EDISON

Spotlight research

PowerHouse Energy Group

Alternative energy

12 September 2019

Fuelling the hydrogen economy

Over the last 18 months PowerHouse and its partners Peel Environmental and Waste2Tricity (W2T) have put most of the building blocks in place for commissioning the first commercial distributed modular generation (DMG) waste-to-energy plant by the end of FY20. This potentially represents the first of dozens of small sites in the UK and abroad using unrecyclable plastic that would otherwise go to landfill to generate hydrogen for electric vehicles and electricity.

Expanding pipeline with Peel Environmental

In August 2019, PowerHouse signed a collaboration agreement with Peel Environmental. This seeks to develop 11 DMG facilities at sites in the UK, primarily on Peel's land, including a project announced previously at Peel's Protos Energy Park on Merseyside. Investors in these projects are being offered a potential IRR of over 30%. PowerHouse will receive fees for each project for carrying out tests on the proposed feedstock and providing a customised front-end engineering design. Additionally, once each plant is commissioned, PowerHouse will receive operating licence fees. Peel estimates the development costs for this enlarged pipeline of 11 sites would be at least £130m. This business model removes the need for PowerHouse to finance the construction of plants, eliminating a major dilution risk for shareholders, and potentially accelerates roll-out.

First revenue-generating contract

Project developers Peel and W2T have already secured a customer on the Protos estate for the electricity and hot water generated, as well as a primary feedstock and back-up supply. They are now working on securing planning and operating permits for the plant, and financing before they can proceed to the construction and commissioning phase. PowerHouse's first contract, received in April 2019, was to carry out tests on the feedstock that will be used at this site and provide a front-end engineering design for a DMG unit using the site-specific feedstock.

Valuation: Defined route to profitability

PowerHouse has a qualified pipeline of over 30 sites in the UK where DMG units may be deployed. We calculate that it will reach break-even on sales of two DMGs per year. We estimate that deployment on 10 sites in a year, such as those already identified by Peel Environmental, could generate c £6m operating profit.

Historic financials

Year end	Revenue (£m)	EBITDA* (£m)	PBT* (£m)	EPS* (p)	DPS (p)	P/E (x)
12/15	0.0	(0.4)	(0.8)	(0.20)	0.0	N/A
12/16	0.0	(0.8)	(1.3)	(0.23)	0.0	N/A
12/17	0.0	(1.6)	(1.7)	(0.17)	0.0	N/A
12/18	0.0	(1.9)	(1.9)	(0.12)	0.0	N/A

Note: *EBITDA, PBT and EPS are normalised, excluding amortisation of acquired intangibles, exceptional items and share-based payments.

Price	0.41p
Market cap	£8m

Share price graph

Share details

Code	PHE
Listing	AIM
Shares in issue	1.92bn
Net cash (£m) at end Dec 2018	0.8

Business description

PowerHouse Energy designs, delivers and licenses plastic regeneration processes for the generation of hydrogen and electrical energy. It also provides associated customer engineering and testing services, and operational support for applications in the UK and across the world.

Bull

- DMG technology provides mechanism for diverting waste plastic from landfill.
- Hydrogen generated from DMG plants may be used for fuel cell vehicles.
- Electricity from DMG plants complements intermittent supply from wind and solar sources.

Bear

- Commercial-scale unit not constructed yet.
- Deployment of DMG units dependent on developer securing funding for developments.
- Limited cash reserves.

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Edison profile page

PowerHouse Energy Group is a research client of Edison Investment Research Limited

Investment summary

Company description: Distributed modular generation

PowerHouse Energy owns an innovative waste-to-hydrogen DMG reactor technology. This technology provides a mechanism to dispose of a wide range of waste streams including unrecyclable plastic by converting them to a carbon-neutral product which may be used to power fuel cell electric vehicles (FCEVs) or to generate electricity. Unlike competitive techniques for converting municipal waste to energy, the reactors 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.

Financials: Sufficient funding until end June 2020

Operating losses widened by 38% year-on-year during FY18 to £2.5m, reflecting higher R&D and staff costs and higher share-based payments. Losses before tax (adjusted for share-based payments) rose more slowly, by 16% to £1.9m, following the settlement of a substantial loan from former investor Hillgrove. The company started and finished FY18 with £0.8m cash. Three equity raises, all at 0.5p/share, with total net proceeds of £3.4m were balanced by £1.9m cash consumed in operations and repayment of the £1.4m Hillgrove loan. The notes to the FY18 accounts state that the directors have prepared working capital projections, which show that the cash balance at end FY18 (there is no debt) is sufficient to enable the company to continue operations for the foreseeable future. This conclusion is based on signed agreements from all the directors and certain contractors to waive future remuneration or fees and a letter of support from one of its shareholders, who is also a director of the company, that he intends to make up to £300k available for at least 12 months from the end of June 2019. Since cash consumption depends on how long it takes for Peel and W2T to secure funding for the first DMG deployment and the level of revenues PowerHouse can derive from providing engineering services, there remains a risk, in our opinion, that it will need to raise more finance.

Valuation: Defined route to profitability

The company's revised business model positions it as a technology provider, receiving licence income when DMG units are deployed, supplemented by fees for providing engineering services and operational support. This provides a platform to establish the company as a sustainable and profitable business. We estimate that the company would reach break-even on only two DMG deployments per year, with fees from engineering contracts, the first of which was received in April, mitigating cash burn until that point is reached.

