

ECT Chairman attends JOGMEC seminar on hydrogen from Latrobe Valley brown coal

13 May 2019: Environmental Clean Technologies Limited (ASX: ECT) (ECT or Company) is pleased to announce it had the honour of being invited to the Japan Petroleum, Natural Gas and Metals Mineral Resources Organisation (JOGMEC) as part of a Victorian government event in Tokyo on Friday 10 May 2019.

Key points:

- ECT attends alongside Victorian government and Latrobe Shire representatives
- Hydrogen industry focus
- Coldry and COHgen technologies of greatest interest

Japan is investing heavily in hydrogen, viewing the element as central to its future energy security.

ECT presented a compelling overview of its technologies (attached), highlighting the fundamental importance of efficient, cost-effective drying as the 'gateway' enabler of higher-value, low or zero emission applications for Victoria's vast, world-class lignite reserves.

The event, focused on coal-to-hydrogen, was hosted by Atsushi Ikeda, General Manager, JOGMEC Metals & Coal Business Support Division, who introduced the following presenters:

- Ms Jane Burton, Acting Executive Director, Earth Resources Policy and Programs, Department of Jobs, Precincts and Regions, Victorian Government
- Mr Ian Filby, Project Director, The CarbonNet Project, Department of Jobs, Precincts and Regions
- Mr Roland Davies, Chair, Energy Resources Working Group, Gippsland Regional Partnership
- Darren Howe, Deputy Mayor, Latrobe City Council

ECT's Chairman, Mr Glenn Fozard was the only Australian project proponent in attendance as Mr Roland Davies outlined the Latrobe Valley's advanced lignite upgrading and conversion project pipeline.

Specifically, ECT's Coldry technology was profiled as a cost-effective, zero-CO₂ drying process that could harness waste heat from, in the case of hydrogen, a gasification plant. Drying lignite prior to gasification is essential.

In addition, the Company provided an overview of its catalytic organic hydrogen generation process (COHgen), an emerging technology aimed at the lower cost, lower emission generation of hydrogen from lignite.

Mr Fozard, who himself went to school in Japan when he was 17, conveyed the technical and commercial fit of ECT's suite of technologies with Japan's coal-to-hydrogen objectives.

Mr Fozard commented, "As a private sector listed company, we were honoured to be invited to what is ostensibly a Victorian government event arranged to support the ongoing engagement with Japanese business via its key industry body, JOGMEC, with the view to advancing investment in low carbon, high value applications for Victoria's lignite resource.

“Now that JOGMEC and Japanese corporations have met us and understand what our company can offer, we’ll be developing these relationships with a number of these Japanese companies to further discuss opportunities for our technologies.”

Mr Ian Filby, Project Director of CarbonNet outlined the critical role that Carbon Capture and Storage (CCS) will play in commercialising hydrogen produced from the Latrobe Valley’s brown coal.

Mr Fozard continued, “Whilst in its early stages of development, COHGen represents a massive potential cost saving to hydrogen producers given the nature of how we extract the hydrogen-rich syngas from the coal; keeping most of the carbon fixed by not turning that carbon gaseous.”

Hydrogen production cost, including CCS as cited by Mr Filby, is around \$3.00/kg. Without the requirement to capture CO₂ the cost is estimated to be closer to \$1.50/kg. COHGen provides the hydrogen industry the opportunity to minimise CO₂ emissions upfront, significantly mitigating the cost of CCS. The challenge for ECT will be to see how close it can get COHGen to zero-CO₂ emissions.

The Role of Lignite in the Hydrogen Industry

The hydrogen industry is attracting bi-partisan support from the two major Australian political parties with programs in place at both State and Federal level to encourage development of what is touted as a potential AUD10 billion export market by 2030 for Australia in what may become an AUD2.5 trillion market globally by 2050.

Both ‘green’ and ‘brown’ hydrogen production routes are being explored, with Australia’s Chief Scientist, Alan Finkel coming out in support of ‘green’ hydrogen while acknowledging the need to rely on ‘brown’ hydrogen as a stepping stone due to its lower cost and shorter timeframe to commercial scale deployment.

‘Green’ hydrogen production relies on ‘spare’ wind or solar power to split water molecules via a process called electrolysis, to make it economic. However, ‘spare’ wind or solar electricity is ultimately paid for by domestic electricity consumers, essentially subsidising hydrogen production for export.

Electrolysis requires a lot of electricity, making it very expensive at large scale, hence the concept of ‘spare’ wind or solar electricity is essential to bringing that cost down because it’s energy that would otherwise go to waste if not used. Use of dedicated wind and solar energy to make hydrogen for a large export market is presently, and for the foreseeable future, uneconomic.

As an example, in 2016-17, South Australia experienced ‘spare’ wind output for 139 hours, spread across 30 days¹, or less than 2% of the time.

Unfortunately, AUD10 billion worth of hydrogen exports would require ~93TWh of electricity, equivalent to 35,000MW of new dedicated wind capacity. The figures for solar are much worse.

For context, current installed wind capacity in Australia is ~5,600MW with a further ~5,700MW under construction or financially committed as at the end of 2018, worth ~AUD8 billion².

As such ‘green’ hydrogen production cannot scale to reliably meet export production quotas while retaining the cost benefit of ‘spare’ wind and solar electricity economics.

