

Pyrum Innovations

New tyres from old

Pyrum Innovations has developed a patented pyrolysis technology that extracts recovered carbon black and oil from end-of-life tyres that is of sufficiently high quality to be used as raw material for making new tyres. The company has been operating an industrial-scale plant since May 2020 and intends to increase capacity across a portfolio of plants, some jointly owned with partners, to 130,000 tonnes of used tyres a year by end 2025.

Superior pyrolysis technology supports circular economy

Disposing of used tyres has become increasingly difficult since the EU prohibited the disposal of tyres in landfill in 2000 and carbon emissions taxes can make incineration a costly alternative. Traditional pyrolysis techniques enable operators to recover the energy content of tyres via pyrolysis gas and oil. Pyrum's patented process is highly unusual in producing pyrolysis oil that, together with the recovered carbon black extracted, is suitable for using as feedstock for making new tyres. As the pyrolysis gas is used to generate electricity to power the reaction, the process is energy self-sufficient as well, further strengthening its environmental credentials.

Offtake agreed with BASF, Continental and Schwalbe

As sustainability moves higher up the agendas of major companies, tyre manufacturers and chemical companies are exploring ways of using more recycled material in their products. Pyrum has already signed an agreement with BASF to take its pyrolysis oil for use as a chemical feedstock and with international tyre producers Continental and Schwalbe to purchase its recovered carbon black for use in new tyres. It also has an agreement with Continental to supply used tyres and with Michelin to supply tyre waste from a production plant in Germany.

Valuation: Increasing capacity to 130,000 tonnes in the medium term

Management's mid-term target is to increase capacity to c 130,000 tonnes of used tyres a year from jointly and wholly-owned plants. Based on data supplied by Pyrum, we calculate that this portfolio could generate annual revenues of €27m and EBITDA of €24m. Management's long-term target is to increase capacity to c 450,000 tonnes/year, which could generate annual revenues of €99m and EBITDA of €80m. Each sale of a pyrolysis plant to a third-party would represent an additional €25–27m revenues and €6–7m EBITDA.

Historical financials

Year end	Revenue (€m)	EBIT (€m)	PBT (€m)	PAT (€m)	P/E (x)	Yield (%)
12/19	0.2	(1.7)	(1.8)	(1.8)	N/A	N/A
12/20	0.7	(3.4)	(3.6)	(3.6)	N/A	N/A

Source: Pyrum Innovations data

Industrial support services

30 March 2022

Price €92.52

Market cap €305m

€0.10:NOK1

Share price graph



Share details

Code	PYR
Listings	Deutsche Börse Scale, Euronext Growth Oslo
Shares in issue	3.3m
Last reported net cash at end June 2021	€5.8m

Business description

Pyrum Innovations has a patented pyrolysis process that it is deploying in recycling plants to extract high-quality raw materials from used tyres. The raw materials, which include recovered carbon black and pyrolysis oil, are fed back into the material cycle. Pyrum also markets the pyrolysis recycling plants worldwide.

Bull

- Pyrum's process provides an environmentally friendly way of disposing of end-of-life tyres.
- Materials recovered from Pyrum's process are of sufficient quality to be used to make new tyres and polymers.
- Pyrum's pyrolysis process is energy self-sufficient.

Bear

- Recycling plant roll-out dependent on forming SPVs with partners and obtaining permits.
- Formation of SPVs dependent on owners obtaining finance for new technology.
- Plant viability dependent on availability of end-of-life tyres.

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Company description: Patented pyrolysis recycling process

