EDISON

PowerHouse Energy Group

Re-initiation of coverage

Opening the door to the hydrogen economy

Alternative energy

PowerHouse Energy's innovative, distributed waste-to-hydrogen technology satisfies the joint needs of powering fuel cell electric vehicles, finding an alternative means of waste disposal to landfill or incineration and providing a predictable form of clean energy to complement intermittent supplies such as wind and solar. The hydrogen and electricity are produced close to point-of-use, saving transportation costs and reducing transmission losses and the associated carbon footprint. The company has a pilot system near Ellesmere Port, Merseyside, and intends to commence commercial production in FY18.

Year end	Revenue (£m)	EBITDA (£m)	PBT* (£m)	EPS* (p)	DPS (p)	P/E (x)
12/14	0.0	(1.2)	(1.5)	(0.4)	0.0	N/A
12/15	0.0	(0.4)	(0.8)	(0.2)	0.0	N/A
12/16	0.0	(0.8)	(1.3)	(0.2)	0.0	N/A
06/17**	0.0	(0.6)	(0.7)	(0.1)	0.0	N/A

Note: *PBT and EPS are normalised, excluding amortisation of acquired intangibles, exceptional items and share-based payments. **Six months ended June 2017.

Demonstration DMG system proves technology

PowerHouse has developed a distributed modular gasification (DMG) technology for converting many types of consumer and industrial waste to syngas. Independent laboratory analysis indicates that the hydrogen component of syngas is suitable for use in fuel cells. Importantly, the process takes place at a much higher temperature than incineration or conventional gasification, so harmful furans and dioxins are destroyed, removing a potential barrier to deployment.

Preparing for commercial roll-out in FY18

PowerHouse is still at the pre-commercial revenue stage, but management expects to have a commercial version of the DMG system available early in 2018, with the first revenue-generating installations operational later in the year. PowerHouse intends to adopt a build-own-operate (BOO) model, most probably partnering with third parties that will provide capital to fund the system construction in return for a share of revenue. PowerHouse has recently agreed heads of terms to locate the first commercial DMG system at a Peel Environmental site at Ellesmere Port.

Valuation: Proposition dependent on volume roll-out

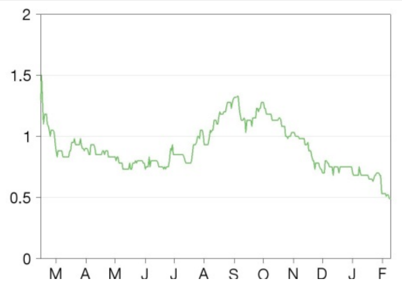
The rate of roll-out of DMG systems is not yet certain, although management intends to be operating dozens of them in the long term. We therefore present an indicative valuation scenario that calculates the NPV for an individual DMG system generating electricity only (£1.7m at 10% WACC and 2.5% terminal growth rate) and an individual DMG system optimised for the production of pure hydrogen for fuel cells (£11.8m at 10% WACC and 2.5% terminal growth rate). As the mechanism for funding DMG system roll-out has not been established, we do not model any split of the profits with any potential third parties providing funding. Investors should also note the dilutive impact of any further equity placings as the group will need to raise additional cash to finance operations through to profitability.

12 February 2018

Price	**0.49p**
Market cap	**£7m**

Net cash (£m) at end June 2017, excluding £1.6m placing in August 2017	0.1
Shares in issue (including shares from August placing and issue of equity in January 2018)	1,417m
Free float	92%
Code	PHE
Primary exchange	AIM
Secondary exchange	N/A

Share price performance



%	1m	3m	12m
Abs	(30.7)	(50.3)	(41.2)
Rel (local)	(24.6)	(47.6)	(40.7)
52-week high/low		1.50p	0.49p

Business description

PowerHouse Energy has developed an innovative, distributed waste-to-hydrogen and waste-to-energy process, which takes advantage of the growing global need for distributed hydrogen production, as well as the distributed grid and local wire power delivery.

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Prelims	June 2018

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Edison profile page

PowerHouse Energy Group is a research client of Edison Investment Limited

Investment summary

Company description: Distributed modular gasification

PowerHouse Energy owns an innovative waste-to-hydrogen distributed modular gasification (DMG) system technology. This technology provides a mechanism to dispose of a wide range of waste streams by converting them to a carbon-neutral product, which may be used to power fuel cell electric vehicles (FCEVs) or to generate electricity for export to the grid, or consumption within an enterprise. Unlike competitive techniques, the DMG systems do not produce toxic dioxins and furans and have a small footprint. This makes them suitable for deployment at enterprise or community level, producing hydrogen or electricity close to the point of consumption. Since the end of March 2017, PowerHouse has been working on a demonstration 1-3tpd third-generation DMG system near Ellesmere Port, Merseyside, confirming that the equipment can operate through multiple temperature cycles, output syngas with higher than 50% hydrogen by volume and deliver hydrogen that is sufficiently pure for use in fuel cells.