Sensitivities: Risk will reduce with commercialisation

While the DMG reactor has undergone more than a year of testing, thus reducing technical risk, risk remains regarding operation in a commercial environment. Importantly, while the purity of the hydrogen produced has been confirmed in third-party tests, the gas output has not been fed into a working fuel cell. While there remains risk associated with scaling up from the 1–3tpd demonstration reactor to a 25tpd commercial project, work with DNV GL has reduced this. 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 reactors 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 will be affected by macroeconomic factors and environmental legislation.

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Company description: Responsible, economic energy recovery

PowerHouse Energy Group is commercialising an innovative waste-to-hydrogen, distributed modular generation (DMG) reactor technology. This reactor converts hydrocarbon waste streams, including unrecyclable plastic, into syngas or hydrogen. Syngas can be used to generate electricity for export to the grid or for use in an enterprise. Since the technology operates at a higher temperature than conventional gasification techniques and incorporates gas processing and clean-up, it produces no char or oil residue or toxic dioxins and furans. The syngas should therefore be sufficiently clean to power FCEVs 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. Longer term, the conversion of plastic to gas will permit storage of energy in the syngas until it is needed to make up shortfall from renewable generation sources. Importantly, the conversion provides a route for diverting plastic from disposal in landfill. The technology is carbon emission neutral when operating in power generation mode, and carbon emission negative when generating hydrogen.

The small footprint, modular design of the reactor means that, once commercialised, PowerHouse will offer waste-to-energy systems based on one or more reactors, 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 25tpd (tonnes of waste per day) DMG reactor would potentially generate up to 2,000kg of hydrogen each day, sufficient to drive 2,000 FCEVs an average of 57 miles each. Alternatively, it could generate c 1.6MW electricity (equivalent to a medium-sized wind turbine), sufficient to power around 3,000 homes. This means the DMG reactors can be located close to where the waste material is produced and collected, and generate electricity or hydrogen or electricity fuel close to where it is required, thus cutting down on the costs and energy used in transportation.

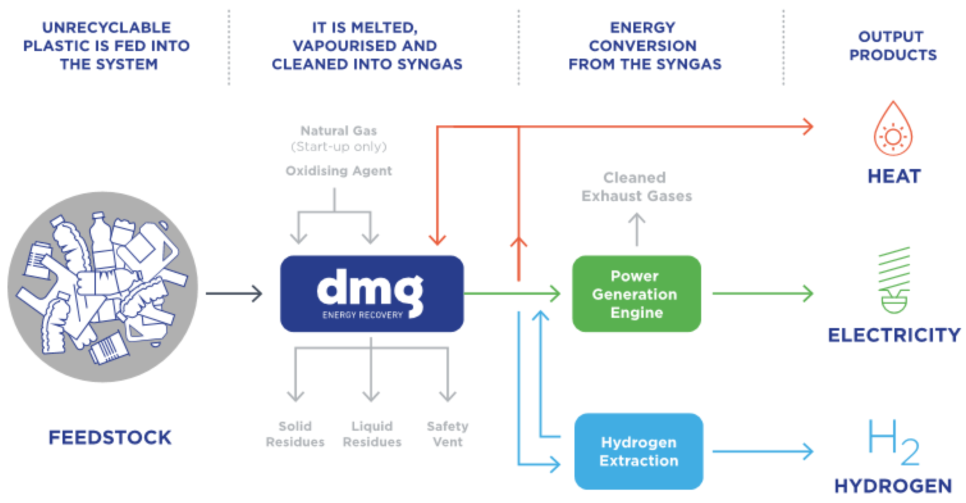
Although PowerHouse listed in 2011, it is still at a relatively early stage of corporate development, as any significant commercial progress was precluded until DNV GL completed its independent validation of the full-scale design in October 2018. The company's 1–3tpd demonstration reactor situated near Ellesmere Port in the UK has been in operation for over a year and provided electricity to the local micro-grid. Based on results from these trials, the company has finalised designs for a 25tpd commercial reactor that have been independently verified. It intends to generate revenues from operating licence fees and operational support once DMG plants developed by third parties have been commissioned, as well as less substantial fees for tests on potential feedstock for proposed installations and customisation of the generic design for specific feedstocks. This business model, which was adopted in November 2018, removes the need for PowerHouse to finance the construction of plants, eliminating a major dilution risk for shareholders. It also enables the company to qualify for EIS investment status.

PowerHouse currently has two full-time employees, although this number will increase as the company progresses towards commercialisation. PowerHouse is currently partnering with Peel Environmental and Waste2Tricity (W2T). PowerHouse supplies the technology, while its partners secure sites for the reactors, negotiate planning and operating permits and contracts for sourcing feedstock and supplying electricity or hydrogen, and will either operate the reactors themselves or sell them to third parties once operational. In H119 the partners secured a site for the first DMG operation, which is on Peel Environmental's £700m Protos energy hub near Ellesmere Port in England, and signed up a customer on the Protos estate for the electricity and hot water generated, as well as a primary feedstock and back-up supply. UK engineering consultancy, Engsolve, which has worked on numerous gasification projects, provides supplementary design support. PowerHouse has pre-qualified five potential contractors to undertake design and execution, enabling it to support projects on multiple sites in parallel.

Technology: Ultra-high temperature gasification

PowerHouse's DMG technology is an innovative, patentable process that has been developed over the last 20 years. The DMG unit uses a process in which complex organic molecules are broken down into their constituent elements through indirect heat in an oxygen-starved environment. The reactor is based on a thermal conversion chamber, which is an established technology and uses standard components. Installation is simplified and de-risked through the use of prefabricated components, off-the-shelf skids, pre-assembled piping and structures and limited hook-up demands.