‘Brown’ hydrogen is proposed to be produced from brown coal via a method similar to that of the currently dominant ‘steam reforming’ process which uses natural gas and water as its raw materials (accounting for

¹ Source: AEMO report - SOUTH AUSTRALIAN RENEWABLE ENERGY REPORT, November 2017

² Source: <https://www.cleanenergycouncil.org.au/resources/technologies/wind>

>90% of the current hydrogen market). The idea being, brown coal is a cheaper raw material than natural gas, and cheaper than electrolysis.

According to CarbonNET, presenting at the event, hydrogen production costs are expected to be as follows:

Reference		Electrolysis	Coal gasification + CCS
World Energy Outlook 2018	Current	5.60-8.40	3.15
	Best Case (2040)	4.80	3.15
CSIRO Hydrogen Roadmap August 2018	Current	4.78-5.84 (Alkaline cell)	2.57-3.14
		6.08-7.43 (PEM)	
	Best Case	2.54-3.10 (Alkaline Cell)	2.14-2.74*
		2.29-2.79 (PEM)	
Hydrogen in a Low Carbon Economy, UK Committee on Climate Change November 2018	Current	5.40	4.08
	Best Case (2040)	2.65-4.60	3.20-4.30

Notes:

- *from Brown Coal
- PEM – Polymer Electrolyte Membrane
- All costs in AUD/kg of hydrogen

The flagship coal-to-hydrogen project in Australia is the Japanese-led Hydrogen Energy Supply Chain (HESC) consortium, with support from the Australian Federal and Victorian State governments, which has embarked on an AUD500 million project; a world-first pilot project to safely and efficiently produce and transport clean hydrogen from Victoria's Latrobe Valley to Japan.

HESC aims to establish an integrated commercial-scale hydrogen supply chain that encompasses production, transportation and storage, with the goal of delivering liquefied hydrogen to Japan.

According to HESC's website, the project will be developed in two phases:

1. The **pilot phase** will demonstrate a fully integrated supply chain between Australia and Japan over one year by 2021.
2. The decision to proceed to a **commercial phase** will be made in the 2020s with operations targeted in the 2030s, depending on the successful completion of the pilot phase, regulatory approvals, social licence to operate and hydrogen demand.

ECT broadly sees an opportunity to provide its Coldry and (after further development) COHgen technologies to the hydrogen production industry, delivering innovative lignite drying and hydrogen production methods, reducing cost and CO₂ intensity.

For further information, contact:

Glenn Fozard – Chairman info@ectltd.com.au

About ECT

ECT is in the business of commercialising leading-edge energy and resource technologies, which are capable of delivering financial and environmental benefits.

We are focused on advancing a portfolio of technologies, which have significant market potential globally.

ECT's business plan is to pragmatically commercialise these technologies and secure sustainable, profitable income streams through licensing and other commercial mechanisms.

About Coldry

When applied to lignite and some sub-bituminous coals, the Coldry beneficiation process produces a black coal equivalent (BCE) in the form of pellets. Coldry pellets have equal or superior energy value to many black coals and produce lower CO₂ emissions than raw lignite.

About Matmor

The Matmor process has the potential to revolutionise primary iron making.

Matmor is a simple, low cost, low emission production technology, utilising the patented Matmor retort, which enables the use of cheaper feedstocks to produce primary iron.

About the India R&D Project

The India project is aimed at advancing the Company's Coldry and Matmor technologies to demonstration and pilot scale, respectively, on the path to commercial deployment.

ECT has partnered with NLC India Limited and NMDC Limited to jointly fund and execute the project.

NLC India Limited is India's national lignite authority, largest lignite miner and largest lignite-based electricity generator.

NMDC Limited is India's national iron ore authority.

Areas covered in this announcement:

