2 Production

In this scenario, the Fuel Gas product generated by the Hazer Process, plus additional natural gas where necessary, is combusted to provide the process heat energy required for the underlying Hazer Process reaction.

This approach is designed to offer the lowest cost hydrogen production opportunity (based on consumed feedstocks only) for implementation of the Hazer Process, and as such offers a direct comparison to SMR or other CO_2 emitting hydrocarbon-based hydrogen production processes.

Like for like comparison of the Hazer Process and SMR indicates that the Hazer Process could deliver significantly lower commodity input/output costs relative to the equivalent commodity costs associated with SMR, while also reducing the emissions traditionally associated with SMR or other hydrocarbon-based production processes.

Typical gas consumption for SMR-based hydrogen production is in the range of 160 – 200 GJ (3.2 – 4.0 tonne) of natural gas per tonne of hydrogen, including gas used for conversion feedstock and process energy requirements. Assuming equivalent gas supply cost for the Hazer Process and SMR, and secondary revenue generation from the sales of graphite concentrate produced by the Hazer Process at an assumed price of A$500/tonne, the model indicates that the net consumables cost for hydrogen production using the Hazer Process could potentially be around **75% less than the equivalent costs of SMR.**

Modelling also highlights that under the same operating conditions, the Hazer Process would offer approximately **70% reduction** in CO_2 emissions compared to SMR-based hydrogen production.

HAZER PROCESS VS. ELECTROLYSIS

Lowering the CO_2 emissions associated with hydrogen production is critical for new hydrogen opportunities in the energy industry, including applications in fuel cell powered vehicles, clean electricity generation and synthetic fuels. The demand for low emission hydrogen production has seen increased interest in electrolysis-based hydrogen production using renewable electricity.

Electrolysis is a process that converts water into hydrogen and oxygen, a process which is currently estimated to account for less than 5% of the world's total hydrogen production. While electrolysis is potentially emission free, the process requires a significant external power supply to produce hydrogen.

To model comparison of the Hazer process to electrolysis, a process flowsheet was developed as shown in Figure 2 below and a computer-based process model was developed to simulate potential process performance. In this scenario, the Fuel Gas product generated by the Hazer Process is provided back to the natural gas supply or other gas users, and the process heat energy required for the underlying Hazer Process reaction is supplied by electrical heating options powered by renewable sources. Under this scenario, with the process energy required being provided by essentially CO_2 free electricity, the overall CO_2 footprint of the hydrogen production is negligible.

