PITT STREET RESEARCH

Environmental Clean Technologies

A promising cleantech play

Share Price: A$0.001

ASX: ECT

Sector: Commercial & Professional Services

13 November 2019

ECT has been built on a 'clean coal' technology

The company's leading technology, called 'Coldry', allows the transformation of low-grade brown coal into a product with qualities closer to high-grade black coal. A related technology called Matmor allows primary iron to be made using lignite instead of coking coal. ECT has recently started to move into the waste-to-energy space with a technology called CDP-WTE.

Currently addressing later- stage cash flows

ECT from 2015 to 2019 collaborated with two Indian semi-state-owned companies on developing Coldry and Matmor plants in India, however this collaboration failed to yield commercial results before ECT withdrew. ECT is currently executing on an alternate value creation strategy it outlined in September 2019 which involves expanding and upgrading the Bacchus Marsh Coldry facility for end-products beyond coal in addition to the company's move into the waste-to-energy sector. This may include other acquisitions currently being discussed internally. We think the move towards later-stage commercialisation of cleantech opportunities will be welcomed by new and old shareholders. There also remains the potential for ECT to obtain new public or private sector backing to develop Matmor plants in India.

Now a player in the waste-to-energy space.

Recently ECT has moved to into the waste-to-energy space, where there is potentially a shorter lead-time to commercialisation and higher finished product margins. In June 2019 the company announced that it had acquired a waste-to-energy technology. The technology, called CDP-WTE, has the potential to provide a low-cost way to process wood, end of life plastics and other wastes into diesel fuel, particularly when the feedstock is combined with fuel produced from the Coldry technology. ECT has also recently diversified its exposure to the solid fuel market with the inclusion of recycled and waste wood products.

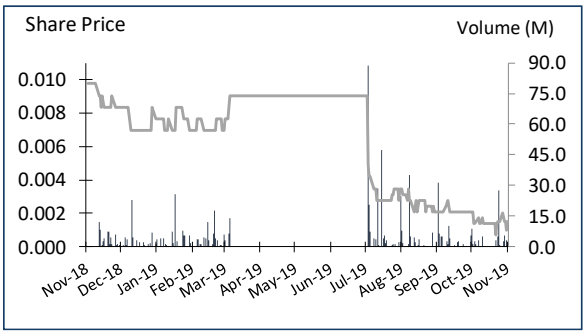
The current rights issue potentially funds for the company to cash flow break even.

ECT's rights issue, announced in October 2019, will raise a minimum A2.75m and up to A$7.45m. 1.55 new shares at 0.1 cent per share will be offered for everyone 1 share held. For every three shares taken up ECT will issue a three-year option exercisable at 0.3 cents. This raising can potentially fund the company to cash flow breakeven, should the September 2019 strategy be successfully executed.

Market Cap. (A$ m)	4.8
# shares outstanding (m)	4,800.5
# share fully diluted	4,800.5
Market Cap Ful. Dil. (A$ m)	4.8
Free Float	100%
12 months high/low ($)	0.011 / 0.001
Average daily volume ('000)	2.9
Website	ectltd.com.au

Source: Company, Pitt Street Research

Share price (A$) and avg. daily volume (k, r.h.s.)



Source: Thomson Reuters, Pitt Street Research

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This report serves as an initial introduction to Environmental Clean Technologies and its various technologies and market opportunities. We will endeavour to publish a more in-depth report shortly, including a full financial model and valuation range, highlighting the financial opportunity for Environmental Clean Technologies and its investors.

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Introducing Environmental Clean Technologies

Environmental Clean Technologies (ASX:ECT) is a Melbourne-based company developing a suite of technologies designed to upgrade waste and low grade resources with low carbon emissions. The company's leading technology, called 'Coldry', allows the zero net emissions transformation of low-grade brown coal into a product with qualities closer to high-grade black coal. Coldry provides the base technology platform upon which its other technologies are then integrated. ECT has developed a Coldry pilot plant at Bacchus Marsh in outer Melbourne and has looked to develop commercial-scale plants in Australia and India. The company also has technology which produces low emission/low cost primary iron and low emission hydrogen production technology. ECT has recently started to move into the waste-to-energy space.