ECT (ASX:ECT)	ECT Finance	ECT India	India Project	Aust. Project	R&D	HVTF	Business Develop.	Sales
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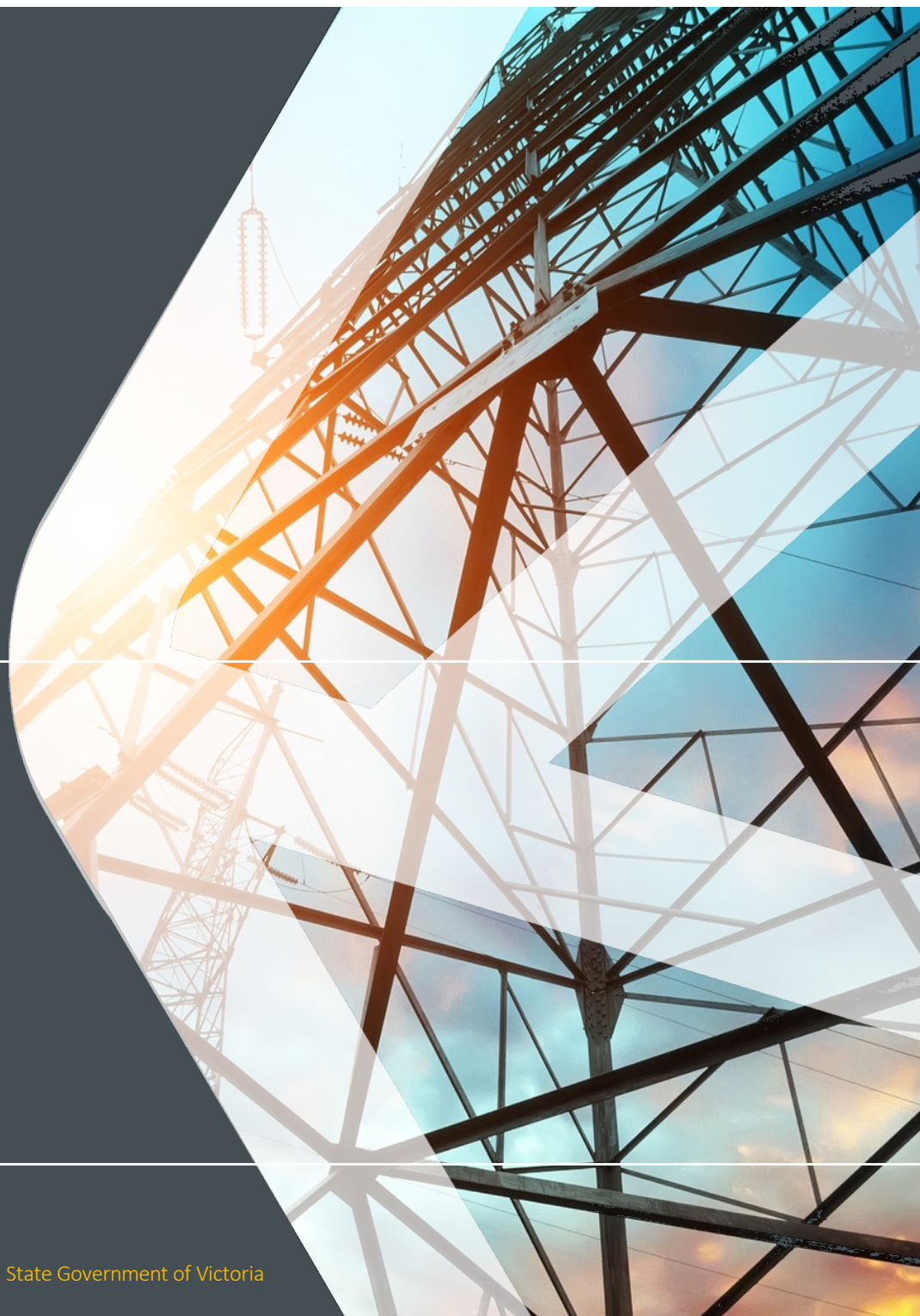
ENVIRONMENTAL CLEAN
TECHNOLOGIES LIMITED

排出のない亜炭の化学
に向かって

Capturing the chemistry of
lignite without the
emissions

*“Bridging the gap between today’s use
of resources and a zero-emissions
future.”*

May 2019



始めまして

Nice to meet you

1991年に1年間富山県の石動高校で勉強させて頂きました。

In 1991 I attended Isurugi High School in Toyama prefecture as an exchange student for 1 year.

それまでは日本語が全く話せなかったのに、その時に出来た彼女のおかげで覚えた日本語は、少し「田舎臭い」富山弁とよく言われました。

Since then, I haven't had much of a chance to use Japanese but Japanese people often say that my pronunciation is excellent although with a strong country dialect.

日本で過ごした1年は、私の人生にとって非常に大切な経験です。日本・オーストラリアの関係兼ビジネスをより円滑に行わせたいと思っています。

The year I spent in Japan has been very influential on my life and I look forward to an opportunity where I can unite Australian and Japanese mutual interest through ECT's technologies.

よろしくお願いいたします。

Best regards.



Glenn Fozard グレン・フォザード
Chairman ECT代表取締役社長
Environmental Clean Technologies Ltd.

Overview

Targeting lignite for its valuable chemical constituents

褐炭・亜炭からより価値のある化学物質を作る

1



THERMAL
FUEL

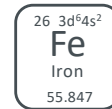
Coldry

TRL 8-9

低コスト褐炭・亜炭を使った排出量ゼロアップグレードーションテクノロジー。

化学業界に最も適切兼安価な原料。

3



IRON
&
STEEL

Matmor and HydroMOR TRL 6-7

低品質鉄鉱石と褐炭・亜炭を原料とした低排出・低温テクノロジー製鉄。

高品質な鉄鉱石と無煙炭に代わる原料。

2



HYDROGEN

COHgen

TRL 2-3

褐炭・亜炭から水素を抽出する低排出テクノロジー。

炭素のガス化を抑えたまま水素を抽出。二酸化炭素の回収・貯留が不要。

4



DIESEL

Waste-to-Energy

TRL 5-6

水分を取り除かれた褐炭とリサイクルごみを利用したディーゼル製造技術。

可燃ごみを利用した低温・低圧「発エネルギー」テクノロジー = 世界で最低排出量のごみからエネルギーへのテクノロジー。

Overview

Targeting lignite for its valuable chemical constituents

褐炭・亜炭からより価値のある化学物質を作る

1



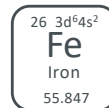
THERMAL
FUEL

Coldry

TRL 8-9

Mechanical and chemical process of de-watering high moisture content lignite. Coupled with access to low-grade waste heat, delivers a zero net emission solution to essential upgradation of brown coal for more efficient downstream usage. This is ECT's "Gateway" solution.

3



IRON
&
STEEL

Matmor and HydroMOR

TRL 6-7

Coupled with Coldry, the process produces a composite pellet that combines lignite and waste iron ore sources. These pellets are fed into a vertical retort to produce a Direct Reduced Iron product suitable for the melt stage of steel production. The process operates at considerably lower temperatures and the use of readily abundant, low-cost feedstocks delivers superior economic returns in comparison to conventional primary iron processes.