Exhibit 1: DMG process



Source: Company

The company's IP lies in its understanding of the details of the thermal conversion chamber design and the operating parameters. The IP is protected by automating control of the process so that operators do not need access to the details. In addition, PowerHouse has started to protect the IP by filing for the first of a family of patents.

Competitive position of technology

Exhibit 2: Competitive waste disposal technologies

Incineration	Pyrolysis	Standard gasification	Plasma arc gasification	DMG process
Combustion in unrestricted amounts of oxygen to give CO_2 and H_2O	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 residue.
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 airborne pollutants	Airborne pollutants reduced in process and then further scrubbed.
Typically, 50–300k tonnes of waste processed/year	Typically, 25–150k tonnes/year	Typically, 60–650k tonnes/year	Typically, 20–700k tonne/year,	Potentially <12k tonnes/year. Process designed so two trains can be installed under local authority permit.

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 vaporises the waste material, controlling conditions in the chamber to break down the longer chains of hydrocarbon materials. There is no combustion of the waste to create dioxins. As the syngas is not contaminated with tar it can potentially be used to generate hydrogen for use in fuel cells or used in a combined-cycle gas turbine engine. A gas engine gives an electrical conversion efficiency of up to 40% 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 the DMG process generates electricity from material that would otherwise incur a tipping fee on disposal, this improves the economics of adoption. DMG operators will receive a fee from the third party whose waste they are destroying, effectively subsidising the energy generation and making smaller modular generation based in the community economically viable. Modelling £15.0m capital costs for a single DMG unit, hydrogen prices of £7/kg, electricity prices of £80/MWh and waste disposal fees of £100/tonne, management calculates that the potential IRR for investors in individual projects is over 30%.

Gasification for waste-to-energy projects

Exhibit 3: Gasification equipment

Company	Plasma	Status	Size	Feedstock
Advanced Plasma Power	Yes	Pilot in Swindon, UK. Company placed in administration in December 2018. Issues with technology and securing funds to cover project overspend.	20tpd	Municipal solid waste and commercial/industrial waste
Alter NRG/Westinghouse Plasma	Yes	Commercial operation in China, India and Japan. Tees Valley project closed 2016	24-150tpd	Municipal solid waste water sludge, hazardous waste
ArcSec Technologies	Yes	Pilot under construction in Alabama	11 acre site	Multiple waste streams
Ankur Scientific Energy Technologies	No	1,000+ systems installed in Cuba, India, Singapore, Thailand and elsewhere. Not EU safety compliant	Small-scale	Biomass
Bioenergy Infrastructure Group	No	Site at Protos operational March 2019 Site at Levenseat, Lanarkshire experiencing delays with commissioning Hull site on hold following delays to commissioning	21.5MW 288tpd 657tpd	Waste wood RDF* RDF
Covanta	No	Demonstration plant operational at its Tulsa, Oklahoma waste-to-energy site	375tpd	Municipal waste
EQTEC	No	Operational projects in Europe and India	20-100tpd	Primarily biomass
Hitachi Metals/Westinghouse Plasma	Yes	25tpd plant operational in Japan. 150tpd plant commissioned in Japan but closed because of problems with waste contracts	25tpd and 150tpd	Municipal waste and dried sewage sludge
InEnTec	Yes	Operational at landfill site in Oregon.	N/A	Municipal waste
NextChem (Maire Tecnimont)	No	Partnership signed with ENI to convert non-recyclable waste into chemical products and fuel	N/A	Industrial waste
PEAT International	Yes	National Cheng Kung University, Taiwan	3-5tpd	Multiple waste streams
Plasco Energy	Yes	Project in Ottawa was cancelled because of lack of government funding. Company placed in administration.	<405tpd	N/A
PowerHouse Energy Group	No	Pilot on Merseyside, UK	C 3tpd	Shredded plastic, tyre crumb
PRM Energy Systems	No	Over 20 systems in commercial operation in the US, Europe, and South-East Asia	20-2,000tpd	Biomass including sewage sludge
Progressive Energy with Peel Environmental	No	Planning application for plant at Protos site submitted. Due to start operation in 2022. Manufacturing syngas	480tpd	Waste wood and RDF
Shell Global Solutions	No	c 100 plants in operation	N/A	Refinery residues

Source: Edison Investment Research. Note: *Refuse derived fuel.

We note that there are dozens of companies globally developing waste-to-energy gasification equipment, some of which use plasma arc technology to achieve the high temperatures required. Exhibit 3, which is not intended to be exhaustive, lists those companies which appear to have operational projects. We note that some projects have failed because of issues securing large volumes of waste and transporting it over a long distance to supply a single large-scale plant. Unlike many companies developing gasification equipment, PowerHouse's solution is small scale, so it can be located close to a source of waste, circumventing this problem. Its solution is also relatively unusual in using unrecyclable waste plastic such as film, food trays and rigid plastics as a primary feedstock to generate hydrogen. Other gasification companies typically use different feedstocks. For example, the Bioenergy Infrastructure Group's plant at Protos uses waste wood and Progressive Energy's proposed plant at Protos will use waste wood and RDF. Other waste-to-energy technologies using waste plastic deploy pyrolysis techniques to convert the waste to liquid fuel. Management notes that DMG offers potentially lower waste sorting and cleaning costs compared with other energy-from-waste processes and is less sensitive to the calorific range of the feedstock.