ECT in its current form has largely been built on Coldry and Matmor/HydroMOR. The company's work on Coldry began in 2006[1] with the acquisition of Asia Pacific Coal and Steel Pty Ltd, which held the rights to the Coldry technology, and a related iron-production technology called Matmor[2]. ECT spent the next twelve years largely focused on developing the Coldry and Matmor technologies, with a goal to establishing large-scale commercial Coldry and Matmor plants in Victoria and in India for producing high value solid fuel and primary iron. These commercial projects have completed feasibility and basic engineering design phase.

Early development of COHGen allows ECT to play into the hydrogen production market. This technology, which ECT first unveiled in November 2017, allows hydrogen production from lignite. Given the rise in recent years of hydrogen as an increasingly valuable fuel source, we see potential for this technology to find a valuable commercialisation partner in the near term.

Recently ECT has moved to into the waste-to-energy space, where there is potentially a shorter lead-time to commercialisation and higher finished product margins. In June 2019 the company announced that it had acquired a waste-to-energy technology[3]. The technology, called CDP-WTE, has the potential to provide a low-cost way to process wood, end of life plastics and other wastes into diesel fuel, particularly when the feedstock is combined with fuel produced from the Coldry technology.

ECT believes it can be cash-flow break-even within 12 months

As well as waste-to-energy, ECT is also working on generating positive group cashflows from expansion of its existing Coldry pilot plant. A September 2019 market release lays out a plan for the company to be cashflow positive within twelve months, which involves expanding and upgrading the Bacchus Marsh facility for end-products beyond coal in addition to the company's move into the waste-to-energy and hydrogen sectors.

If ECT is so good, how come it is only capitalised at A$4.8m (US$3.3m)?. We believe the current low market capitalisation of ECT is due to disappointment over the India collaboration not working out as planned. Also, ECT is currently completing a rights issue. However, after this is completed ECT will seek to execute on the value creation strategy it outlined in the September 2019 announcement. This may include other acquisitions currently being discussed internally. We think the move towards later-stage commercialisation of cleantech opportunities will be welcomed by new and old shareholders. There also remains the potential for ECT to obtain new public and/or private-

[1] Prior to 2006 the company's main focus was Enersludge, a pyrolysis and gasification-based method for managing sewage sludge. For background on Enersludge see Water Sci Technol. 2004;49(10):217-23. The company worked on Enersludge as 'Environmental Solutions International Ltd' but changed its name to 'Environmental Clean Technologies Ltd' in late 2006 to reflect the change of focus. For many years it retained the old ASX code of ESI but changed this in mid-2018 to ECT.

[2] See ECT's 10 February 2006 market release headlined '*ESI enters into an agreement to acquire 100% of Asia Pacific Coal and Steel Pty Ltd*'.

[3] See the company's 7 and 13 June 2019 market releases.

sector backing to develop Matmor plants in India. In this note we look first at the Coldry and Matmor technologies before evaluating the new CDP-WTE technology and the potential for ECT to pursue commercialisation pathways that are more 'accelerated' than has previously been the case with Coldry and Matmor.

Nine reasons to look at Environmental Clean Technologies

1. **Coldry is arguably the best brown coal conversion technology available.** While there are various technologies for drying high-moisture coal in order to upgrade it, Coldry is the world's first low-temperature, low-pressure drying method capable of producing a black coal-equivalent product via a low-cost process that has zero carbon emissions.
2. **Matmor can produce iron from lignite**. As the world's first and only technology to allow iron to be made using low-grade coal at relatively low temperatures, the commercial potential of this technology is strong in periods of high iron ore pricing.
3. **ECT and its collaborators have done considerable work on the design of commercial-scale Coldry plants.** As well as successfully operating a Coldry pilot plant at Bacchus Marsh in Melbourne since 2004, ECT itself has completed detailed feasibility and scoping for a proposed commercial plant in Australia while ECT's Indian collaborators published a feasibility study in August 2016. All this work potentially speeds the process by which such plants could ultimately obtain project financing and be built in the future.
4. **ECT is now adapting its Coldry pilot plant for uses beyond simple solid fuel**. This approach has potential to lead to economic returns in the near term for relatively low capital inputs.
5. **There is potential for new collaborators in the Indian iron and steel industry to look at Coldry and Matmor**. India is not only a major producer of lignite, iron and steel but has a number of private sector operators with higher risk appetite than the semi-state companies that could potentially realise value from Coldry and Matmor.
6. **ECT's CDP-WTE technology may provide a rapid commercialisation pathway**, with relatively little capital required to go from pilot plant to commercial-scale plant with this waste-to-energy technology.
7. **ECT with COHgen may have a valuable hydrogen source.** Given the rise in recent years of hydrogen as a fuel, we see potential for this technology to find a valuable commercialisation partner in the near term.
8. **ECT has a quality leadership team**. We believe that ECT under Chairman Glenn Fozard has all the skills necessary to realise value from its various technologies.
9. **The current rights issue potentially funds for the company to cash flow break even**. ECT announced a rights issue in October 2019 to raise between A$2.75m and A$7.45m. 1.55 new shares at 0.1 cent per share will be offered for everyone 1 share held. For every three shares taken up ECT will issue a three-year option exercisable at 0.3 cents. This raising can potentially funds for the company potentially to cash flow break even should the September 2019 strategy be successfully executed.