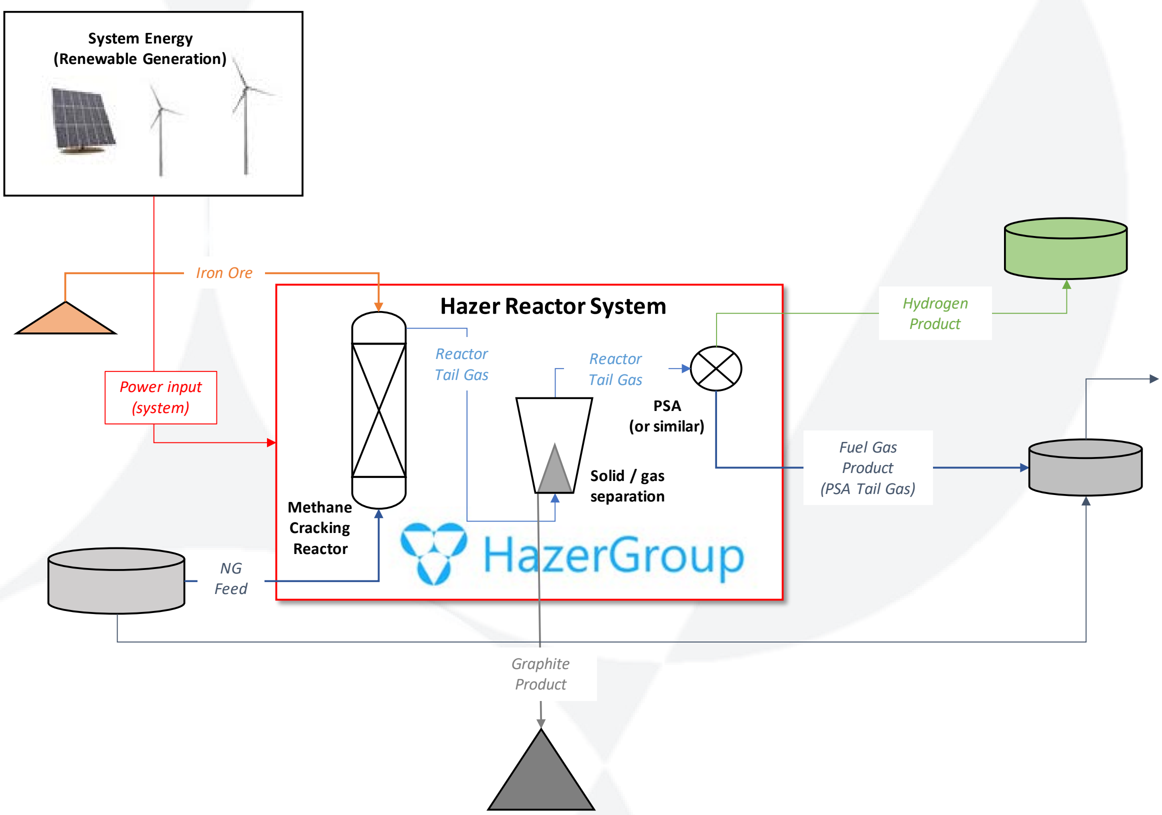

Figure 2: Conceptual process flowsheet for the Hazer Process simulation utilising renewable energy for low emission H_2 Production

Typical external power consumption for electrolysis-based hydrogen production is 60-70 MWhrs per tonne of hydrogen. Utilising the Hazer Process in this operating model, the net energy demand for hydrogen production is less than 10 MWhrs per tonne of hydrogen, indicating that by combining a renewable energy system with natural gas supply, Hazer-based hydrogen production could produce approximately **6x** the amount of hydrogen compared to electrolysis, with the same near-zero CO_2 emission footprint.

The combination of increased hydrogen production per renewable energy unit, plus potential secondary revenue generation from the sales of graphite concentrate indicates that the Hazer Process could potentially offer significantly lower net consumables costs for hydrogen production whilst providing the near-zero CO_2 emission hydrogen production profile preferred for hydrogen's adoption in the energy market.

Assuming natural gas pricing of A$8/GJ, and a sale price for graphite concentrate of A$500/tonne, the modelling shows that the Hazer Process could reduce the net consumables costs for hydrogen production by over 85% compared to electrolysis-based systems (based on power cost of A$100/MWhr). Without graphite sales, net consumable costs for hydrogen production would still be around **50%** of electrolysis-based systems using the same energy costs.

Managing Director Geoff Pocock said; *"These results show the clear and compelling potential benefits available to hydrogen producers by basing hydrogen production on the Hazer Process rather than Steam Methane Reformation or electrolysis production processes. These simulation and modelling results indicate that Hazer has a potential opportunity to create significant value through cost savings for producers in the $100bn pa global hydrogen industry, as well as offering cost competitive and low emission energy solutions"*

MODELLING AND ANALYSIS BASIS

The mass and energy balance modelling was undertaken using Aspen Plus, a market-leading chemical process modelling and optimization software package, commonly used for the design, operation, and optimisation of chemical manufacturing facilities. The process modelling is based on fundamental thermodynamics and engineering principles as well as data generated by the Company's development activities, to provide greater understanding of production ratios, commodity requirements and energy cost factors required for hydrogen production.

The results of process modelling for the Hazer Process under the different conversion scenarios are shown in Table 1 on the follow page, indicating the quantity of feedstocks and utilities required, and products produced.

Table 1: Mass and Energy feeds and outputs (per tonne of Hydrogen Product)[1,4]				
Hazer Process Overall Conversion	**(%)**	**50%**	**70%**	**90%**
Primary Product				
H_2 Product (99.999%)[2]	(t)	1.0	1.0	1.0
Graphite Product (85-90% w/w)	(t/t H_2)	5.0	4.4	4.1
Gas Input and Output				
Natural Gas Feed	(t/t H_2)	11.9	7.5	5.4
	(TJ/t H_2)	0.60	0.38	0.27
Output - Fuel Gas By-Product	(TJ/t H_2)	0.33	0.13	0.03
Net Gas (Energy) Consumption	***(TJ / t H_2)***	***0.27***	***0.25***	***0.24***
Other Feed				
Iron Ore feed	(t/t H_2)	1.02	0.90	0.83
Process Heating Duty	(MWhrs / t H_2)	9.26	8.23	7.67
Electricity (For Gas Compression)	(MWhrs / t H_2)	0.62	1.20	1.53

1. Values are calculated based on:
   a. 50% conversion of natural gas feed in reactor (single pass)
   b. Gas recycling to achieve higher overall conversions in some scenarios
   c. 80% hydrogen recovery rate in hydrogen purification unit
2. Hydrogen purity may be adjusted based on final application demands
3. Process heating could be fully / partially met through combustion of fuel gas product (rather than export of fuel gas), however this would increase systemic / overall CO_2 emissions footprint from residual CH_4 combustion.
4. These results are derived from computer simulation to model performance. The Company has not, to date, produced hydrogen or graphite in the quantities shown in this model.