Financials: Balance sheet is transformed during FY17

The balance sheet was considerably strengthened during FY17 to support the preparations for commercial roll-out. In February 2017 PowerHouse completed a fund-raising of £2.5m (gross) at 0.8p/share. £2.0m of the proceeds were used to repay part of a convertible loan note from Hillgrove, the remainder of which was converted to shares. In August 2017 PowerHouse completed a fund-raising of £1.6m (gross) at 1p/share. Losses before tax (adjusted for share-based payments) narrowed by 14% to £697k during H117 as, although operating costs were similar to prior year levels, finance costs reduced from £242k to £70k, reflecting the repayment of the Hillgrove loan. PowerHouse is preparing for commercial roll-out of the DMG system technology during FY18. The group ended H117 with £145k net cash (prior to the August placing) compared with £3,184k net debt at the beginning of the period. Our top-level analysis (page 11) shows that management will need to raise additional finance to take the group through to profitability.

Valuation: Proposition based on volume roll-out

The indicative NPV calculation valuing a standalone hypothetical DMG system presented in our valuation section on page 10 relies on data from management. As a full-scale DMG system is still at the design phase, there are no actual data for energy conversion efficiency or the waste gate fees and electricity or hydrogen prices PowerHouse will receive, so we have applied sensitivity tests to the key input parameters.

Sensitivities: Risk will reduce with commercialisation

While the DMG system has undergone over 300 hours of testing, thus reducing technical risk, there remains risk regarding operation in a commercial environment and with different types of waste. Importantly, while the purity of the hydrogen produced has been confirmed in lab tests, the gas output has not been fed into a working fuel cell. There is also risk associated with scaling up from the 1-3tpd demonstration DMG system to a 25tpd commercial project. There is significant uncertainty about PowerHouse's ability to convert the high level of interest in the technology into revenues and the timing of that, as well as risk associated with scaling up operations to support commercial activities. Demand for hydrogen from PowerHouse's systems will be determined by the roll-out of fuel cells for e-transport and stationary energy generation applications. In common with all companies offering waste-to-energy technologies, PowerHouse Energy will be affected by macroeconomic factors such as the availability of waste, demand for electricity and regulations affecting waste disposal.

Company description: Local power from local waste

PowerHouse Energy Group is developing an innovative waste-to-hydrogen, distributed modular gasification (DMG) technology. This converts hydrocarbon waste streams including shredded plastic or tyre crumb into syngas or hydrogen. Syngas can be used to generate electricity for export to the grid or for use within an enterprise. Since the technology operates at a higher temperature than conventional gasification techniques, it produces no char or oil residue or toxic dioxins and furans. The syngas should therefore be sufficiently clean to power fuel cell electric vehicles and gas engines. Powering a gas engine is a more efficient route than using the syngas or the burning waste to produce steam to power a turbine. The conversion also permits storage of energy in the syngas until it is needed to make up shortfall from renewable generation sources.

The small footprint, modular design of the DMG system means that, once commercialised, PowerHouse will offer waste-to-energy systems based on one or more modules, each capable of handling 25 tonnes of waste per day, which is equivalent to the refuse from a small town of 6,000 homes. A 50tpd (tonnes of waste per day) DMG system would potentially generate c 2,000kg of hydrogen each day, sufficient to drive 2,000 FCEVs an average of 57 miles each. Alternatively, it could generate c 3.0MW electricity (equivalent to a large wind turbine), sufficient to power around 6,000 homes. This means that the DMG systems can be located close to where the waste material is produced and collected, and generate hydrogen or electricity close to where it is required, thus cutting down on the costs and energy used in transportation.

Although PowerHouse listed in 2011, it is still at a relatively early stage of corporate development. Over the last six years it has been refining its proprietary, patentable DMG technology. It has recently concluded extended combustion trials on a small 1-3tpd demonstration system situated near Ellesmere Port in the UK and moved to the design and engineering phase of a 25tpd commercial system. Management intends to be producing electricity commercially from one or more commercial scale systems by the end of FY18, potentially followed by over a hundred units located at waste collection sites throughout the UK over the next decade. Management's preferred strategy is to build, own and operate these waste-to-energy plants, deriving revenues from the sale of electricity or hydrogen. Initially, it is likely to operate systems in partnership with third parties, supplementing this income with revenues from equipment sales to help with cash generation.

PowerHouse currently has only seven employees, although this number will increase as the company progresses towards commercialisation. To accelerate commercialisation, PowerHouse is partnering with industry expert, Waste2Tricity, which is facilitating introductions to parties interested in operating DMG systems, providing locations for systems or supplying the waste streams required, as well as advising on permitting and planning requirements. Local engineering consultancy, Engsolve, is providing support as the system design is refined. Volume manufacturing of the DMG systems will be outsourced, probably to Eastern Europe.

Technology: Ultra-high temperature gasifier

PowerHouse's DMG technology is an innovative, patentable process that has been developed over the last 18 years. The DMG unit uses a process in which complex organic molecules are broken down through indirect heat in an oxygen-starved environment into their constituent elements. A typical composition of syngas output is 50% H_2, 35% CO, 10% CH_4 and 5% CO_2. The proportions may be varied once the gasification process is complete to produce syngas suitable for different end-applications, for example maximising the amount of hydrogen if the system is intended to serve an FCEV refuelling station. A DMG module is based on rotary kiln equipment, which is an established technology and uses standard components. The current iteration system is a complete rework of older variants, learning from problems experienced when developing earlier-generation equipment. Management may patent some of the elements of DMG system operation.