Macro opportunity driven by green economy

PowerHouse Energy is positioned to take advantage of the increasingly onerous restrictions regarding the disposal of waste, of rising 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, and the small but rising demand for pure hydrogen to power FCEVs. PowerHouse's technology provides a way of not only disposing of waste in an environmentally responsible manner but also extracting financial value from it.

Addressing the issue of plastic waste

According to the PlasticsEurope Market Research Group, the amount of post-consumer plastic waste collected in Europe rose from 24.5m tonnes in 2006 to 27.1m tonnes in 2016, a CAGR of 1.0%. In 2016, 42% was used to generate energy (4.9% CAGR), 31% was recycled (6.0% CAGR) and the remaining 27% (-5.4% CAGR) sent to landfill, with recycling overtaking landfill for the first time. Of the 8.4m tonnes recycled, 63% was processed in Europe, with the remainder exported for treatment. The proportion of plastic waste recycled varies according to the regulatory environment. In Germany, where the regulatory environment virtually prohibits landfill, 38.6% of the 5.1m tonnes of plastic waste collected was recycled, 60.6% converted to energy and only 0.8% consigned to landfill. For the UK's 3.8m tonnes of plastic waste collected, the respective proportions were 32.1%, 38.3% and 29.6%. Management estimates that if all of the plastic waste currently collected in the UK was gasified, it would support 500 25tpd DMG units. We note that while plastic waste is currently receiving most media attention, this is not the only type of waste that can be gasified by PowerHouse's DMG technology. In 2017, UK household waste totalled 26.9m tonnes (2016: 27.3m), 45.0% (2016: 44.7%) of which was recycled.

The regulatory environment is moving in favour of recycling. In January 2018, the EU announced its Plastic Waste strategy, under which all plastic packaging on the EU market would be recyclable by 2030, the consumption of single-use plastics would be reduced and the intentional use of microplastics would be restricted. In response to this, the European Association of Plastic Manufacturers issued its Plastics 2030 – Voluntary Commitment, which contains a set of initiatives to achieve high rates of re-use and recycling, with the ambition to reach 60% for plastics packaging by 2030 and 100% re-use, recycling and/or recovery of all plastics packaging in the EU-28, Norway and Switzerland by 2040. In December 2018, the UK government announced its new Resources and Waste Strategy, which will extend producer responsibility for packaging, ensuring that producers pay the full costs of disposal for packaging they place on the market, stimulate demand for recycled plastic by introducing a tax on plastic packaging with less than 30% recycled plastic, ban plastic products where there is a clear case for it and alternatives exist, and improve recycling rates by ensuring that a consistent set of dry recyclable materials is collected from all households and businesses. While this government initiative primarily promotes plastic recycling, which theoretically reduces the amount of plastic available for gasification, we view this initiative as positive for PowerHouse as it will increase the amount of plastic waste collected from homes, a significant proportion of which (PowerHouse estimates around 30%) is not recyclable. In addition, the new Resources and Waste Strategy includes the objective to 'encourage innovative waste treatment technologies that create transport fuels through the Renewable Transport Fuels Obligation', which is directly applicable to PowerHouse's technology.

Fuelling the hydrogen economy

An exciting opportunity for PowerHouse longer term is the ability to generate hydrogen at a local level for use in FCEVs, demand for which is being driven by concerns about the air pollution caused by petrol and diesel vehicles and the potential to reduce the carbon emissions from vehicles The International Energy Authority (IEA) notes that at the end of 2018 there were around 11,200 FCEVs globally, with sales of around 4,000 during the year, which was 80% more than 2017. Most of the sales were in California, where the Zero Emission Vehicle (ZEV) program has driven demand. While up to 2,000 small trucks powered by fuel cells were manufactured in China, only 400 were registered for road use because of the lack of refuelling infrastructure. Targets for FCEV adoption require a sharp rise in the hydrogen infrastructure required to fuel the vehicles (see Exhibit 4).

Exhibit 4: National FCEV and hydrogen fuelling station targets

Country	2020	2023	2025	2028	2030
FCEVs					
US	13,000	40,000			
Japan	40,000		200,000		800,000
France		5,000		20,000-50,000	
China	5,000		50,000		1,000,000
Netherlands	2,000				
Korea	10,000		100,000		630,00
Fuelling stations					
US	80	100			
Japan	160		320		
France		100		400-1,000	
China	100		300		500
Germany	100		400		1,000
Korea	100		210		520

Source: IEA

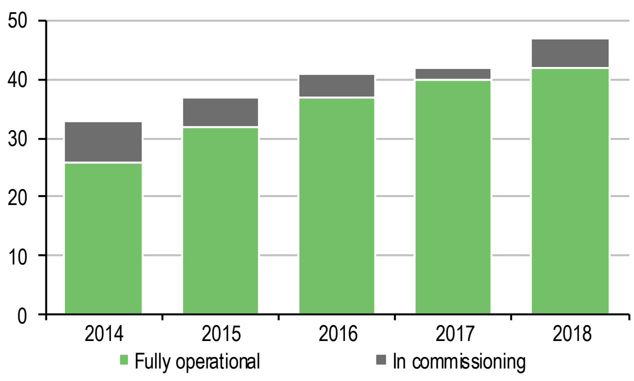
Most industrial hydrogen is made in steam methane reformers, which generate significant volumes of carbon dioxide, so using hydrogen made this way in refuelling stations goes against the premise of reducing carbon dioxide emission and the use of fossil fuels. Instead of using hydrogen that has been manufactured 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 cost of conversion per kilogram of hydrogen produced this way is significant. The small footprint of the DMG unit means it could be used as an alternative mechanism for producing hydrogen on site, which is net negative with regards to carbon dioxide emissions. Moreover, as the waste can be processed close to where it was originally produced, as for example in local community DMC deployments, the carbon footprint associated with transporting it is significantly reduced, especially if the alternative is shipping the waste overseas.