The current rights issue will raise a minimum A$2.75m

Coldry continues to hold promise as one of the better 'clean coal' technologies available

Coldry can convert brown coal to a black coal equivalent. First developed in the 1980s, Coldry allows lignite, that is, brown coal, to be processed into a coal product similar in properties to higher-grade black coal. Lignite is considered a low-grade coal because it has a high moisture content which means that it produces less energy when it is heated, typically for use in electricity generation. Upgrading lignite to a black-coal equivalent using Coldry will result in reduced carbon emissions because less coal will be required for the equivalent level of power generation, while the potential price of the black coal equivalent product will likely be much higher than raw lignite because of the higher calorific value per tonne. Since power stations are significant users of lignite around the world, particularly in Australia, Germany, India, Poland, Russia, Turkey and the US[4], ECT has until recently focused on developing Coldry to integrate as part of power station coal supply, targeting a reduction in overall emissions. While there are various technologies for drying high-moisture coal in order to upgrade it[5], Coldry is the world's first low-temperature, low-pressure drying method capable of producing a black coal-equivalent product via a low-cost process that has zero carbon emissions.

Coldry works by reducing the moisture content of lignite. Coldry was first developed by Professor R.B. Johns and colleagues at the University of Melbourne, working with the mining company CRA[6], in the early 1980s[7]. The Coldry process involves 'attritioning' of raw lignite to a mean particle size of approximately 10 µm, which initiates a low-pressure extrusion and densification process that releases >85% of the water contained within the porous coal structure. Coldry pellets are able to be produced, conditioned and dried to a resultant moisture content of <15%, as opposed to the ~60% level of typical lignite[8], and a calorific value of ~24 Mj/kg, equivalent to black coal, as opposed to the standard 8 Mj/kg of brown coal[9]. A major benefit of the technology is the low levels of heat required in the drying process, which means that waste heat from a nearby power plant or industrial facility can be integrated for this purpose. In June 2009, ECT acquired the Intellectual Property related to Coldry, which it had previously used under license.

ECT has operated a Coldry pilot plant in Melbourne since 2004.

ECT has operated a Coldry pilot plant in Melbourne since 2004. Asia Pacific Coal and Steel commissioned a 10,000 tpa Coldry pilot plant at Bacchus Marsh in 2004 to demonstrate the technical viability of the technology in batch processing. This plant was upgraded to continuous processing in 2007[10] and to a 15,000 tpa capacity in 2016[11]. ECT calls the Bacchus Marsh operation a HVTF, that is, a High Volume Test Facility. There was a fire at the facility on 21 October 2019 which caused an estimated A$2.0-2.5m damage but this will be covered by insurance[12].