The individual process steps are:

1. Small granules of material with high calorific values, eg tyre crumb, shredded plastic or tiny chips of PVC pipe, is passed into the rotating, ultra-high temperature gasification chamber at atmospheric pressure in a non-combustive environment. The reactor, typically operating at above 1,000°C, breaks down the material, converting it into synthesis gas.
2. The syngas passes out of the reactor. Any non-combustible material is removed. This waste is not classified as a hazardous material, even if the input material contains heavy metals, because these are fused into the glassy slag formed at high temperatures. The resultant slag may be sold for use in road-building in accordance with local environmental regulations.
3. The syngas is tailored to maximise the hydrogen content and the hydrogen used to generate power for FCEVs or in stationary fuel cells. Management estimates that a DMG system processing 25tpd of waste will generate c 1,000kg of hydrogen gas each day.
4. Alternatively, the syngas may be used to generate electricity in a gas-powered generator, turbine or fuel cell. Management estimates that around 30% of the energy represented by the calorific energy of the waste material is converted to electricity, and 30% of that electricity is used to power the DMG system. Depending on the calorific value of the waste material, management estimates that a 25tpd DMG system will generate c 1.5MW of electricity.

Competitive position of technology

Exhibit 1: Competitive waste disposal technologies

Incineration	Pyrolysis	Gasification	Plasma arc gasification	DMG process
Combustion in unrestricted amounts of oxygen to give CO_2 and H_20	Combustion in absence of oxygen to give syngas	Combustion in limited amounts of oxygen to give syngas	Combustion in limited amounts of oxygen to give syngas	Combustion in limited amounts of oxygen to give syngas
>850C°	300-850°C	>650°C	>5,000°C	>1,000°C
Heat from burning waste raises steam for steam turbine	Syngas impure so burnt to raise steam for steam turbine	Syngas impure so burnt to raise steam for steam turbine	Syngas pure so potentially used to power more efficient gas turbine or fuel cell	Syngas pure so potentially used to power more efficient gas turbine or fuel cell
Non-combustible material forms non-toxic bottom ash	Non-combustible material forms toxic char	Non-combustible material forms non-toxic bottom ash	Non-combustible material forms non-toxic bottom ash	Non-combustible material forms non-toxic bottom ash
Potential airborne pollutants treated with toxic chemicals. Still risk of emitting furans and dioxins.	Reduced amount of airborne pollutants. Still risk of emitting furans and dioxins.	Reduced amount of airborne pollutants. Still risk of emitting furans and dioxins.	No furans or dioxins	No furans or dioxins
Typically 50-300k tonnes of waste processed/year	Typically 25-150k tonnes/year	Typically 60-650k tonnes/year	Typically 20-700k tonne/year, although MagneGas has a small scale system	Potentially <18k tonnes/year for distributed power generation (2x25tpd system)

Source: Edison Investment Research

PowerHouse's DMG technology potentially has numerous advantages compared with other waste-to-energy techniques. Crucially, since it operates at a much higher temperature than pyrolysis, standard gasification or incineration processes, it atomises the waste material, avoiding the formation of tars and potential pollutants such as dioxins and furans. As the syngas is not contaminated with tar it can potentially be used in a fuel cell or in a combined-cycle gas turbine engine. A gas engine gives an electrical conversion efficiency of 30% compared with 14-27% for steam boiler and turbine systems associated with incinerators. Greater efficiencies may be achievable if the heat produced is harnessed effectively. A higher electrical efficiency may be realised if the output gas is optimised for hydrogen content and used to power fuel cells.

Importantly, as a DMG system generates electricity from material that would otherwise incur a tipping fee on disposal, the technology does not need to achieve a comparable energy conversion rate to conventional generation systems to be commercially viable, or to secure green subsidies. This is because PowerHouse will receive a fee from the third party whose waste they are destroying, effectively subsidising the energy generation. For example, according to industry analyst, WRAP, in 2016 the median UK gate fee for incineration with energy recovery was £83/tonne.

Macro opportunity driven by green economy

PowerHouse Energy is positioned to take advantage of the small but rising demand for pure hydrogen to power FCEVs, the increasingly onerous restrictions regarding the disposal of waste, and in demand globally for energy, especially energy generated close to the point of consumption and energy to balance the variable output from wind and solar power.

Fuelling the hydrogen economy

In our opinion, the most exciting opportunity for PowerHouse is the ability to generate hydrogen at a local level for use in FCEVs. The potential number of vehicles is estimated by Global Market Insights to be 1.2m units by 2023, driven by concerns about the air pollution caused by petrol and diesel vehicles and the potential to use electricity from renewable sources to reduce the carbon emissions from vehicles. A study commissioned by the UK government in 2013 noted that there could be 1.6m hydrogen-powered vehicles on UK roads by 2030. Widespread adoption of FCEVs will require a network of hydrogen refuelling stations. The UK government study estimated that 65 would be required initially, rising to 1,150 by 2030. Most industrial hydrogen is made by steam-treating natural gas, so using this in refuelling stations goes against the premise of reducing carbon dioxide emission and the use of fossil fuels. Instead of using hydrogen that has been manufactured in this way and transported over a considerable distance, most of the refuelling stations currently deploy on-site electrolysis technology from Hydrogenics or ITM Power. This technology uses electricity, potentially but not necessarily from renewable sources, to split water into oxygen and a hydrogen that is sufficiently pure for fuel cell operation. The small footprint of the DMG unit means that it could be used as an alternative mechanism for producing hydrogen on site. Since the waste used as feedstock has already had its carbon footprint accounted for, the syngas is effectively carbon neutral. Moreover, as the waste can processed close to where it was originally produced, the carbon footprint and costs associated with transporting it are significantly reduced, especially if the alternative is shipping the waste overseas.