2



HYDROGEN

COHgen

TRL 2-3

Coupled with Coldry, the process produces a composite pellet that combines a unique catalyst with lignite. These pellets are fed into a vertical retort to produce a hydrogen heavy syngas, leaving most of the carbon fixed in the pellet. Low carbon emission production of hydrogen aims to eliminate Carbon Capture and Storage.

4



DIESEL

Waste-to-Energy

TRL 5-6

Currently finalising a HOA for the acquisition of this type of technology, ECT is aiming to develop a unique and continuous process for the low-temperature and low-pressure catalytic depolymerisation of Coldry pellets combined with other waste feedstocks like construction wood and end of life plastics to produce diesel, bitumen and asphalt. Lignite's chemical properties, once converted to Coldry, act as a feedstock stabiliser in the conversion of waste streams to transportation diesel.

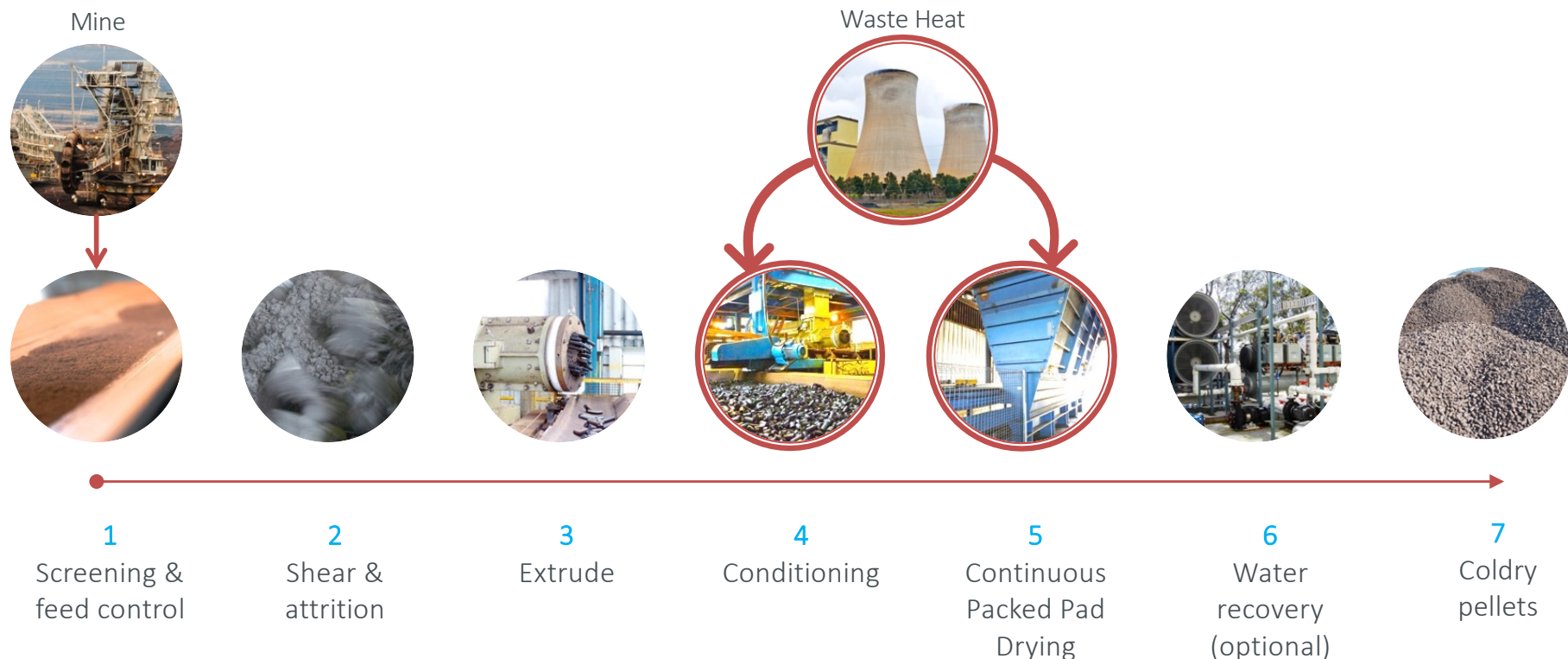
1 | Coldry Process: cost-effective lignite drying

- Low temperature
- Low pressure
- 60% moisture to <15%
- Zero direct CO₂ emissions

“One distinct advantage of Coldry is the relative low heat requirements in the drying process, allowing for the opportunity to make use of waste heat from an industrial facility or power plant.”

Dr Victor Der

Former Assistant Secretary for Fossil Energy, US Dept. of Energy
General Manager, North America, Global CCS Institute