ECT has been seeking to build a commercial-scale Coldry plant in Victoria's Latrobe Valley. The Latrobe Valley, in the Gippsland region east of

[4] Source: Geoscience Australia.
[5] Such as steam tube drying, brown coal briquetting and hydrothermal dewatering.
[6] A Rio Tinto precursor.
[7] See *Upgrading solid fuels*, US Patent 4,758,244, issued July 1988, priority date 17 February 1983. See also Johns et. al. (1899*), The conversion of brown coal to a dense, dry, hard material*, Fuel Processing Technology, Volume 21, Issue 3, March 1989, Pages 209-221. A Wikipedia article headlined '*Densified coal*' describes the Coldry technology.
[8] See the company's market release dated 31 July 2007 and headlined '*Overview of Coldry process'*.
[9] The Coldry pellets burn at 1,350-1,400 degrees C versus 700-800 degrees C for untreated brown coal.
[10] See the company's market release dated 13 September 2007 and headlined '*Completion of the Coldry Process production trial*'.
[11] See the company's market release dated 16 December 2016 and headlined '*High Volume Test Facility upgrades complete*'.
[12] See ECT's market release dated 8 November 2019 and headlined '*Company update'*.

Melbourne, is noted for its large deposits of lignite[13], (which potentially constitute a quarter of the world's total), as well as three lignite-fired power stations - Loy Yang, Hazelwood[14] and Yallourn. ECT has long sought to develop a commercial-scale Coldry plant in the Latrobe Valley, using local lignite as the principal feedstock[15]. The company completed preliminary feasibility studies for such a plant in 2009 and by 2013 had completed the design work[16]. ECT had hoped that it would receive government grants to develop Coldry under the Advanced Lignite Demonstration Program initiative of the Australian and Victorian governments[17], however it was not successful[18]. Capacity of the Latrobe plant may ultimately be in the order of 200,000 tpa[19] and the company has estimated that major commercial plant of around this size cost A$60m[20], although earlier work had suggested A$360-470m for a 2 million tpa project[21]. Feasibility and scoping for Basic Engineering design of this proposed commercial plant was completed in 2018 and 2019.

ECT did a lot of work on large scale plants for its technology in India

ECT has worked in recent years at developing a commercial-scale integrated Coldry-Matmor plant in India. India's rapidly growing economy has long featured high demand for coal for power generation but a too-high reliance on lignite mined in the southern state of Tamil Nadu[22]. On the reasonable assumption that a commercial-scale Coldry plant in India might have capital costs a quarter the level of a Latrobe Valley plant[23], ECT from 2015 to 2019 collaborated with two Indian semi-state-owned companies - National Mineral Develop Corp[24] and NLC India - on developing Coldry and Matmor plants in India. A techno-economic feasibility study was completed in August 2016. A Master Project Agreement between the parties was signed in May 2018. This joint venture contemplated spending A$35m in R&D ahead of building a 500,000 tonne integrated steel plant at Neyveli in Tamil Nadu[25] that would have cost A$300m[26]. However, subsequent advancement of this project after mid-2018 was tied up in bureaucratic delays. ECT took the decision in June 2019 to withdraw when it became clear that National Mineral Develop Corp's board would not be providing project funding in the near term. ECT now has the opportunity to partner with alternative coal and steel operators in India.

Why hasn't ECT been successful with Coldry to date and why can it succeed in the future? We argue that ECT's lack of success with Coldry has been largely due to the downturn in coal prices from 2011 to 2016, which dampened investor and corporate interest in new coal technology innovations. While coal recovered between 2016 and 2018, it has subsequently given up most of that recovery. We argue that, ultimately, the low capital cost to develop a Coldry plant in India will attract new partners that can develop a highly economic project at current coal prices.

[13] With measured deposits of 65 billion tonnes - see earthresources.vic.gov.au
[14] Decommissioned in March 2017.
[15] ECT's Bacchus Marsh HVTF sources lignite from the mine next door to the Yallourn Power Station.
[16] See the company's market release dated 20 August 2013 and headlined '*Coldry demonstration plant construction ready*'.
[17] The Advanced Lignite Demonstration Program (ADLP), announced in August 2012, was designed to promote development of lignite beneficiation technology. It commenced in May 2014. A company called Coal Energy Australia has received a grant of A$30m to develop a technology based on a pyrolysis process to generate up to four products from lignite, including high-quality PCI Coal, pyrolysis oil, ammonium sulphate and coal gas.
[18] See the company's market release dated 3 January 2014 and headlined '*ADLP outcome and fast tracking India*'.
[19] See the company's 4 September 2019 market release headlined '*Targeting positive cash-flow inside twelve months*'.
[20] See the company's 30 May 2014 Extraordinary General Meeting presentation, slide 8.
[21] See the company's 20 July 2011 market release headlined '*Victorian Coldry Project and capital raising*'.
[22] Around four-fifths of India's lignite is in Tamil Nadu – source: Government of India, Ministry of Mines. There are also major deposits in the states of Gujarat and Rajasthan.
[23] See the company's 30 May 2014 Extraordinary General Meeting presentation, slide 8.
[24] nmdc.co.in.
[25] NLC India, formerly Neyveli Lignite, owns the major lignite mine at Neyveli, around 200 km south of the Tamil Nadu capital of Chennai, as well as a lignite mine at Barsingsar in Rajasthan, and power stations fed by the mines.
[26] See the company's May 2019 presentation entitled '*Capturing the chemistry of lignite without the emissions*', slide 10.