Making money from waste

PowerHouse's technology provides a way of not only of disposing of waste, but also of extracting financial value from it. In the UK and other European countries the amount of waste per head of population has fallen over the last couple of decades as a result of the EU Landfill Directive. This stipulated that the amount of biodegradable municipal waste must be reduced to 50% of 1995 levels by 2009 and to 35% of 1995 levels by 2016. In the UK, the average amount of waste produced per person in 1995 was 498kg. The amount peaked at 602kg in 2004, dropped to a low of 477kg in 2012 and has since risen slightly to reach 485kg in 2015. While the amount of waste produced per person is expected to continue to rise, the rate of increase is expected to be small. Forecasts from the European Environment Agency predict municipal waste increasing at 1.1% CAGR between 2015 and 2030 in countries covered by the Organisation for Economic Co-operation and Development (OECD), 1.3% in Europe.

However, even though the amount of waste produced per person in the UK has fallen, the lack of landfill capacity means that disposing of the waste has become increasingly difficult. UK government initiatives exhorting consumers to "Reduce, Reuse, Recycle", combined with retailers' programmes to save on packaging costs, have helped cut the percentage of domestic waste going to landfill from 83% of the total in 1995 to 22% in 2015. The reduction is partly the result of greatly increased recycling rates: 7% of domestic waste was recycled in 1995 compared with 27% in 2015. There has also been a sharp increase in the amount of waste incinerated: 9% in 1995 compared with 31% in 2015. There is a similar pattern elsewhere in Europe. While the UK may not be subject to the EU Landfill Directive for much longer, the lack of suitable landfill sites suggests that the imperative to avoid landfill will become even stronger. In April 2017 the standard tax rate payable by operators of landfill sites was raised from £84.40/tonne to £86.10/tonne. We note that the shift to recycling will be significantly affected by the recent decision by the Chinese government to ban the import of plastic waste. Greenpeace estimates that since 2012 British companies have shipped more than 2.7m tonnes of plastic waste to China, ie two-thirds of plastic waste exported. PowerHouse estimates that around 30% of this plastic is non-recyclable and that if this was gasified, it would support 20 DMG facilities and generate 30 tonnes of hydrogen per day.

Outside the OECD the issue is simply one of dealing with rising volumes of waste arising from increasing urbanisation and growing populations. A report for the World Bank published in 2012 predicted that, without changes in behaviour, global solid waste generation was on track to increase by 70% between 2010 and 2025, rising from more than 3.5m tonnes per day in 2010 to more than 6m tonnes per day by 2025. The global cost of dealing with the waste is predicted to rise from $205bn/year in 2010 to $375bn by 2025, with the sharpest cost increases in developing countries. This presents significant challenges for the governments of developing countries. For example, in December 2011 Mexico City closed its main landfill site at Bordo Poniente, which at its peak had received 12,000 tonnes of waste per day, following initiatives to recycle or compost around half of the waste collected. However, no alternative disposal sites were allocated for the remainder of the waste, and plans to incinerate it were pulled following opposition from people living close to the proposed sites of incinerators.

Providing balance in the renewable energy mix

Energy demand in the UK fell by 14% (on a temperature-corrected basis) in the decade between 2005 and 2015, reflecting a continued shift from manufacturing to service industries, more efficient cars, better insulated homes and more efficient domestic appliances. UK government statistics predict that the total amount of electricity supplied will decline by 14% from 322TWh in 2015 to 276TWh in 2025. It will then return to 2015 levels by 2031 and reach a level 18% higher than 2015 by 2035. However, even though energy demand is expected to decrease in the short term, the power generation industry needs to address the challenges created by the closure of 72TWh of coal generation capacity between 2015 and 2025. The government survey predicts that 19TWh of natural gas generation capacity will be added during the period and 31TWh of renewable energy, increasing the proportion of energy generated from renewable sources from 25% in 2016 to 40% by 2025. This increase in renewable sources means that the power generation industry will need to invest in improved transmission networks to move the energy to where it is required, in storage (the government study estimates 3GW of battery storage by 2030) and in intermittent generation systems to address the variability in output from wind turbines.

Waste-to-energy is currently a very small proportion (3.3% in 2016) of all renewable energy generated in the UK, where at least 70 waste-to-energy facilities collectively output 2.7TWh power (source: wrap.org.uk). The majority of these are incineration plants, generating electricity during the time that the waste material is being burnt. In contrast, the syngas produced by PowerHouse's gasification technology may be stored until additional generation capacity needs to be brought online to offset a drop in output from wind or solar sources, making it a better addition to the renewables mix. Moreover, the PowerHouse technology is scaled to be appropriate for disposing of waste close to where it is produced and generating electricity close to where it will be consumed, reducing the financial and energy cost of transporting both waste and electricity. In centralised power generation systems around 8% of the initial energy content in the gas is dissipated as the electricity is distributed over the grid to household or business premises. We note that the economics of waste-to-energy generation are different from wind or solar plants, because local authorities currently pay an average of £83/tonne for waste to be incinerated. This means that adoption of PowerHouse's DMG technology is not dependent on green subsidies to be commercially viable, although it may be eligible for support under the Renewables Obligation scheme, nor does it need to achieve an energy conversion rate comparable to conventional generation systems.