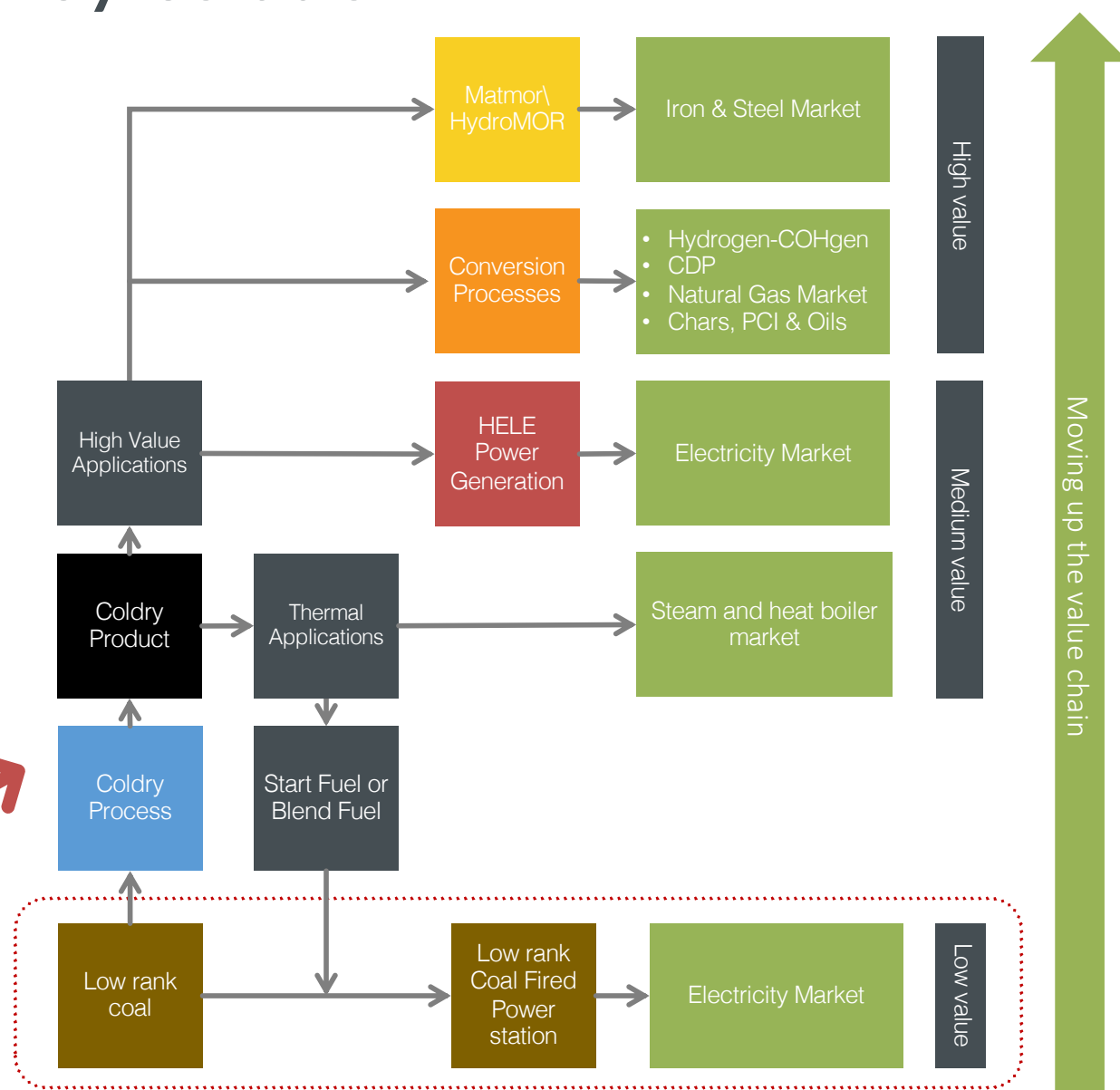
1 | Coldry: the 'gateway' solution

Value Proposition

- Opens new markets
- Establishes new revenue streams
- Diversifies energy and resource options
- Upward revaluation of stranded or low value low rank coal assets
- Enhanced efficiencies
- Mitigate CO₂ emissions

Cost-effective low rank coal drying is the 'gateway' enabler.

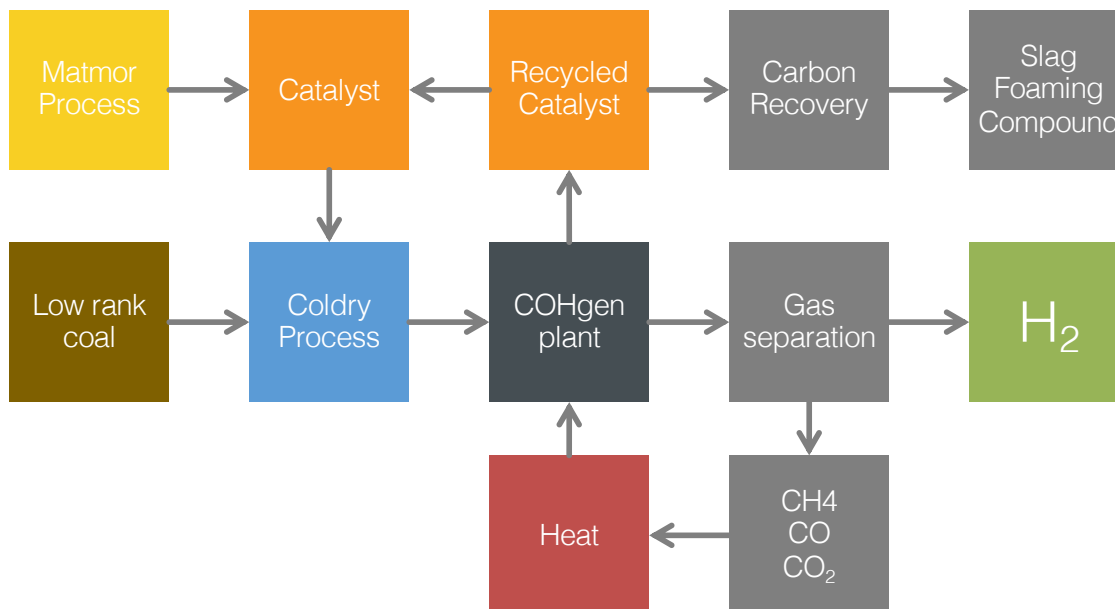
Traditional utilisation pathway is 'low value'.