Providing balance in the renewable energy mix

UK government statistics show that renewables have increased from 3% of electricity generation capacity in 1996 to 39% in 2017.This increase in renewable sources means 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. While energy derived from waste is currently a very small proportion of all energy generated in the UK, with municipal waste combustion accounting for only 6% of all renewable energy used in 2017, in the future it could provide a mechanism for addressing imbalances between energy demand and supply. While this is not an immediate opportunity for PowerHouse, we believe that it merits attention.

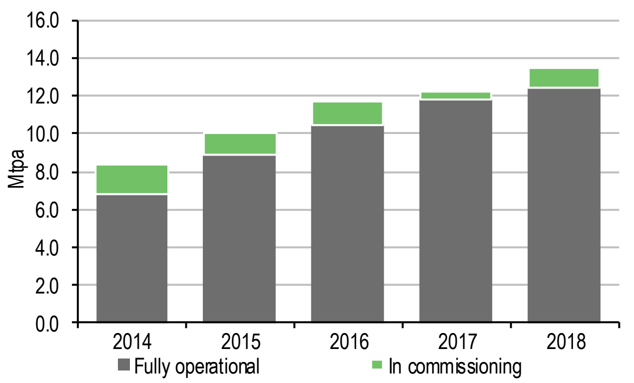
This is because less than half of the UK's energy-from-waste plants are accredited as 'recovery operations rather than 'disposal'. Most of those classified as recovery operations are incineration plants, generating electricity during the time that the waste material is being burnt. In contrast, the syngas produced by PowerHouse's DMG 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. This is in contrast to centralised power generation systems, where 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.

Exhibit 5: Number of EfWs in UK



Source: Tolvik Consulting

Exhibit 6: EfW capacity UK



Source: Tolvik Consulting

Executing the strategy

Refining the technology

During FY17 and FY18, PowerHouse focused on improving the performance of its third-generation 1–3tpd demo DMG unit at Thornton Science Park on Merseyside. This demonstration unit was used as the basis for the front-end engineering design for a full-scale unit. While this has not been constructed, the independent validation by DNV GL confirmed that this design can process 25tpd of high calorific waste, generating electricity and, in conjunction with other equipment, produce up to two tonnes of hydrogen per day. The design incorporates pre-fabricated components and pre-assembled piping and structures to make it easy to install. The components have been sourced from manufacturers with proven design, manufacturing and operating experience who will provide guarantees for the component operation in the DMG system.

The demonstration unit has also been used to conduct tests on many different forms of plastic feedstock for recyclers, including a number of internationally recognised waste companies, which may potentially host DMG units at their sites. Feedstocks included shred tyres, mixed automotive plastic, cable insulation, shredded labels and mixed plastics, shredded beach waste, solid recovered fuel (SRF) and biomass. Successful execution at the Protos site should help convert this interest into more widespread adoption of the technology.

Exhibit 7: Technology milestones

Date	Milestone
H117	Modification of control systems to meet the UK safety standards, enhancements to gas systems and revision of feed and steam generation systems in conjunction with local engineering consultancy Engsolve. 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.
August 2017	In-house demonstration that the syngas produced contained over 50% hydrogen, some carbon monoxide and methane and no carbon dioxide.
October 2017	Confirmation by independent third-party laboratory 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.
November 2017	Completion of technology trials preparatory to starting the design and engineering of the first commercial-scale unit.
March 2018	Demonstration unit in operation for six months.
June 2018	Demonstration unit connected to Thornton Park micro-grid.
July 2018	Generic Front-End Engineering Design (FEED) for 25tpd unit complete.
October 2018	Independent validation of full-scale design by DNV GL confirms that a unit could convert 25tpd of feedstock comprising high calorific value waste material and that the energy-rich syngas can be combusted to produce power for distributed electrical generation. Also, that the DMG technology allows for integration of a process for the co-production of high-purity hydrogen from a proportion of the syngas in addition to generating power.

Source: Company data

Forming partnerships to commercialise the technology

Now that the design is complete, PowerHouse can offer proposals for the deployment of DMG at waste management sites. As noted above, it is working with partners to accelerate commercial engagement. Once the first commercial site in the UK is operational, PowerHouse intends to target multiple sites in the UK and overseas. As well as the pipeline of opportunities on Peel sites, it has received interest from internationally recognised waste companies, from major industrial complexes wanting to provide energy for their sites with net zero carbon dioxide emissions and from local councils.

PowerHouse intends to adopt the licencing and partner engagement model to penetrate international markets, focusing initially on Spain, Japan, Korea and other parts of Asia. Japan is a key market because the government is keen to reduce its reliance on fuel imports. After the shut-down of many nuclear power plants in the wake of the Fukushima disaster in 2011, imported fossil fuel now accounts for over 90% of Japan's primary energy supply. A third of this fuel is petrol from the Middle East, the supply of which is subject to geopolitical risks. In addition, the government has set targets of a 26% reduction in greenhouse gas emissions between 2013 and 2030 and an 80% reduction of current levels by 2050. Widespread adoption of DMG would provide a stable, secure supply of carbon dioxide-neutral hydrogen generated from plastic waste produced within Japan.