Executing the strategy

Corporate history

PowerHouse Energy was created through the reverse takeover of AIM-listed Bidtimes by PowerHouse Energy Inc in April 2011. At that time, PowerHouse Energy consisted of a US business that designed, built and installed combined heat and power systems, and had a 30% stake in Pyromex, a Swiss designer of DMG modules. The remaining 70% stake in Pyromex was acquired in 2012 and from that point the group has focused on commercialising the DMG opportunity.

Refining the technology

A prototype 25tpd DMG system based on the Pyromex technology was trialled at a waste transfer station near to Munich between 2010 and early 2015. This second generation systems was helpful in generating interest in the technology, gaining an understanding of the commercial environment in which DMG systems operate, and instrumental in defining the revised design features incorporated in the third-generation DMG variant that was successfully tested at Ellesmere Port.

During FY15 and much of FY16 PowerHouse worked with engineers at OrePro to refine the Pyromex technology. (OrePro is an Australian engineering company developing equipment based on rotary kiln technology that is backed by former PowerHouse investor and founder of underground coal gasification pioneers Linc Energy, Peter Bond.) The key changes made during this period enabled the system to run efficiently for an extended period at a sufficiently high temperature to ensure complete combustion of the waste material and to cope with the thermal stresses experienced when the system is started up or closed down.

This 1-3tpd demo unit was shipped from Queensland to Thornton Science Park on Merseyside in Q117. Working together with local engineering consultancy Engsolve, PowerHouse spent several months recommissioning the unit and modifying the control systems so that it met the UK safety standards required to proceed with full-scale operation, testing and demonstration at the Thornton site. During this process, the engineering team took the opportunity to make enhancements to the gas systems and revised the feed and steam generation systems. The demonstration unit went through a sequence of extended tests to check on the suitability of different feedstock types, to provide thorough analysis of the gas output, to supply detailed operational data for designing the first commercial unit and to demonstrate the technology to interested parties. In August the team demonstrated that the syngas produced contained over 50% hydrogen, some carbon monoxide and methane and no carbon dioxide. In October, independent third-party laboratory analysis confirmed that conventional pressure swing adsorption (PSA) equipment is able to separate and clean up the hydrogen component of the syngas to fuel cell quality, ie 99.999% purity. In November management announced that it had completed trialling the technology, and was now ready to start on the design and engineering of the first commercial-scale unit.

Next steps

Management expects to have the first commercial 25tpd unit built, installed and commissioned during H218. The timescales for commercial roll-out are not yet certain. PowerHouse estimates that it can establish a working, electricity-generating, end-to-end project on a site within about six to 18 months, depending on the capacity of the installation. As the units are made from standard components, it is likely that manufacture of units after the first four or five will be carried out by third parties in Eastern Europe. The main factors that could limit roll-out are likely to be availability of finance for each project; the time needed to secure planning approval, operating permits and a secure feedstock supply for each project; and the number of technical staff available to support development of multiple projects in parallel.

As PowerHouse has only a handful of employees, management decided to accelerate commercial roll-out by contracting industry facilitators Waste2Tricity to provide key services. Waste2Tricity is helping to identify and secure sites for locating commercial units, helping with the planning and permitting of DMG systems, the negotiation of contracts for sourcing feedstock and supplying electricity or hydrogen and arranging finance. The contract with Waste2Tricity is initially for 24 months commencing January 2017, but may be extended. Waste2Tricity will receive £20,000 in fees each month, initially payable in shares. Once each of the commercial projects in which it is involved with Waste2Tricity becomes profitable, PowerHouse will split the profits of the project (calculated after each party has deducted any project-related costs, which include the fees payable to Waste2Tricity) 50/50% with Waste2Tricity. We note that Waste2Tricity is owned by Howard White, founder of AFC Energy, whose son is the sole owner of Yady Worldwide, a significant investor in both AFC Energy and PowerHouse.

Waste2Tricity has already brokered a Memorandum of Understanding (MoU), effective until 1 May 2018, between Peel Environmental and PowerHouse. Under the terms of the MoU, the two parties will work together to develop, construct and operate a waste-to-energy facility deploying one or more DMG systems at Peel Environmental's new site adjacent to Thornton Park. In addition, PowerHouse has signed an agreement with an unspecified partner, which we infer is Peel Environmental, and which will provide up to £0.5m to meet the cost of preparing and funding applications for planning permission and environmental permits of the initial demonstration unit and first five DMG systems provided that these five systems are sited at locations of the partner's choosing on a prioritised basis and subject to the demonstration unit achieving certain milestones. The first £0.1m tranche was paid in July after the first syngas was produced at Thornton Science Park.

In December 2017 PowerHouse signed heads of terms with Peel Environmental for locating the first commercial scale system at Peel Environmental's site at Ellesmere Port. This site is adjacent to Thornton Park, where the demonstration scale system is situated. It is a good location because it has access to the national gas grid, the commercial electricity grid, as well as both road and waterway access. Management and Peel Environmental have begun the planning and permitting process, with signature of the lease contingent on achieving approvals from the appropriate authorities. Surveying activities and initial site engineering will commence in early 2018.