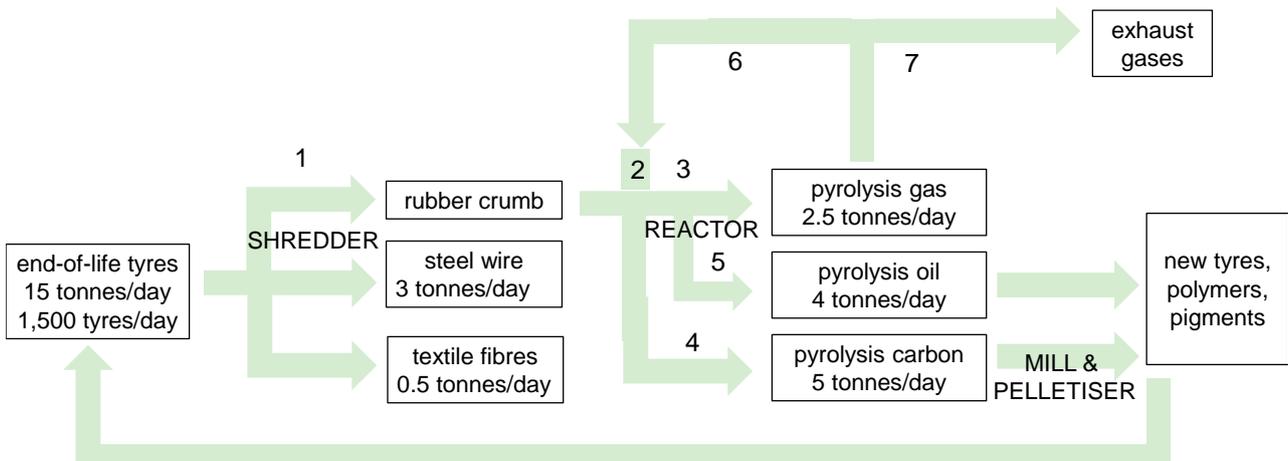
Pyrum Innovations has developed a patented pyrolysis process that it is currently using at industrial scale to recycle used vehicle tyres. The process outputs pyrolysis oil, carbon black, steel and textile material, all of which may be sold and returned to the material cycle, as well as pyrolysis gas. The gas is converted to electric power and heat, so the pyrolysis reactor requires no energy from external sources. Operators of Pyrum’s pyrolysis plants receive revenues from sale of the pyrolysis oil, carbon black and other outputs from the recycling process, as well as a fee from the suppliers of the used tyres for disposing of what is for them a waste material. In addition to being economically viable, the process is environmentally friendly. Pyrum estimates that the process reduces CO₂ emissions by up to 98% compared to using old tyres as a cheap fuel in cement kilns.

Pyrum has been operating an industrial-scale pyrolysis recycling facility with a yearly recycling capacity of 5,000 tonnes since May 2020 and has delivered over 900 tonnes of pyrolysis oil to chemical giant BASF and to Michelin. It already has agreements in place with BASF to purchase pyrolysis oil, with international tyre manufacturer Continental and bicycle tyre specialist Schwalbe to purchase carbon black and with Continental, Michelin and Schwalbe to supply the company with tyre waste. BASF and Continental are strategic shareholders, holding respectively an 8% and a 1% stake. The company has two basic business models: (1) the development, construction and operation of pyrolysis recycling plants and (2) the sale of pyrolysis recycling plants. It is already in discussions with partners regarding the construction of another six plants scheduled to commence operation by mid-2025 and intends to build a total of over 20 plants in the longer term.

Pyrum is based in Dillingen, Germany, where its first pyrolysis recycling plant is located. It currently employs over 70 people. It listed on the Euronext Growth index on 30 September 2021, prior to which it raised €39.4m (net), which is primarily allocated to finance the expansion of the existing plant in Dillingen and future pyrolysis plants. It listed on the Frankfurt Stock Exchange on 30 March 2022 to facilitate trading for shareholders. No additional finance was raised at this time.

Patented technology

Exhibit 1: Pyrum’s patented process for recycling end-of-life tyres (current capacity plant)



Source: Edison Investment Research. Note: Steps 1 to 7 are described below.

Pyrum’s patented pyrolysis recycling process heats material, typically tyre crumb though it could be used for other materials, to temperatures of 700–750°C in the absence of oxygen, so that instead of burning, a chemical and physical decomposition occurs. The process has multiple stages:

1. Used and defective tyres from cars and trucks are shredded into rubber granules from 1mm to 12mm across. The steel wire and textile fibres in the tyres are separated out. The steel wire is sold and sent for scrap processing and recycling. The textile fibres are used as insulation, fibre reinforcement in concrete or as a substitute fuel. The tyres are provided by waste collection companies such as Jakob Becker and Remondis, which collect them from car garages, car manufacturers and municipalities and pay Pyrum for taking them. Pyrum also has a contract in which it is paid to take the production waste from Michelin's factory in south-west Germany and a contract with Schwalbe to take old tyres collected in over 8,000 bicycle shops across Germany.
2. The rubber granules undergo pyrolysis treatment in Pyrum's patented vertical reactor. The products from the pyrolysis reaction are separated into coke (carbon) and vapour.
3. The vapour is condensed, separating out the pyrolysis oil from the pyrolysis gas.
4. The coke is cooled, then ground, sifted, graded and converted into carbon black pellets, which are easy to use and transport. Carbon black is used as an industrial raw material, primarily as a rubber-reinforcing additive in tyres but also as a pigment, UV stabiliser and conductive or insulating agent in a range of rubber, plastic, ink and coating applications. Pyrum has signed a memorandum of understanding (MoU) with Continental to off-take recovered carbon black. It also has an MoU with Schwalbe to off-take recovered carbon black and pyrolysis oil. The agreements indicate a price range of €550–700/tonne for carbon black. Pyrum expects that the quality of the recovered carbon black it supplies will enable it to obtain prices towards the upper end of this range.
5. Any water or floating carbon particles are removed from the pyrolysis oil, which is then stored in tanks and sold under the 'ThermoTireOil' brand. Pyrum has EU REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) approval for the oil. So far it is the only company to have obtained REACH approval for pyrolysis oil produced from rubber waste. This is significant, because without the approval the oil can only be sold to customers with approvals to handle waste materials. Having REACH approval means that the oil can be used in various industries including the chemical industry, refineries and the production of carbon black. BASF mixes the oil with fossil fuel to make chemical products that have the same properties as those made entirely with fossil fuel. These chemical products are used by its customers in the textile, medical packaging and automotive industries. Under the terms of a framework agreement with BASF, Pyrum is paid €150–350/tonne of oil.
6. The pyrolysis gas is cleaned and used to power a combined heat and power (CHP) engine. The electricity generated is used to power the pyrolysis reactor and other processing steps. The heat recovered is used to process the coke into recovered carbon black pellets.
7. The exhaust gases from the CHP unit are cleaned so they meet legally prescribed limits for sulphur dioxide and nitrogen oxides (NOx).

Business model

Pyrum's preferred business model is the development, construction and operation of pyrolysis recycling plants deploying its patented process as it provides predictable and recurring revenues, but it is more capital intensive compared to the sale of plants.

In addition, Pyrum intends to sell recycling plants to third parties, primarily in regions outside Europe as it does not intend to operate its own plants there, to finance the investment in its own plants. In this situation, Pyrum would act to undertake the engineering, procurement and construction (EPC) of the 'Pyrum Technology part', which is the tower housing the pyrolysis reactor, the cooling system and power generators, and would engage subcontractors for other parts of the plant, such as the shredder, pelletizer and carbon treatment. The manufacturing of crucial plant parts such as the pyrolysis reactor, engines and the automation system is also outsourced to partner companies.

Pyrum has also adopted combination of these two business models in which Pyrum sells a plant to a third-party in a special purpose vehicle (SPV), while holding an equity share of 15–30% in the SPV. This capital-light model allows Pyrum to roll-out plants relatively rapidly while receiving recurring revenues in the longer term in the form of dividends from the SPV (see Exhibit 3).

Pyrum will also generate revenues from maintenance and remote monitoring support fees for customer plants, commissions from the sale of shredding units from ELDAN Recycling for customer plants, fees for carrying out lab analyses and tests on potential feedstocks and royalties for granting distribution licences to third parties for various countries. Management intends to establish a distribution company that would pool the materials output from individual pyrolysis plants, so they can be sold in bulk, thus achieving better prices. The sales agreement with ELDAN Recycling works both ways. ELDAN is able to sell Pyrum's pyrolysis plants to customers that are currently using ELDAN equipment to shred end-of-life tyres and need a market for the tyre crumb.

Future developments

In the medium term, Pyrum intends to apply its pyrolysis technology to other markets such as recycling carbon-fibre-reinforced polymer (CFRP) and hydrogen production. It is also involved in the BlackCycle EU-funded project led by Michelin to create a process for recycling recovered materials from used tyres back into new tyre production.

Carbon-fibre-reinforced-polymer: CFRP is a light plastic that is reinforced with carbon fibres to give it strength, so it is used to make wind turbine blades as well as in the aerospace, automotive, sports and leisure and construction industries. Currently, there is no economic process for recycling CFRP. Pyrum is a member of the consortium working on the EU funded 'Infinity' project for recycling CFRP, extracting both recovered carbon fibre that is of sufficiently high quality to be used in the aerospace industry and pyrolysis oil. The project runs from October 2020 to September 2022 and is currently at the semi-industrial phase.