These results remain preliminary and un-optimised, and there is expected to be further scope for optimisation in energy and process efficiencies as the process conditions and plant design are further developed.

ECONOMIC COST ANALYSIS

The above process modelling results have then been compared against commodity inputs required for alternative hydrogen production systems, being Steam Methane Reforming (SMR), globally being the most commonly globally used hydrogen production process, and electrolysis, which is being widely considered for the production of “green” hydrogen. Economic cost analysis has been undertaken on the basis of the mass and energy balance modelling results, commodity input costs and output product revenues only, and no allowance is made for capital costs and other operating costs.

Economic modelling was undertaken based on the two possible Hazer Process scenarios as shown in Figures 1 and 2 above. In all scenarios, the Hazer Process was modelled to produce a graphite product of approximately 85-90% purity, in line with observed production purity from the Company's reactor systems. The Fuel Gas was assumed to be re-delivered to existing natural gas distribution as a low-carbon natural gas product at a value equal to its underlying energy value (with no premium assumed to be associated with its lower carbon footprint). Base case modelling assumes that graphite concentrate (85-90% purity) has a benchmark value of A$500/tonne - this value is significantly lower than recent analyst estimates that suggest long term pricing for graphite concentrates (92-94%) of US$725/tonne (over A$900/tonne).

SENSITIVITY ANALYSIS

The modelling above is subject to a number of key assumptions, including overall methane conversion through the Hazer process, natural gas and renewable energy input pricing and the sale value / credit associated with both Hazer's raw graphite concentrate and the Fuel Gas product. Sensitivity analysis below has focused on the impact of input gas pricing and graphite revenue on comparison scenarios.

Sensitivity – Hazer vs. SMR

Figure 4 below shows the impact of changing gas prices and graphite values on the input commodity costs associated with the Hazer Process by comparison to SMR:

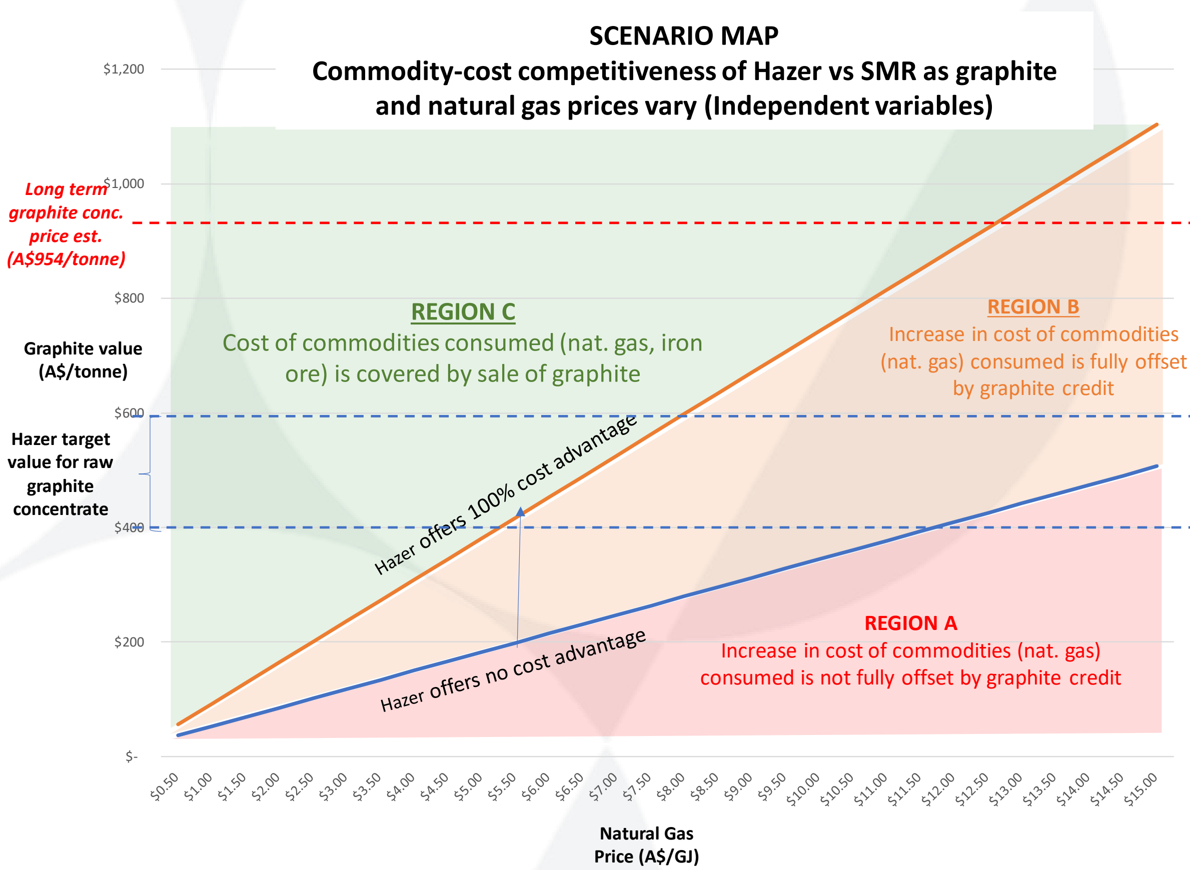

Figure 4: Sensitivity analysis comparing net consumables cost (gas cost less graphite credits) for the Hazer Process v SMR

At high gas prices and low graphite value (Region A), SMR provides cheaper hydrogen production commodity-costs due to insufficient revenue from graphite sales under the Hazer Process to offset the increased cost of natural gas. As the sale value of the graphite increases and / or the cost of natural gas decreases, the relative cost analysis changes to Region B, where the Hazer Process offers lower consumable commodity costs due to graphite sales offsetting the increased costs associated with natural gas consumption. As gas prices decline further and / or graphite values increase (Region C), the Hazer Process offers potentially commodity-cost "free" hydrogen production – where consumable commodities costs are fully offset by revenues from the sale of graphite.

The sensitivity analysis above suggests that the Hazer Process offers potential substantial cost savings where realised graphite prices of **A$400 – A$600** can be achieved. Sensitivity analysis also shows commodity costs for hydrogen production can be fully offset by graphite revenues within this lower price range where natural gas input costs are in the range of **A$5-A$8/GJ** or lower**.**

More substantial cost savings can be realised as gas prices decline and / or graphite values increase. Figure 4 also shows the recent market analyst estimates for long term graphite concentrate (92-94%, fine powder) of US$725/tonne (over A$900/tonne), and demonstrates the potential for a commodity-cost advantage by the Hazer Process over SMR at graphite values below this level.

Sensitivity – Hazer vs Electrolysis

Figure 5 below shows the required graphite price for Hazer consumables cost (natural gas, power and iron ore) to be cost competitive against consumables cost (power) for electrolysis-based hydrogen production systems.