Resolution of legacy issues

From 2012 onwards PowerHouse was dependent on successive tranches of finance from Hillgrove Investments, an investment vehicle of Peter Bond, which were provided under a convertible loan note agreement. The loan was secured by a debenture over the assets of the company and was accruing 15% interest per annum. In February 2017 Peter Bond's effective control over PowerHouse was curtailed by settling the loan (£3.4m including accrued interest) through a cash payment of £2.0m and conversion of the £1.4m balance into 280.4m new shares at the previously agreed 0.5p conversion price. These shares were not issued immediately and are shown as a £1.4m loan on the balance sheet as at end H117. The cash paid in part settlement of the loan was supplied from the proceeds of a placing raising £2.5m (gross) at 0.8p. Yady Worldwide contributed £0.5m to this raise. These shares held by Yady are also subject to a 12-month lock-in. At the end of January 2018 the £1.4m Hillgrove loan was converted to 280m new shares, 216m of which were placed with third parties at 0.51p/share. The remaining 65m will remain under PowerHouse control until the end of July 2018.

Management

During 2015 and 2016 costs were minimised by retaining only one executive director, Keith Allaun, who had been appointed executive chairman in June 2012 and was previously engaged by Linc Energy as Executive Vice President, Corporate Development. He has also worked with Apple, Yahoo!, Amazon and Hewlett-Packard. Now that the technology is approaching commercialisation, the executive team has been expanded. The former CEO and MD of Thyssenkrupp Industrial Solutions' Oil & Gas business unit for the UK, David Ryan, took charge of programme development in February 2017. In March 2017 Christopher Vanezis joined as CFO, although this is not currently a board position. Christopher is a chartered accountant with over 15 years' experience in the energy sector, including major infrastructure projects both in the UK and internationally. In October 2017 the former chief executive of Alkane Energy, Dr Cameron Davies, became non-executive chairman, enabling Keith Allaun to become CEO.

In May 2017 PowerHouse formed an advisory panel. The current member of the panel are Peter Jones OBE, formerly a board member of Biffa; Myles Kitcher, MD of Peel Environmental; Keith Riley, formerly MD of Technology Innovation Services at Veolia; Howard White, deputy chairman of Waste2Tricity; and Roudi Baroudi, a member of the United Nations Economic Commission for Europe's Group of Experts of Gas, who has worked on project and programme development with the World Bank, the IMF, the European Commission USAID and the Arab Fund for Economic and Social Development.

Sensitivities

- **Regulatory impact:** The EU Waste Framework Directive is broadly beneficial for PowerHouse Energy as the legislation makes it more economically attractive for businesses to use waste to produce energy rather than sending it to landfill. However, it also favours recycling of materials such as plastics, rather than recovering the energy content from the material, potentially limiting the amount of high caloric value waste available for gasification. Management believes that in practice there will be sufficient energy-rich material available that is not suitable for recycling because it cannot be separated efficiently from other waste streams. In addition, the need to secure permits to operate systems may delay commissioning of a new plant by over a year. For example, planning permission for the proposed plasma gasification waste-to-energy plant at Bilsthorpe, Nottinghamshire, in which both Peel Environmental and Waste2Tricity are involved, was submitted in July 2014, but the proposal only received approval from the secretary of state in June 2016. All DMG plants must comply with the Waste Incineration Directive 2000, which sets limits on harmful emissions such as dioxins and furans, forcing the closure of plants that are non-compliant.
- **Availability of waste:** The economic case for PowerHouse Energy's technology depends on the level of gate fees. These are dependent on the relative availability of waste and reduce if there is an excess of waste-to-energy capacity. Average UK gate fees reduced from £86/tonne in 2015 to £83/tonne in 2016, reflecting a concentration of capacity in the M62 corridor. There is competition for waste from facilities in the Netherlands, where there is over-capacity. As it is more efficient to run the DMG units continuously, it is essential for operators to secure a steady stream of waste feedstock of appropriate quality. It is likely, therefore, that units will be located on combined waste disposal/energy generation complexes. We note that a plasma gasification plant that operated successfully in Utashinai, Japan, closed in 2013 because it lost its waste supply contracts. The recent ban in China on importing plastic waste will increase the availability of suitable input material.

- **FCEV adoption:** Roll-out of waste-to-energy plants outputting hydrogen for refuelling stations is predicated on volume adoption of FCEVs. This is not certain and will depend, in our opinion, on fuel cell manufacturers succeeding in bringing down the cost of the technology and on FCEVs retaining a range advantage compared with battery-powered electric vehicles. We note that the DMG systems will initially be configured to produce electricity and will gradually switch to hydrogen production as demand increases. If demand does not increase as expected, PowerHouse Energy will still have a viable business generating electricity.
- **Technology still at pre-commercial phase:** The DMG system is still in a development phase. Consequently, there is no guarantee that the technology will generate syngas or electricity consistently over an extended period when working in a commercial environment with standard municipal waste, that the syngas produced in a commercial environment can be made sufficiently pure to be suitable for use in gas engines or for fuel cells, which are particularly sensitive to contaminants, or that the technology can be scaled up from a 1-3tpd to a 25tpd system. As the technology is still at a pre-commercial stage, the metrics used to build our valuation model are not based on actual data from the existing test unit. Similarly, there is no record of actual gate fees, prices received for supplying electricity or hydrogen or the likely cost of manufacturing systems, although our model uses a sensitivity analysis to address this uncertainty. There still remains some risk that a commercial version of the system will not be available in early 2018 as per management's expectations.
- **Scaling up organisation**: Until H117, staffing levels and other costs were kept to a minimum to conserve cash. Now that the technology is approaching commercialisation, the cost base is expanding. There is risk associated with managing this process to ensure that revenues and costs are aligned without impeding potential technology roll-out, and that growth can be achieved without undue reliance on related parties that take a substantial proportion of any profits generated.