BlackCycle project: this EU-funded Horizon2020 project runs from May 2020 to August 2023 and is led by Michelin. During 2021 Orion Engineered Carbons, one of the world's largest producers of carbon black, demonstrated that carbon black produced from Pyrum's pyrolysis oil was qualitatively equivalent to carbon black produced from fossil fuels.

Hydrogen production: pilot-scale tests have shown that up to 40% of Pyrum's pyrolysis gas consists of hydrogen, with one tonne of rubber generating up to 13kg of hydrogen. A single Pyrum pyrolysis line (5,000 tonnes of used tyres/year) could thus produce approximately 240kg of hydrogen per day, which is enough to power a fleet of eight fuel cell buses operating a commuter service. Pyrum intends to separate hydrogen from the pyrolysis gas and sell it. The remaining pyrolysis gas from which the hydrogen has been removed can still be converted into electricity, keeping the pyrolysis reactor self-sufficient with respect to energy. The technology for separating the gases has not yet been applied at commercial scale.

Recent newsflow and upcoming catalysts

The key events in Pyrum's evolution so far are summarised in Exhibit 2. The most significant next step for Pyrum is the expansion of capacity at the Dillingen site from 5,000 tonnes of end-of-life tyres/year to 20,000 tonnes/year by adding two more pyrolysis reactor towers. Pyrolysis gas from the two new reactors will be used to generate electricity using air-to-air turbines rather than CHP engines. As the gas will be heated up 1,200°C compared with 400°C in a CHP engine, any toxins will be decomposed, so management is confident that the exhaust will be significantly within the more stringent limits for toxins in exhaust gases that will come into force in 2025. Substituting the CHP engine with an air-to-air turbine will also substantially reduce downtime for maintenance. In addition, Pyrum has ordered a new, more powerful shredder from ELDAN Recycling, which will

increase shredding capacity and also enable Pyrum to supply higher purity steel wire that can be processed directly into new steel. The total cost of this expansion, which is scheduled to complete by the end of 2022, is around €20m. Management expects the first of the two new reactors to start commercial production in Q422 and the second to start production in FY23.

Exhibit 2: Important events

Year	Event
2008	Formation of Pyrum Innovations
2008/09	Construction and improvement of a pilot plant on a scale 1:3
2009	Operation of a fully functional pilot plant
2010	Test runs of potential customers with pilot plant
2011	EU funding commitment
2012	Planning and approval phase of a functioning industrial plant
2012/13	Building permission and start of a construction of the first industrial plant
2013–15	Construction of the 5,000 tonnes industrial plant in Dillingen, Germany
2015	Completion of the first industrial plant and first test runs
2016	Regulatory and material testing authorities approve the first industrial recycling facility
2015–18	Test runs of the recycling plant in 24/7 operation
2018	First company in Europe to receive a REACH certification for its pyrolysis oil
2019	Operation of the upgraded industrial plant and construction of one of the biggest shredding units in Germany. Permanent run of the shredding unit since November 2019.
2020	Since May 2020 continuous production process of the pyrolysis plant and delivery of pyrolysis oil. Construction of coke/carbon mill (running since January 2021). €9.0m cash investment from BASF plus provision of €7.0m convertible loan, acquisition of 10% stake in Pyrum and off-take agreement for pyrolysis oil.
2021	Off-take agreements with international tyre producers Continental and Schwalbe for carbon black. Heads of terms agreement with Suez Recycling and Recovery UK to plan and construct pyrolysis plants. Contract to take production waste from Michelin plant in SW Germany. Memorandum of understanding and strategic partnership with Schwalbe. First waste bicycle tyres delivered. Private placement and start of trading on Euronext Growth Oslo. Continental takes 1% stake. Construction starts on capacity expansion at Dillingen site.
2022	Sales agreement with ELDAN Recycling. Development agreement with Continental. Continental to supply end-of-life tyres to Pyrum. Listing on Deutsche Boerse Scale index.

Source: Pyrum Innovations data

Looking further forward, Pyrum expects to have around 11 plants in place within five to six years and more than 20 plants in the long term. These will be a mix of self-owned and operated plants, plants sold to third parties and plants operated under the SPV-model. In the medium term, management intends to adopt the roll-out plan shown in Exhibit 3, though we note the exact order of execution may be different from that shown. The potential revenues and profits from this roll-out are explored in the valuation section of this note.