2 | COHgen Process: hydrogen production

Features

- Low temperature
- Lower CO₂ emissions than natural gas steam reforming process
- >50% H₂ concentration in gas stream
- Low cost feedstock - lignite
- Replace natural gas
- Scalable
- Cheap, abundant catalyst
- Catalyst reusable
- Majority of carbon captured in solid form



3 | Matmor Process: primary iron production



Matmor employs a hydrogen-based chemical reduction pathway, making it the world's **first** and **only** low temperature, low rank coal-based iron making process.

Inputs

Iron ore
waste streams

Low-rank coal



Waste
Heat

1
Mix &
extrude

2
Condition

3
Low temp
drying

4
Composite
pellets

5
Matmor
Retort

6
DRI
pellet

7
Steel
refining
(Electric
Arc
Furnace)

8
Casting

9
Finished
steel
product

3 | Matmor Process: benefit comparison

→ Lower Temperature

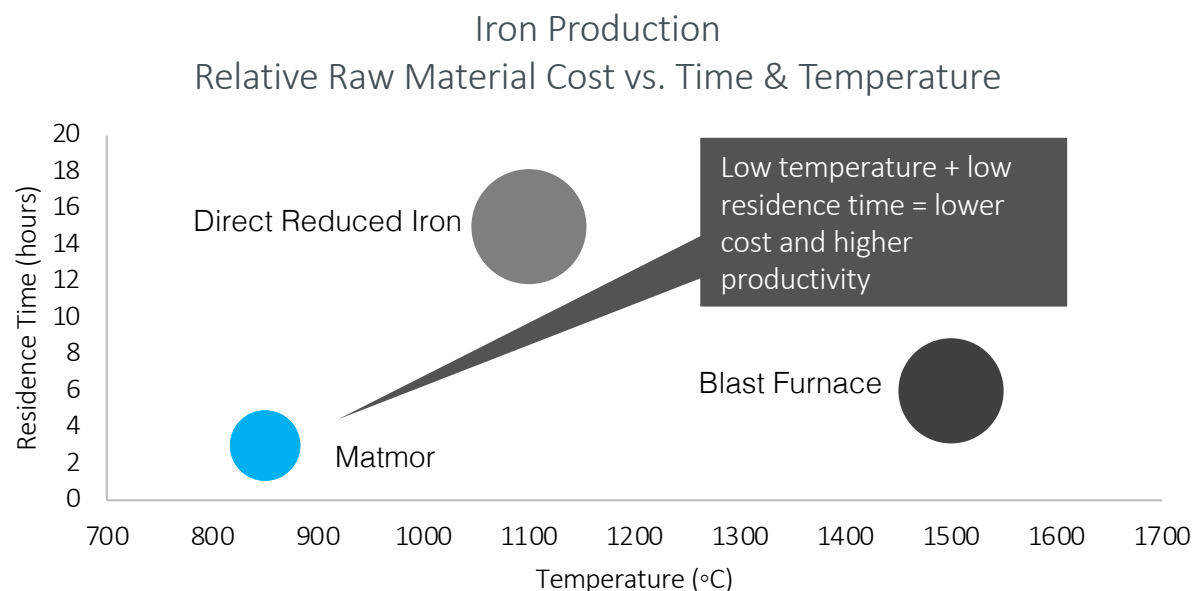
Temperature is a proxy for asset capital intensity

→ Lower residence time, higher productivity

Residence time is a proxy for asset productivity

→ Lower Cost Inputs

Bubble size represents 'Relative Raw Material Cost'