First full-scale DMG project in Ellesmere Port

The most commercially advanced project so far will be located at Peel Environmental's 54-acre Protos energy hub site near Ellesmere Port in Cheshire. Electricity from this project will be supplied under a Memorandum of Understanding (MoU) to recycling company Advanced Sustainable Developments (ASD), which intends to open a PET (polyethylene terephthalate) plastics recycling facility at Protos. Under the terms of the MoU, the electricity generated by the DMG system will be fed into a private grid on the Protos site and supplied at a discount (no information on the magnitude of this discount is available at the moment) to current power market prices to ASD. In addition, ASD has agreed to supply the DMG unit with unrecyclable plastic for use as feedstock, paying a price for disposal that is significantly below current landfill prices.

Development partners Peel and W2T now have a site for the first DMG operation, a customer for the electricity and hot water generated, and a primary feedstock as well as a back-up supply. In April, PowerHouse was engaged to carry out tests on the proposed PET feedstock and provide a front-end engineering design for a commercial-scale DMG unit using this particular feedstock. This engineering work is preparatory to the developers securing planning and operating permits. The first stage of the engineering work, modelling noise and emissions has been completed, confirming that there are no emission regulation issues. The results have been shared with the local community and councils as part of a consultation process prior to applying for planning permission. This will be submitted at the same time as an operating permit is applied for. Peel and W2T continue to seek financing for the plant. These discussions should be supported by the announcement of the formal collaboration with Peel at another 10 sites (see below), which is a strong endorsement of DMG. Moreover Peel, which is leading engagement with potential hydrogen customers, intends to become actively involved in the financing discussions. When these steps are completed, the developers can proceed to the construction and commissioning phase, triggering the payment of operating licence fees to PowerHouse post commissioning.

Collaboration with Peel Environmental extends pipeline

PowerHouse has recently signed a collaboration agreement with Peel Environmental. This seeks to develop 11 DMG facilities at sites in the UK, primarily on Peel's land, including Protos. The collaboration is part of Peel's strategy to develop 'Plastic Parks' where waste plastics that cannot be recycled are used to generate electric power and hydrogen rather than being sent to landfill. W2T will act as project developer for each facility. Peel will provide suitable sites on industrial parks, fit the infrastructure, identify sources of waste plastic and purchasers of power and hydrogen and help W2T secure funding from investors for each site. As with the Protos site, PHE will receive fees for each project for carrying out tests on the proposed feedstock and providing a customised front-end engineering design. Additionally, once each plant is commissioned, PHE will receive operating licence fees. Peel estimates that the development costs for this enlarged pipeline of 11 sites would be at least £130m.

Next steps

PowerHouse is currently focused on completing the front-end engineering design for the DMG unit at the Protos site. This information will be included when W2T applies for planning and operating permits for the plant in September in anticipation of receiving planning permission in October. We note that PowerHouse is in further negotiations for contracts for DMG applications at a number of other UK sites as well. This includes testing feedstocks and using data from the demonstration equipment to assess the feasibility of DMG installation at potential host sites. These activities should help W2T secure additional development projects when the Protos project is operational, as well as generating revenues in the short term.

Management

In February 2019 the former CEO and MD of Thyssenkrupp Industrial Solutions' Oil & Gas business unit for the UK, David Ryan, became CEO, having been in charge of PowerHouse's programme development since February 2017. Prior to his employment with Thyssenkrupp, he founded and built a successful engineering consulting organisation, Energy & Power, which was acquired by Thyssenkrupp in 2012. Until February 2019, David was also a director of W2T, acting as a director of PowerHouse under a director swap. He relinquished the W2T role on becoming PowerHouse's CEO. The leadership change reflects the company's move closer to commercialisation, with technical engagement now being a crucial part of the sales and delivery process. The other members of the executive team are Bruce Nicholson and Christopher Vanezis. Bruce was appointed commercial operations manager in April 2018. He previously worked for an independent project management company, where he was involved with a wide range of organisations including multi-nationals, such as Thyssenkrupp, EDF, Tullow Oil and BHP, as well as smaller independents. Christopher became CFO in March 2017. He is a chartered accountant with c 30 years' experience in the energy sector, including major infrastructure projects both in the UK and internationally, and is also Waste2Tricity's finance manager.

The former chief executive of Alkane Energy, Dr Cameron Davies, has been non-executive chairman since October 2017. 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 for £60m.