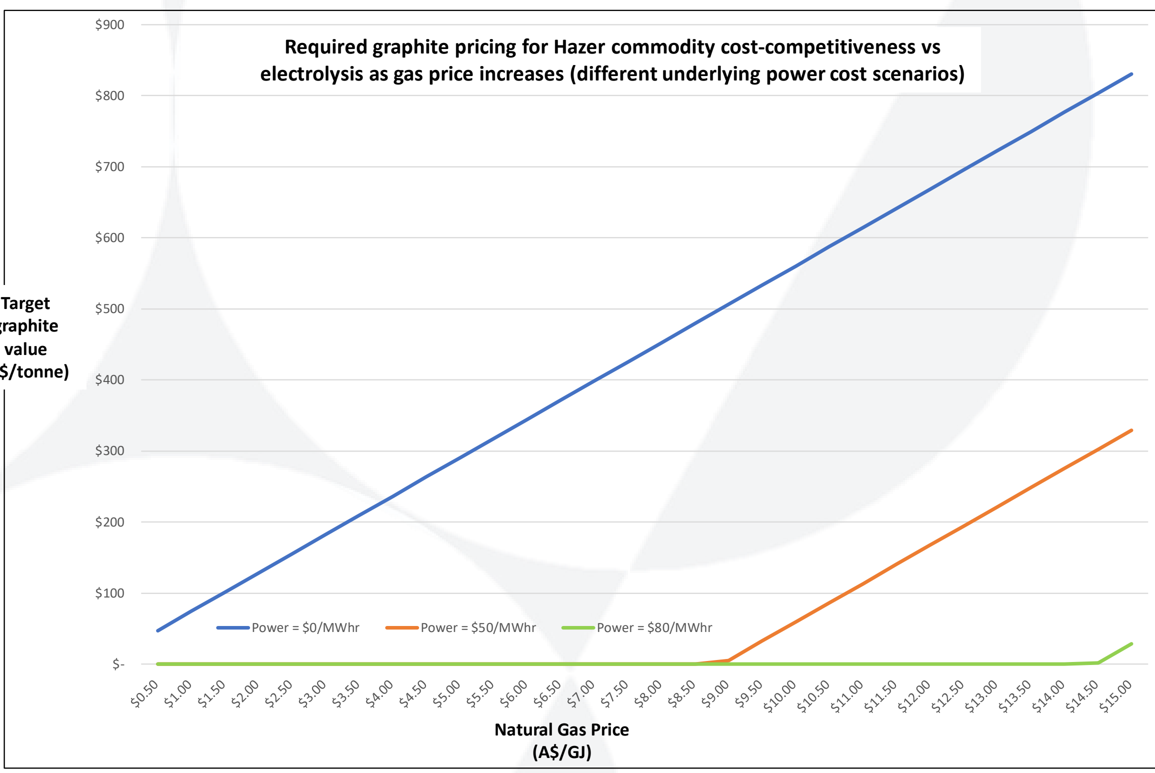

Figure 5: Sensitivity analysis - Graphite price required for commodity cost equivalence of Hazer Process v electrolysis for near-zero CO_2 hydrogen production

The analysis considers the relative input commodity costs for electrolysis (electricity equal to 60 MWhr / tonne H2) and the Hazer Process (being 10MWhr of electricity and 270GJ of natural gas). Where the net cost of the Hazer input commodities is greater than that for electrolysis, Figure 5 above shows the price per tonne of graphite needed to be realised to offset any increase in input commodity costs to enable the Hazer Process to be commodity-cost competitive. The analysis shows that once power costs become non-trivial (A$80/MWhr or more), then the Hazer Process offers lower commodity costs for hydrogen production irrespective of the value of the graphite produced.

Where power costs are significant (A$80/MWhr or more), the cost of the gas plus power associated with production via the Hazer process is less than the electricity cost of electrolysis at gas prices up to A$14.50/GJ. As electricity prices decline, the savings associated with the decreased electricity demands of the Hazer Process correspondingly decline, such that revenue from sales of graphite is necessary at lower gas price thresholds – for example at electricity price of A$50/MWhr, graphite revenue is necessary for commodity cost competitiveness when gas prices exceed A$9.50/GJ. Where electricity is available for no cost, then graphite sales are necessary to offset all costs of commodities required for hydrogen production via the Hazer Process.

Given the heavy electricity consumption required for the electrolysis process, only when that electricity is available for very low economic cost does electrolysis appear to be an economically preferred alternative.

QUALIFICATIONS

The process modelling referred to in this announcement is not a preliminary economic assessment or evaluation of the Hazer project. The process modelling and economic analysis has been undertaken to assess the comparative commodity input costs of the Hazer Process against two other well-known methods for hydrogen production. The analysis indicates the potential cost savings for hydrogen production by the Hazer Process and will assist the Company in its decisions regarding continued research and development, scale up and commercialisation of the Hazer Process and, ultimately to determine project viability. There is no certainly that further work will result in the cost savings indicated by the process modelling. Further evaluation work and appropriate studies are required to establish sufficient confidence in the project viability of the Hazer Process.

The process modelling and initial analysis of input and output commodities undertaken by the Company are encouraging and indicate that the Hazer Process has significant potential as low cost, low emission hydrogen production process compared to two known hydrogen production processes.

However, it is important to note that this is not a scoping study of the potential technical and economic viability of the Hazer Process. It is a theoretical process modelling and computer simulation to indicate performance of the Hazer Process against SMR and electrolysis-systems.

The economic cost analysis is not intended to be forecast financial information. The potential cost savings referred to in this announcement are conceptual and are based on assumed commodity cost inputs and scenario assumptions as set out in this announcement. The process modelling referred to in this announcement does not include any other costs such as ancillary operating costs, incidental consumables and maintenance, labour and capital expenditure that would be incurred for the Hazer Process, SMR or electrolysis-based processes.

While the Company considers that the material assumptions relevant to the theoretical model are based on reasonable grounds, there is no certainty that they will prove to be correct or that the range of outcomes indicated will be achieved. Further research, development and scale up work for the Hazer Process are required before the Company can evaluate the technical and economic assessments for the Hazer Process and consider project viability.

Given the theoretical nature of the modelling, investors should not make investment decisions based solely on the results of the process modelling and cost analysis referred to in this announcement.

[ENDS]

ABOUT HAZER GROUP LTD

Hazer Group Limited ("Hazer" or "The Company") is an ASX-listed technology development company undertaking the commercialisation of the Hazer Process, a low-emission hydrogen and graphite production process. The Hazer Process enables the effective conversion of natural gas and similar feedstocks, into hydrogen and high quality graphite, using iron ore as a process catalyst.

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