Exhibit 3: Roadmap

Estimated first production	Business model*	Production capacity tonnes used tyres/year	Details
Q422	100% owned	20,000	Expansion of Dillingen facility with lines 2 and 3. Construction started Q321.
Q223	SPV	20,000	Project with Korn Recycling in Albstadt, Germany. Binding agreement currently under negotiation. Off-take agreement with BASF ready for signature when financing completed.
Q423	SPV	20,000	Ireland MoU currently under negotiation. Oil off-take agreements with BASF signed.
Q224	SPV	20,000	Several potential sites near Hannover and Munich under evaluation. Oil offtake guaranteed from BASF. Cooperation with Continental to supply end-of-life tyres and offtake for recovered carbon black under negotiation.
Q324	100% owned	10,000	Luxembourg Production site being assessed. Around 18 months to construct plant.
Q424	100% owned	20,000	Several building sites in Germany under consideration. Oil offtake guaranteed from BASF. Cooperation with undisclosed tyre manufacturer for carbon black offtake and tyre supply under negotiation.
Q125	SPV	20,000	Port of Antwerp Negotiating MoU with client. Oil off-take agreements with BASF signed.
Q325 onwards	Sale	20,000	In early-stage negotiations regarding over 10 potential plants.

Source: Pyrum Innovations data. Note: *All SPVs assume Pyrum owns a 15% stake.

Market overview

Potential market size

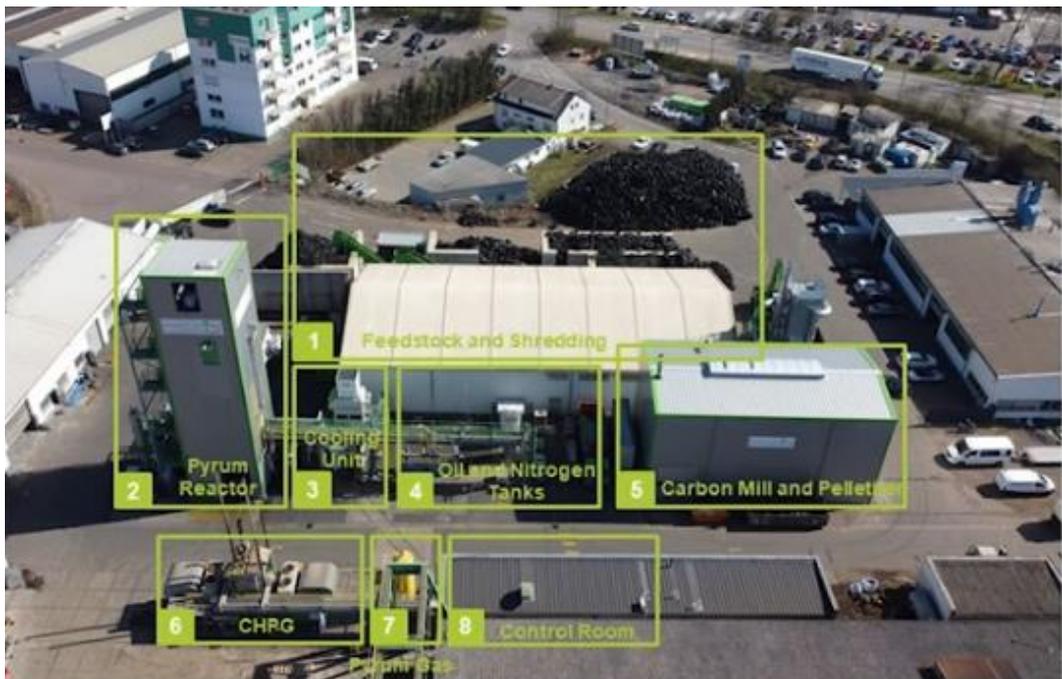
Currently Pyrum addresses the end-of-life tyre market. According to a [report](#) published by the World Business Council for Sustainable Development in December 2019, the global end-of-life tyre market is around 30.9 million tonnes per annum. Around 56% of these tyres are incinerated or sent to landfill, rather than recovered. This proportion on its own represents a significant opportunity for Pyrum because since 2000 the EU has prohibited the disposal of tyres in landfill to prevent oil inside the tyres leaching into the water table landfill and will close down plants incinerating tyres if the level of toxic particulates emitted are too high. Incineration is also becoming a less viable option because of carbon emissions taxes. These vary from less than €1 per tonne of carbon emissions in Poland to more than €100/tonne in Sweden.