ECT is now adapting the Bacchus Marsh HVTF for uses beyond power station coal. The company is currently developing a 'char' product (for use as a smokeless fuel[27] and a carburiser for specialty metallurgical applications) and is also looking to sell syngas from Bacchus Marsh that can be used for steam or electricity production or in some cases, as chemical feedstock in the synthesis of more valuable products. Additionally, ECT is working to create a service business from Bacchus Marsh where its engineers consult in the development of steam and hot water systems[28]. ECT argues that this approach can lead to economic returns on Bacchus Marsh in the near term for relatively low capital inputs.

Matmor/Hydromor and COHgen allow other valuable products to be made from lignite

Matmor allows primary iron to be made using lignite instead of coking coal. This technology works by mixing recycled or low grade iron bearing materials (ores, millscale, etc) with lignite, processing that mixture as per the Coldry process, and then running it through a specialised furnace (vertical retort) that produces metal from the lignite/iron pellet via a reduction reaction. Matmor was developed in the early 2000s[29] by the Calleja Group, owner of the Maddingley Brown Coal Mine at Bacchus Marsh near which ECT's Coldry pilot plant is located[30] and also a foundation shareholder in Asia Pacific Coal and Steel. ECT acquired the Matmor intellectual property in December 2014. Matmor is the world's first and only technology to allow iron to be made using low-grade coal at relatively low temperatures (ie only 850-1,050 degrees C).

Hydromor is 'Matmor 2.0'. The original Matmor process relied on a carbon-based reduction reaction and used an oxygen lancing step in which oxygen was injected into the vessel at the base of the retort, allowing metal to be separated from the slag prior to casting. ECT superseded the 'Matmor' process in late 2016 following research breakthroughs that led to a new hydrogen-based reduction technology which the company called Hydromor. The new technology works faster than Matmor[31], and at a lower temperature. The oxygen lancing step was replaced by a new discharge method enabling multiple product options, either in DRI-form[32], or hot metal, or solid iron.

ECT knows how to extract various valuable products from lignite

Hydromor has notable advantages against other iron production technologies such as rotary kiln or conventional blast furnace production, most notably the faster speed of production at markedly lower temperatures and the ability to utilize alternative raw materials, effectively decoupling ironmaking from the high cost coking coal and premium iron ore markets. It is worth noting that the Hydromor technology can be used to produce other metals, such as nickel or manganese.

The path ahead for Hydromor may involve India. Since 2006 ECT has largely prioritised Coldry and regarded Matmor and Hydromor as the technology to be developed after Coldry. The Indian joint venture with NMDC and NLC had intended to develop both projects. We see potential for Hydromor to be

[27] That is, of the kind use to fuel barbeques.
[28] For background here see the company's 3 November 2017 market release headlined *'Boiler trials and Coldry logistics and sales agreements'*.
[29] The technology's inventor was David Wilson, who was also a co-inventor of the Coldry process - see WO/2005/028977, *Dryer, drying method and drying plant*, invented by David Wilson, priority date 25 September 2003.
[30] See maddingleybrowncoal.com.au.
[31] *See* WO/2018/094453, *Low temperature direct reduction of metal oxides via the in situ production of reducing gas*, priority date 23 November 2016. Invented by Keith Henley-Smith, Adam Giles, Lachlan Bartsch and Ashley Moore.
[32] That is, Direct Reduced Iron, a common feedstock to steel making where iron ore is directly reduced to iron by a reducing gas or elemental carbon produced from natural gas or coal.

partnered with a more aggressive private sector iron and steel company in India in the medium term.