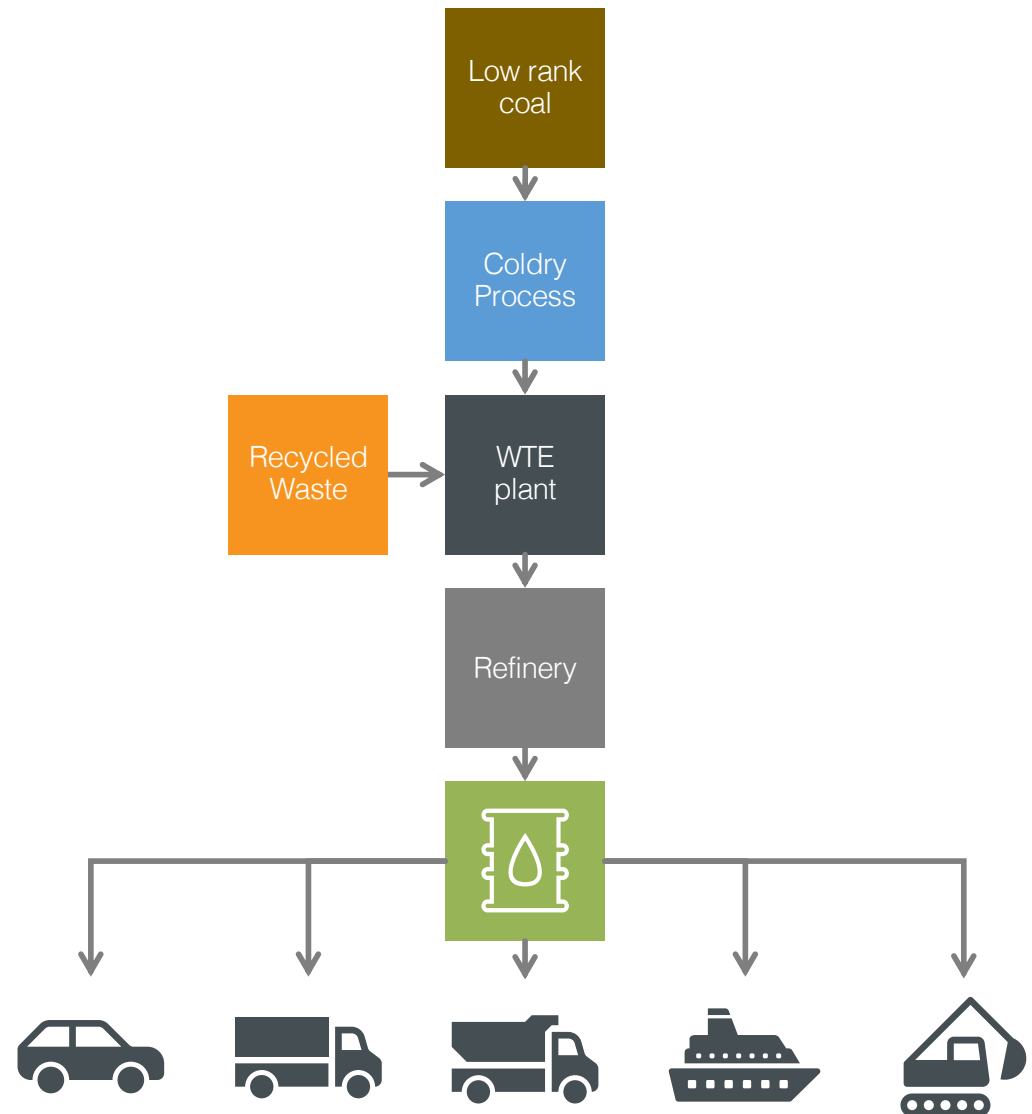


	India - Traditional	India - Alternative	ECT
	Blast Furnace Basic Oxygen Furnace	Coal based Direct Reduced Iron Kiln Electric Arc Furnace	Coldry & Matmor Electric Arc Furnace + power generation
Case/Scenario	Base Case	Base Case	Mid Case
CAPEX (Index)	100%	90%	64%
OPEX (Index)	100%	106%	86%
SALES (Index)	100%	109%	104%
ROI (Index)	100%	130%	250%

4 | Waste-to-Energy (WTE)

As part of the feasibility of the Latrobe Valley project, ECT is exploring a unique continuous process for the low-temperature and low-pressure depolymerisation of Coldry pellets combined with other waste feedstocks, like construction wood and end-of-life plastics, to produce diesel, bitumen and asphalt.

Prospectively, lignite's chemical properties, once converted to Coldry, act as a feedstock stabiliser in the conversion of these other waste streams into transportation diesel.