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 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 from the relevant local authority to operate reactors may delay commissioning 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.The independent international consultancy Fichtner has demonstrated that the DMG process is fully compliant with the legislative emission levels for operation in the UK and elsewhere in the EU.
- **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. 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 which operated successfully in Utashinai, Japan, closed in 2013 because it lost its waste supply contracts. China's decision to ban imports of plastic waste for recycling in 2017 has increased the availability of suitable input material. However, the construction of more waste-to-energy plants, for example Biffa is proposing to construct two facilities with Covanta each with a capacity of 350ktpa, one of which will be located on the Protos site, will make sourcing waste more difficult. Management believes that in practice there will be sufficient energy-rich material available that cannot be processed by other waste-to-energy technology.
- **FCEV adoption:** the 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 reactors will initially be configured to produce electricity and will gradually switch to hydrogen production as demand increases. If demand does not increase as expected, DMG technology will still be a viable route for simultaneously disposing of plastic waste and generating electricity.
- **Technology still at pre-commercial phase:** an independent body has confirmed that the scaled-up reactor design is capable of processing up to 50tpd of waste and converting it to two tonnes of hydrogen gas. This information was used to calculate the IRR of over 30%. DNV GL has also carried out a safety review. Additionally, the 1–3tpd demonstrated plant has proved itself able to generate electricity and to process multiple types of waste streams, and the syngas it outputs has been verified by a third party as sufficiently pure for use with a fuel cell. However, there is no guarantee that the scaled-up technology will generate syngas or electricity

consistently over an extended period when working in a commercial environment, and the hydrogen produced from syngas has not been used with an actual fuel cell, so while technical risk has been reduced, it has not been eliminated. Although switching to components that have been proven in similar situations has significantly reduced the risk profile, the company continues to work with the independent body that validated the DPG design to address items DNV GL identified as presenting risks to scale-up. Many risks have been removed or mitigated following experience gained from working on pyrolysis equipment in Spain for a third party. Successful development of the first commercial sites will remove this risk.

- **Dependence on related parties:** since staffing levels and other costs are being kept to a minimum to conserve cash, PowerHouse's growth is reliant on related parties who may take a substantial proportion of any profits generated. For example, industry facilitator W2T receives a contribution to costs each month, which is currently being paid in shares. These advances will be reimbursed by W2T out of any profits earned from project development. 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. David Ryan is also a director of Engsolve and Nayr Consultants, both of which provide engineering services to PowerHouse.

Valuation

PowerHouse did not generate any revenue during FY18 and as yet there is insufficient information on future performance to construct estimates. This precludes the use of either peer-based multiples or a DCF to conduct a formal valuation analysis. Management notes that the price of a DMG unit would be in the high single-digit millions of pounds per site and expects to realise a gross profit of c 10–12%, representing a gross profit of c £0.8–0.9m per DMG unit deployed.

The company has a pipeline of opportunities on over 30 sites where it is already in meaningful dialogue, for example discussing the suitability of feedstock. If we assume that operating costs increase to c £2m to support commercial operation, we calculate that the company will reach break-even on sales of two units per year and generate c £6m operating profit on annual sales of 10 units.

Financials

Cost-base increases during FY18 in preparation for commercialisation

In February 2018, management expected that it would have the first commercial 25tpd unit built, installed and commissioned by the end of that year. However, in September 2018, management noted that although it was in active negotiations with a number of early adopter customers, commercial deployment had been pushed out to H219 because of delays in securing financing and reliable sources of waste material for processing. As a result, there were no revenues reported for FY18. Administrative costs grew by £0.7m year-on-year to £2.5m. R&D expenses (27% of total costs), which included fees to Engsolve, DNV GL and Nayr Consultants, increased by £146k reflecting work on the front-end engineering design. Staff costs, which were primarily directors' fees (14% of total), rose by £135k. Share-based payments (22% of total) grew by £359k. These include £168k arising from the issue of options to directors (FY17: £0k) and £352k shares issued in payment to some of the company's services providers. In addition, £116k was spent on share issue fees (FY17: £0k). Operating losses widened by 38% to £2.5m. Finance costs reduced from £70k to a minimal £0.2k, reflecting the settlement of a substantial loan from former investor Hillgrove in February 2017. Losses before tax (adjusted for share-based payments) widened by 16% to £1.9m.

Balance sheet significantly strengthened during FY18

The company started FY18 with £0.8m cash. In February and March 2018, it issued 280.4m shares (at 0.5p or £1.4m) as part of the settlement of the Hillgrove loan (£2m cash payout in 2017 and £1.4m shares conversion in 2018). These were originally shown as a loan on the balance sheet because they were subject to a lock-in. Cash was back at £0.8m at end-December and the Hillgrove loan eliminated. The £1.9m cash used in operations and loan repayment was balanced by three fund-raising exercises, all at 0.5p/share, collectively generating £3.4m (net). The number of shares in issue increased by 719.6m during the year to 1,856.4m at the year end.

Sufficient funding until at least end June 2020

The notes to the FY18 accounts state that the directors have prepared working capital projections which show that the cash balance at end FY18 is sufficient to enable PowerHouse to continue operations for the foreseeable future. This conclusion is based on signed agreements from all the directors and certain contractors to waive future remuneration or fees and a letter of support from one of its shareholders, who is also a director of the company, that he intends to make up to £300k available for at least 12 months from the end of June 2019. By mid-FY21, the company expects to be generating substantial revenues from licences as multiple DMG plants are deployed**.** Since cash consumption depends on how long it takes for Peel and W2T to secure funding for the first DMG deployment and the level of revenues PowerHouse can derive from providing engineering services, there remains a risk, in our opinion, that the company will need to raise more finance. The directors believe they will be able to raise further funds as and when required and would consider either issuing new equity capital or other sources

The company is using a variety of measures to keep costs down. As well as getting directors and certain contractors to waive fees, it has undertaken an operational review to reduce monthly overhead by over 25%. This review focuses resources on the first commercial site. During FY18, it upgraded the demonstration apparatus and acquired laboratory equipment for a minimal amount so it can generate revenues from conducting trials on potential feedstocks. This will help the company achieve its objective of starting to generate cash in FY19 from the delivery of engineering and consulting support to customers for feasibility and development services, and of becoming cash positive at an operational level during FY20. Waiving fees does not appear materially dilutive. In April, the company issued 24.1m shares to various service providers, 1.8m shares to the CEO and 3.2m shares to the CFO in lieu of fees.