Indicative valuation commentary

Exhibit 2: Indicative NPV for DMG system producing electricity based on WACC of 10% and terminal growth rate of 2.5%

Variable	Downside sensitivity	Indicative value	Upside sensitivity
Gate fee	£72/tonne	£80/tonne*	£88/tonne
NPV	£1.04m	£1.67m	£2.30m
Electricity sales price	£63/MWh	£70/MWh	£77/MWh
NPV	£0.88m	£1.67m	£2.46m
Calorific value of fuel	22.1MJ/kg	24.5MJ/kg	27.0MJ/kg
NPV	£0.88m	£1.67m	£2.46m
DMG system efficiency	27%	30%	33%
NPV	£0.88m	£1.67m	£2.46m
DMG parasitics	33%	30%	27%
NPV	£1.33m	£1.67m	£2.01m
DMG capex	£6.0m	£5.5m	£4.9m
NPV	£1.12m	£1.67m	£2.22m

Source: Edison Investment Research. Note: *Management notes that disposal fees for tyres are £220/tonne.

Since the rate of roll-out of DMG systems and the mechanism for funding is not yet certain, we present the indicative NPV calculation for a hypothetical full-scale 25tpd system generating electricity only (steady-state annual revenues of £1.5m, EBITDA of £0.7m, NPV £1.7m at 10% WACC and 2.5% terminal growth rate) and for a 25tpd system optimised for the production of pure hydrogen for fuel cells (steady-state annual revenues of £3.9m, EBITDA of £2.5m, NPV £11.8m at 10% WACC and 2.5% terminal growth rate). This calculation relies on estimates from management. As a full-scale (25tpd) system is still in the design phase, there are very limited data on energy conversion efficiency or the remuneration PowerHouse will receive from waste gate fees and sales of electricity or hydrogen, we have applied sensitivity tests to the key input parameters.

The indicative NPV calculations assume that the systems will be built, operated and owned by PowerHouse Energy and co-located at third-party waste transfer sites. It is likely that a variety of funding models will be applied, with some systems being jointly financed by the site operator and PowerHouse, others financed through special purpose vehicles associated with individual projects. Our NPV calculations do not model any profit sharing with other parties and are based on the assumption that 100% of cash flows are attributable to the company. In particular, our analysis does not include the 50% share of profits/cash flows payable to Waste2Tricity under the current agreement for its role in facilitating projects.

Exhibit 3: Indicative NPV for DMG system producing hydrogen based on WACC of 10% and terminal growth rate of 2.5%

Variable	Downside sensitivity	Indicative value	Upside sensitivity
Gate fee	£72/tonne	£80/tonne	£88/tonne
NPV	£11.27m	£11.84m	£12.41m
Hydrogen sales price	£6.75/kg	£7.50/kg	£8.25/kg
NPV	£9.16m	£11.84m	£14.51m
DMG capex	£11.1m	£10.1m	£9.1m
NPV	£10.82m	£11.84m	£12.85m

Source: Edison Investment Research

Financials

Historic financial information is unhelpful in assessing the group's future performance as the Pyromex operations in Munich and Switzerland were closed in February 2015. For the remainder of FY15 and FY16 operating costs were kept to a minimum, with the development work on the DMG system being carried out by a third party, OrePro, in Australia. PowerHouse did not begin to rebuild its employee base until H117.

H117 performance benefits from settlement of Hillgrove loan

H117 operating costs totalled £627k, £203k of which related to R&D expenses, some of which were outsourced. This level of operating costs was very similar to H116. Finance costs reduced from £242k to £70k, reflecting the repayment of the Hillgrove loan. Losses before tax (adjusted for share-based payments) narrowed by 14% to £697k.

Balance sheet significantly strengthened during FY17

As discussed on page 8, in February 2017 the balance sheet was transformed through the settlement of the Hillgrove loan, much of which was satisfied through cash from a placing raising £2.5m (gross) at 0.8p/share. Working capital increased by £41k. There was no capital expenditure. The group ended H117 with £145k net cash (ignoring the £1.4m shares issued as part settlement of the Hillgrove loan, which are shown as a loan on the balance sheet), compared with £3.2m net debt at the beginning of the period. The balance sheet was further strengthened through a share placing raising £1.6m (gross) in August at 1.0p/share.

Cash consumption during H117 (excluding finance costs and proceeds from the placing) totalled £668k. If cash burn were to continue at this rate, management would need to seek additional finance during H218. Given the additional personnel recruited during H117 and the intensified investment in R&D, we expect cash burn during H217 and FY18, excluding any project-related finance, to be higher than H117.