COHgen allows hydrogen production from lignite, the COH standing for 'Catalytic Organic Hydrogen'. ECT first told the market about the technology in 2017 but we understand that patent applications related to this technology have yet to publish. COHgen involves a composite pellet that combines lignite with a catalyst which, inside a retort, produces a hydrogen-rich syngas and fixes most of the carbon in the pellet[33]. Hydrogen is frequently talked of these days as a fuel source[34] but the key is always cost of production and storage. The apparent simplicity of COHGen may attract commercialisation partners in the near term.

CDP-WTE allows ECT to move into the promising waste-to-energy sector

CDP-WTE was acquired in July 2019. This technology, originally developed by a company called CDP Innovations Pty Ltd, allows a range of waste products to be converted to fuels such as diesel. CDP stands for 'Catalytic Depolymerisation Process' and WTE refers to 'Waste-to-Energy'. CDP Innovations was placed in liquidation in late 2018 and ECT acquired the technology from the liquidator in July 2019[35].

A 'Catalytic Depolymerisation' technology. In chemistry, polymers are simply large molecules composed of repeating structural units connected by chemical bonds. Many complex organic hydrocarbons are polymers which, if broken down, can yield simple hydrocarbons that can be used for energy production. The Catalytic Depolymerisation technology which ECT has just acquired uses special catalysts to create these simple hydrocarbons. The technology, which originated from work performed at the University of Queensland's School of Chemical Engineering, is covered by a 2017 patent application made by CDP Innovations' founder[36].

ECT intends to build a CDP pilot plant. Prior to its demise CDP Innovations developed a demonstration unit for CDP in the Chinese city of Qingdao and that plant, whose nominal capacity was a 100L/hr, successfully converted waste timber to a heavy petroleum oil. ECT proposes to build a second, larger pilot plant at Bacchus Marsh where the Coldry process would be used to enhance the waste and biomass feedstock going into the plant, improving efficiency and oil yield.

ECT may not require much capital to develop a CDP-WTE pilot plant.

Why the CDP-WTE technology may provide a rapid commercialisation pathway. A great deal of work has already gone into both Coldry and CDP-WTE. ECT therefore believes relatively little capital would be required to go from pilot plant to commercial-scale plant with the technology, particular given the available waste deposits that the CDP-WTE plants could access.

[33] See the company's May 2019 presentation entitled '*Capturing the chemistry of lignite without the emissions*'.
[34] See, for example, *Hydrogen fuel cell ferry moves closer to reality* by Dan Rosenheim, Bay City Beacon, 25 September 2019.
[35] See the ECT presentation entitled '*ECT CDP Waste2Energy*', available at ectltd.com.au.
[36] See WO/2018/000014, *A method for the production of diesel*, priority date 27 June 2016, Invented by Philip Major and Jimmy Jia.

ECT's September 2019 recovery plan

ECT is now going after near-term cash flow opportunities. We noted above that ECT is now adapting the Bacchus Marsh HVTF for uses beyond power station coal. This is part of a broader plan generated by ECT following the failure of the 2015-2019 Indian collaboration, where the new emphasis was on later stage opportunities. While the market may initially be wary of the company's claims to be in a position to achieve 'positive cash-flow inside twelve months', we think the plan has merit.

- **Bacchus Marsh**. There are ample numbers of customers available in a relatively short journey from Bacchus Marsh for the char and syngas products, as well as the for the steam and boiler consulting team. The state of Victoria, traditionally the heartland of Australian manufacturing, still has a ~A$28bn manufacturing sector across ~ 13,000 businesses employing ~9% of the workforce[37].
- **CDP.** An important aspect of the CDP technology is that it can be applied to most kinds of waste. The ample number of waste feedstocks available for acquisition around Australia therefore bodes well for a rapid realisation of shareholder value[38].