EDISON

Exhibit 8: Financial summary

Year end 31 Dec	£'000s	2014	2015	2016	2017	2018
PROFIT & LOSS						
Revenue		0	0	0	0	0
Cost of Sales		0	0	0	0	0
Gross Profit		0	0	0	0	0
EBITDA		(1,182)	(397)	(784)	(1,609)	(1,940)
Operating Profit (pre amort. of acq intangibles & SBP)		(1,182)	(397)	(784)	(1,610)	(1,941)
Amortisation of acquired intangibles		0	0	0	0	0
Share-based payments		0	0	(68)	(195)	(554)
Exceptionals		(1,038)	0	0	0	0
Operating Profit		(2,221)	(397)	(852)	(1,805)	(2,495)
Net Interest		(329)	(385)	(482)	(70)	(0)
Profit Before Tax (norm)		(1,512)	(782)	(1,266)	(1,680)	(1,941)
Profit Before Tax (FRS 3)		(2,550)	(782)	(1,334)	(1,875)	(2,495)
Tax		0	0	0	0	145
Profit After Tax (norm)		(1,512)	(782)	(1,266)	(1,680)	(1,796)
Profit After Tax (FRS 3)		(2,550)	(782)	(1,334)	(1,875)	(2,350)
Average Number of Shares Outstanding (m)		376.6	390.1	551.4	975.1	1,541.7
EPS - normalised (p)		(0.40)	(0.20)	(0.23)	(0.17)	(0.12)
EPS - normalised fully diluted (p)		(0.40)	(0.20)	(0.23)	(0.17)	(0.12)
EPS - FRS 3 (p)		(0.68)	(0.20)	(0.24)	(0.19)	(0.15)
Dividend per share (p)		0.00	0.00	0.00	0.00	0.00
Gross Margin (%)		N/A	N/A	N/A	N/A	N/A
EBITDA Margin (%)		N/A	N/A	N/A	N/A	N/A
Operating Margin (before GW and except.) (%)		N/A	N/A	N/A	N/A	N/A
BALANCE SHEET						
Fixed Assets		0	0	2	3	2
Intangible Assets		0	0	0	0	0
Tangible Assets		0	0	2	3	2
Current Assets		6	177	154	839	1,049
Stocks		0	0	0	0	0
Debtors		6	1	6	88	905
Cash		0	176	148	750	145
Current Liabilities		(2,416)	(199)	(3,383)	(1,643)	(247)
Creditors including tax, social security and provisions		(235)	(199)	(51)	(241)	(247)
Short term borrowings		(2,181)	0	(3,332)	(1,402)	0
Long Term Liabilities		0	(2,939)	0	0	0
Long term borrowings		0	(2,939)	0	0	0
Other long term liabilities		0	0	0	0	0
Net Assets		(2,410)	(2,960)	(3,227)	(802)	804
CASH FLOW						
Operating Cash Flow		(1,961)	(813)	(637)	(1,311)	(1,909)
Net Interest		(329)	(385)	(482)	(70)	(0)
Tax		0	0	0	0	0
Capital expenditure		0	0	(2)	(1)	(0)
Capitalised product development		0	0	0	0	0
Acquisitions/disposals		0	0	0	0	0
Equity financing		1,225	231	701	4,104	3,402
Dividends		0	0	0	0	0
Net Cash Flow		(1,066)	(966)	(421)	2,722	1,493
Opening net debt/(cash)		1,490	2,181	2,763	3,184	652
Finance leases		0	0	0	0	0
Other		(375)	(384)	0	190	0
Closing net debt/(cash)		2,181	2,763	3,184	652	(840)

Source: Company data

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: David Ryan
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 for £60m. He is also non-executive chairman of Ascent Resources. He became chairman in October 2017.	Mr Ryan was appointed as a non-executive director in February 2017 and assumed an executive role in March that year before moving to his current role in February 2019. 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. He was a director of Waste2Tricity until February 2019.
Commercial Operations Director: Bruce Nicholson	**CFO: Christopher Vanezis**
Bruce was appointed commercial operations manager in April 2018. Prior to that he worked for Cinch Projects, an independent project management company, where he engaged with a wide range of organisations including multinationals, such as Thyssenkrupp, EDF, Tullow Oil and BHP, and also with smaller independents.	Christopher became CFO in March 2017. He is a chartered accountant with c 30 years' experience in the energy sector, in roles with Midlands Electricity, Cinergy Corp and Express Energy Holding. He has worked on major infrastructure projects, both in the UK and internationally, and is also Waste2Tricity's finance manager.

Principal shareholders	(%)
Hargreaves Lansdown (Nominees) A/C 15942	10.4
Hargreaves Lansdown (Nominees) A/C VRA	8.0
Lawshare Nominees A/C SIPP	6.4
Paul Warwick	5.8
Interactive Investor Services Nominees A/5.6C SMKTISAS	5.6
Barclays Direct Investing Nominees	5.3
Yady Worldwide	5.2

Companies named in this report

AFC Energy (AFC:LN), Alkane Energy (ALK:LN), Ascent Resources (AST:LN), Biffa (BIFF:LN), Covanta (CVA:US), Hydrogenics (HYGS:US), ITM Power (ITM:LN)

General disclaimer and copyright

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