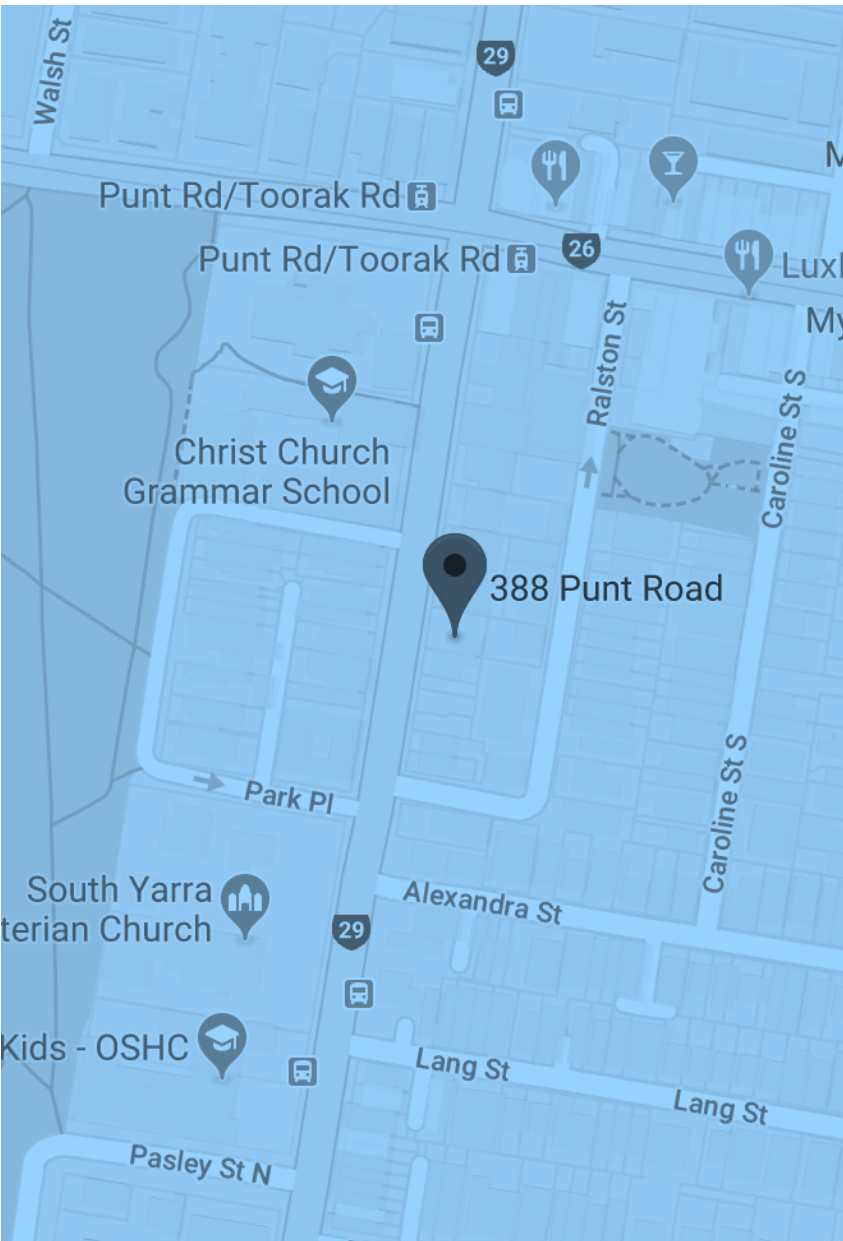
Projects

ECT is pursuing a multi-staged approach to the research, development and commercialisation of its unique technologies.

COHgen is currently proceeding through laboratory testing and patent preparation.

Coldry, W2E and Matmor are targeting commercial-scale demonstration:

Coldry Pilot Plant & R&D Facility	Integrated Coldry-WTE Commercial Demonstration Plant	Integrated Coldry-Matmor Demonstration Plant
<p>High Volume Test Facility and domestic solid fuel sales up to 35,000 tpa</p> <p>Bacchus Marsh, Victoria, Australia</p> <ul style="list-style-type: none"> ✓ Local steam, hot water and process heat industry ✓ Optimisation of fuel mix ✓ Maximise boiler efficiency ✓ Multi-feedstock flexibility ✓ Inbuilt fuel security ✓ Reduce CO₂ emissions ✓ Reduce total cost of operation ✓ Reduce business disruption ✓ On going R&D capability 	<p>Development of a 170,000 tpa Coldry with downstream Waste-to-Energy</p> <p>Latrobe Valley, Victoria, Australia</p> <p>Integrated Coldry and waste-to-energy (WTE) process</p> <ul style="list-style-type: none"> ✓ Enhanced process synergies ✓ Higher-value outputs ✓ Better environmental outcomes ✓ Liquid fuel sales ✓ Solid fuel sales ✓ Zero-emission lignite drying via Coldry 	<p>Partnership with NLC India Limited and NMDC Limited for the scale up and commercialisation of the worlds only lignite-based, hydrogen-driven iron making process</p> <p>Neyveli, Tamil Nadu, India</p> <p>Phase 1: R&D stage</p> <ul style="list-style-type: none"> ✓ AUD35 million ✓ Largest ever R&D project between Australia and India <p>Phase 2: Commercial stage</p> <ul style="list-style-type: none"> ✓ Initial 500,000 tpa integrated steel plant ✓ AUD300 million ✓ International flagship project



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Reference #1 | Technology Readiness Levels (TRL)

As originally developed by NASA, technology readiness levels (TRL) are a method of estimating technology maturity of Critical Technology Elements (CTE) of a technology.

They are determined during a Technology Readiness Assessment (TRA) that examines program concepts, technology requirements, and demonstrated technology capabilities.

TRLs are based on a scale from 1 to 9 with 9 being the most mature technology.

The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology.

TRL	Maturity Stage	Where work is done	Funding level required (conservative)
TRL 1	Basic technology observation and research	Universities, Research Labs	At least \$10K
TRL 2	Basic Technology Research – Research to prove feasibility	Universities, Research Labs	\$10K - \$100K
TRL 3	Research to prove feasibility – Technology development	Universities, Research Labs	\$10K - \$100K
TRL 4	Various stages of technology development	Universities, Research Labs, Development Service Providers	Up to \$100K
TRL 5	Late technology development – Technology demonstration	Development Service Providers Production Foundry, Assembly/Test House	Up to \$1M
TRL 6	Technology demonstration – System/subsystem development	Development Service Providers Production Foundry, Assembly/Test House Product Company	\$1M to \$10M
TRL 7	Final technology demos to system/subsystem development	Development Service Providers Production Foundry, Assembly/Test House Product Company	\$1M to \$10M
TRL 8	System/subsystem development to early stages of system proven through test, launch & operations	Production Foundry, Assembly/Test House Product Company	Up to \$10M or more
TRL 9	System proven through test, launch & operations	Production Foundry, Assembly/Test House Product Company	>\$10M

Reference #2 | What's in a name?

Coldry

Coldry is the combination of the words, Cold and Dry. Given the relative low-grade waste heat used (i.e. <50°C) the Coldry process dries lignite economically and continuously. A feat that typically uses large amounts of paid thermal energy and/or pressure.

Matmor/HydroMOR

The “MOR” in both names refers to “Metal Oxide Reduction”. The transition from Matmor to HydroMOR, reflects our increased knowledge of the key chemical processes occurring to reduce the metal. Namely, the decomposition of hydrocarbons into a hydrogen-rich syngas which allows for a more efficient and lower emissions reduction process.

COHGen

COHGen is short for, Catalytic Organic Hydrogen **Generation**. We are the pre-patent stage of this technology’s development so no more can be divulged at this time.

Waste-to-Energy

At this stage, we cannot disclose the proprietary name given to this technology. ECT is investigating the acquisition of this technology and further updates will be forthcoming.