Capital structure (pre-rights issue)

Class		% of fully diluted
Ordinary shares, ASX Code ECT (million)	4,800.5	100.0%
Current market cap:	A$4.8 million (US$3.3 million)	
Current share price	$0.001	
Share price range (last twelve months)	$0.011-$0.001	
Average turnover per day (last twelve months)	2,920,000	

Board and management

ECT's Chairman, **Glenn Fozard**, brought to the company a finance and capital markets background. He has been a director since 2013 and Executive Chairman since 2015[39]. Chief Operating Officer **Jim Blackburn** and Group Chief Engineer **Ashley Moore** bring technical skills and corporate memory regarding Coldry and Matmor, while non-executive director **David Smith** brings legal and corporate governance skills.

Major shareholders

Currently the only substantial shareholder in ECT is **Lloyd Thomson**, a Mildura businessman, with 5.2% of the company.

[37] Source: '*Victorian government press release dated 1 February 2018 and headlined 'Victoria's manufacturing sector records 12 months of growth'* at connection.vic.gov.au.
[38] Consider, for example, the well-known problem of glass stockpiles in Australia where the low price of imported glass means that it is uneconomic to recycle glass bottles using conventional technologies – see '*Recycling companies stockpiling thousands of tonnes of glass as cheap imports leave market in crisis'* by Caro Meldrum-Hanna, Anne Davies and Deb Richards for the ABC TV programme Four Corners, 5 September 2017 (available at abc.net.au).
[39] He became a director in July 2013 and Non-Executive Chairman in November 2013.

Appendix I – ECT's Intellectual Property

Coldry – WO/2004/001319 *Dryer, drying method and drying plant*, priority date 25 September 2003. Invented by David Wilson.

Matmor – WO/2001/038455 *Retort*, priority date 26 September 2000. Invented by David Wilson,

Hydromor –WO/2018/094453, *Low temperature direct reduction of metal oxides via the* in situ *production of reducing gas*, WO/2018/094453, priority date 23 November 2016. Invented by Keith Henley-Smith, Adam Giles, Lachlan Bartsch and Ashley Moore.

CDP-WTE –WO/2018/000014, *A method for the production of diesel*, priority date 27 June 2016. Invented by Philip Major and Jimmy Jia.

Appendix II – An ECT glossary

Attrition – In coal processing, the grinding of coal material by rubbing or friction, as opposed to impaction of crushing.

Bituminous – Coal that contains bitumen, a tar-like substance. Bituminous coal is considered of higher quality than lignite coal but of poorer quality than anthracite.

Brown coal – See lignite.

CDP-WTE – Short for Catalytic Depolymerisation-based Waste-to-Energy, an ECT technology to produce diesel fuel from low-value resources.

Char – Coal where the coal gas and tar have been removed by combustion. Char is used as a smokeless fuel as well as a carburizer in specialty metal applications.

COHGen – An ECT technology for producing hydrogen from brown coal. The COH stands for 'Catalytic Organic Hydrogen'

Coldry – An ECT technology allowing lignite and some sub-bituminous coals to be converted to Black Coal Equivalent.

HVTF – High Volume Test Facility.

HydroMOR – An ECT technology that uses lignite-derived hydrogen to produce primary iron.

Lignite – Also called 'brown coal', lignite is the coal with the lowest energy content, it being formed from naturally compressed peat.

Matmor – An ECT technology that uses lignite to produce primary iron.

Retort – An airtight vessel in which substances are heated, typically with the aim of producing a chemical reduction reaction. Product gases may be collected in a collection vessel.

Syngas – A synthetic gas produced by gasification of a carbon-containing fuel.

Appendix III – The Indian opportunity for Coldry and Matmor

We argue that India remains a potential important part of the ECT story, for two reasons. Firstly, ECT has spent a considerable amount of time marketing its technology in India so it is widely known in coal and steel industry circles in that country. Second, ECT's major collaboration to date has been with semi-state owned companies that, by the very nature of having the government as a major shareholder, tend to have difficulty making decisions on new technologies.

India is now an important steel producer. An important aspect of India's economy since the beginning of liberalisation in 1991 has been rapid increases in the production of steel. In 2018 India produced 106.6 million tonnes of crude steel, up 4.9% on 2017. This particular increase allowed India to replace Japan as the world's second largest steel producing country[40]. In 2003 India's steel output was only 31.8 million tonnes[41]. We argue that India has been rising rapidly as a producer, not only because of its lower cost of production, but also because of the expertise of its leading private sector players.