Exhibit 4: Financial summary

Year end 31 Dec	£'000	2014	2015	2016	H117
PROFIT & LOSS					
Revenue		0	0	0	0
Cost of Sales		0	0	0	0
Gross Profit		0	0	0	0
EBITDA		(1,182)	(397)	(784)	(627)
Operating Profit (pre amort. of acq intangibles & SBP)		(1,182)	(397)	(784)	(627)
Amortisation of acquired intangibles		0	0	0	0
Share-based payments		0	0	(68)	0
Exceptionals		(1,038)	0	0	0
Operating Profit		(2,221)	(397)	(852)	(627)
Net Interest		(329)	(385)	(482)	(70)
Profit Before Tax (norm)		(1,512)	(782)	(1,266)	(697)
Profit Before Tax (FRS 3)		(2,550)	(782)	(1,334)	(697)
Tax		0	0	0	0
Profit After Tax (norm)		(1,512)	(782)	(1,266)	(697)
Profit After Tax (FRS 3)		(2,550)	(782)	(1,334)	(697)
Average Number of Shares Outstanding (m)		376.6	390.1	551.4	862.7
EPS - normalised (p)		(0.40)	(0.20)	(0.23)	(0.08)
EPS - normalised fully diluted (p)		(0.40)	(0.20)	(0.23)	(0.08)
EPS - FRS 3 (p)		(0.68)	(0.20)	(0.24)	(0.08)
Dividend per share (p)		0.00	0.00	0.00	0.00
Gross Margin (%)		N/A	N/A	N/A	N/A
EBITDA Margin (%)		N/A	N/A	N/A	N/A
Operating Margin (before GW and except.) (%)		N/A	N/A	N/A	N/A
BALANCE SHEET					
Fixed Assets		0	0	2	2
Intangible Assets		0	0	0	0
Tangible Assets		0	0	2	2
Current Assets		6	177	154	235
Stocks		0	0	0	0
Debtors		6	1	6	91
Cash		0	176	148	145
Current Liabilities		(2,416)	(199)	(3,383)	(1,496)
Creditors including tax, social security and provisions		(235)	(199)	(51)	(94)
Short term borrowings		(2,181)	0	(3,332)	(1,402)*
Long Term Liabilities		0	(2,939)	0	0
Long term borrowings		0	(2,939)	0	0
Other long term liabilities		0	0	0	0
Net Assets		(2,410)	(2,960)	(3,227)	(1,259)
CASH FLOW					
Operating Cash Flow		(1,961)	(813)	(637)	(598)
Net Interest		(329)	(385)	(482)	(70)
Tax		0	0	0	0
Capital expenditure		0	0	(2)	0
Capitalised product development		0	0	0	0
Acquisitions/disposals		0	0	0	0
Equity financing		1,225	231	701	2,595
Dividends		0	0	0	0
Net Cash Flow		(1,066)	(966)	(421)	1,927
Opening net debt/(cash)		1,490	2,181	2,763	3,184
Finance leases		0	0	0	0
Other		(375)	(384)	0	(1,402
Closing net debt/(cash)		2,181	2,763	3,184	(145)**

Source: Company data. Note: *Shares issued to Hillgrove in part settlement of loan. **Excluding shares issued to Hillgrove.

Contact details	Revenue by geography
PowerHouse Energy Group 10b Russell Court, Woolgate, Cottingley Business Park, Bingley, BD16 1PE, United Kingdom +44 (0)20 3368 6399 www. powerhousegroup.co.uk	N/A

Management team

Non-executive Chairman: Dr Cameron Davies	CEO: Keith Allaun
Dr Davies is an international energy sector specialist with a good track record of growing profits in a quoted energy company. As chief executive of Alkane Energy, he led the business from its formation in 1994, through venture capital funding and IPO to become a profitable operator of c 160MW of gas to power generation plants. He resigned as director in 2015 when Alkane was acquired by Balfour Beatty Infrastructure Partners. He is also a non-executive director of Ascent Resources. He became chairman in October 2017.	Mr Allaun has a background in venture capital, management consulting and executive management. He has worked with leading companies in emerging technologies for over 25 years, including Linc Energy, Apple, Yahoo!, Amazon and Hewlett-Packard. He was appointed executive chairman in June 2012 and became CEO in October 2017.
Director of Programme Development: David Ryan	**CFO: Christopher Vanezis**
Mr Ryan was appointed as a non-executive director in February 2017 and assumed an executive role in March. He was previously the former CEO and MD of Thyssenkrupp Industrial Solutions' Oil & Gas business unit for the UK. He has over 30 years of complex engineering, business development and project management experience.	Mr Vanezis was appointed CFO in March 2017. He trained with Deloitte and Coopers & Lybrand, qualifying as a chartered accountant in 1990. He has over 15 years' experience in the energy sector, with a strong track record in major infrastructure projects both in the UK and internationally.

Principal shareholders	(%)
Hargreaves Lansdown Asset Management	17.2
Paul Wawick	8.4
Yady Worldwide SA	6.9
RenewMe Limited	6.4
SVS Securities	5.1
Toronto Dominion Bank	4.1
Barclays plc	3.4

Companies named in this report

AFC Energy (AFC:LN), Alkane Energy (ALK:LN), Ascent Resources (AST:LN), Biffa (BIFF:LN), Hydrogenics (HYGS:US), ITM Power (ITM:LN), Linc Energy (LNC:SP), Veolia (VIE:FP)

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