India's private steel companies are now globally important. India still has a large public sector presence in the steel industry through the Steel Authority of India (commonly known as 'SAIL'), which, while a public company traded on the BSE[42], remains ~75% owned by the Indian government. This dominance by the Indian state has, however, not crimped the emergence of some aggressive private steel companies in India. This was evidenced most notably by the 2006 takeover of Arcelor by Mittal Steel to form ArcelorMittal, the world's largest steel producer. It's also noteworthy that two key Indian steel players have become Forbes Global 2000 companies - Tata Steel[43] at No. 552 on the 2019 list with US$20bn in 2018 revenue, and JSW Steel[44] at No. 882 with US$12.2bn in 2018 revenue. Behind these two are multiple emerging players such as Visa Steel[45], Jindal Steel and Power[46] and Mideast Integrated Steels[47].

ECT could have the solution to India's reliance on coking coal imports

The growth in Indian steel has fueled massive coking coal imports. India's coal production has kept pace with the rise of its manufacturing sector generally, increasing from 261 million tonnes in 2003[48] to 600 million tonnes in 2018. However this output is overwhelmingly thermal coal, and, as we noted above, much of it is low-grade brown coal. The fast growth of India's steel industry has turned India into the world's second largest importer of coking coal, since domestic Indian coking coal is not suitable for many steel grades because of quality and cost issues. The ~52 million tonnes of coking coal which India imported in the year to March 2019 represented around a sixth of the country entire import bill[49]. With the Indian government now encouraging increases in domestic thermal coal output to reduce dependence on coal imports[50], the opportunity to increase production of coking coal of the kind represented by Coldry is an obvious one.

We see potential for other operators to collaborate with ECT on Coldry and Matmor. ECT is not prioritising an Indian collaboration at this stage, but with the National Mineral Develop Corp and NLC India collaboration now over, we understand there has been enquiries from other players in the Indian steel industry to pick up where this collaboration left off. Should a new collaboration emerge we believe it will be a major factor in an ECT share price re-rating.

[40] Source: World Steel Association press release dated 25 January 2019.
[41] Source: World Steel Association, *World Steel in Figures* 2004 Edition.
[42] New Delhi, BOM: 500113, sail.co.in.
[43] Kolkata, West Bengal, BOM: 500470, tatasteel.com.
[44] Mumbai, Maharashtra, BOM: 500228, jsw.in.
[45] Kolkata, West Bengal, BOM: 532721, visasteel.com.
[46] New Delhi, BOM: 532286, jindalsteelpower.com.
[47] New Delhi, BOM: 540744, mescosteel.com.
[48] Source: Statista.
[49] See *Canada, U.S. gain as India cuts dependence on Australian coking coal* by Sudarshan Varadhan, Reuters, 26 June 2019.
[50] See *Australian thermal coal exporters warned of falling demand from India* by Ben Smee, The Guardian, 23 August 2019.

Appendix IV – Analyst qualifications

Stuart Roberts, lead analyst on this report, has been covering the Life Sciences sector as an analyst since 2002.

- Stuart obtained a Master of Applied Finance and Investment from the Securities Institute of Australia in 2002. Previously, from the Securities Institute of Australia, he obtained a Certificate of Financial Markets (1994) and a Graduate Diploma in Finance and Investment (1999).
- Stuart joined Southern Cross Equities as an equities analyst in April 2001. From February 2002 to July 2013, his research specialty at Southern Cross Equities and its acquirer, Bell Potter Securities, was Healthcare and Biotechnology. During this time, he covered a variety of established healthcare companies such as CSL, Cochlear and Resmed, as well as numerous emerging companies. Stuart was a Healthcare and Biotechnology analyst at Baillieu Holst from October 2013 to January 2015.
- After 15 months in 2015 and 2016 doing Investor Relations for two ASX-listed cancer drug developers, Stuart founded NDF Research in May 2016 to provide issuer-sponsored equity research on ASX-listed Life Science companies
- In July 2016, with Marc Kennis, Stuart co-founded Pitt Street Research Pty Ltd, which provides issuer-sponsored research on ASX-listed companies across the entire market, including Life Science companies.

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