In addition, pyrolysis may be a better option for processing used tyres than other recovery techniques. Tyre crumb from used tyres is currently used in civil engineering projects to create water retention basins, to make aggregates used in road construction and as backfill in land rehabilitation projects and mining sites. The European Chemical Agency, which is an EU regulatory body, has proposed a ban on the use of shredded tyre granulate outdoors on artificial turf pitches to prevent the release of microplastics into the environment. Tyre crumb can also be used as a feedstock in waste-to-energy systems. The EU Waste Framework Directive recommends that extracting new raw materials from waste such as used tyres is preferable to recovering energy from the material, so is supportive of the adoption of pyrolysis.

Carbon black is one of the main outputs of Pyrum's process. The other main output, pyrolysis oil, may be used to make carbon black. According to Mordor Intelligence, the global carbon black market was 13,000,000 tonnes in 2021 and is expected to grow at a CAGR of 2% between 2022 and 2027.

Competitive position

Exhibit 4: Aerial view of the Dillingen site with single reactor



Source: Pyrum Innovations

Pyrum's pyrolysis process is highly unusual because the tyre crumb moves down a tall vertical reactor under gravity rather than being pushed along a horizontal reactor as happens in older rotary kiln and batch oven processes. The speed at which carbon is removed from the base of the reactor determines the speed at which tyre crumb passes through. Using gravity to move the crumb through the reactor has several advantages. It saves on energy, which means that the pyrolysis reactor itself is self-sufficient with regard to energy, with some left over for shredding tyres, resulting in operating costs that are around one-quarter of older technologies. Having an abundance of energy on-site means that it is economic to heat the tyre crumb to higher temperatures than the competition typically does, eliminating the issue of toxins in the pyrolysis products caused by incomplete decomposition. Adopting a gravity-fed process also means there are no moving parts, making the system more reliable. Unlike a rotary kiln, the pyrolysis tower is airtight, giving better control over the output. Unlike a batch oven, Pyrum's pyrolysis technology is designed to operate as a continuous process, which means that the output is very consistent and that the reactor goes through far fewer heating/cooling cycles than a batch oven, further helping reliability. The reactor only needs to be shut down for maintenance, which takes place every three months and is guaranteed for 10 years.

Another key difference is that the reactor is divided into 150 tiny chambers, each with heating plates that are individually controlled and fitted with their own temperature sensors. This gives very precise control over the quality of the output, meaning that the pyrolysis oil can be used as a feedstock rather than just as an environmentally friendly fuel, as is the case for output from Bolder Industries and Scandinavian Enviro Systems or oil produced by Plastics Advanced Recycling's equipment

Exhibit 5, which is not intended to be comprehensive, gives a list of other companies involved in pyrolysis. The exhibit shows that only a sub-set of these are able to process tyre crumb, which is inherently more difficult to decompose than other material because it is a very good heat insulator.

Exhibit 5: Competitive environment				
Company	Reactor type	Feedstock	Commercial readiness	Business model
Beston Group	horizontal and vertical	plastic, used tyres	Multiple installations	plant sales
Bolder Industries		used tyres	Expanding site in Missouri. Offtake agreement with Tauber Oil.	plant operation
BTG Bioliquids/Empyro	rotating cone reactor	biomass	24,000 tonnes bio-oil produced each year at Empyro plant	plant sales
CHAR Technologies	horizontal revolving heat tube	woody material and organic waste	1 tonne/day plant commenced operation 2019. Commenced surveying commercial scale plant in Ontario. Planning commercial scale project in Quebec.	plant operation & sales
Ensyn	electrically heated screw	cellulosic biomass	Six facilities in commercial operation	plant operation & sales
ETIA (part of VOW ASA)		biomass, sewage sludge, RDF, plastics, used tyres	Order for industrial-scale plant from Wakefield BioChar July 2021	plant sales
Feeco International	rotary kiln	biomass, RDF, plastics, used tyres	Not stated – sells related equipment as well	plant sales
LyondellBasell		plastic waste	Using material from own site in Germany as feedstock for internal production of polypropylene and polyethylene	plant operation
Plastics Advanced Recycling Corp	rotary kiln	plastic waste, used tyres	Offering systems but no information on sales	plant sales
PyroCore	horizontal	automotive shredder residue, biomass, RDF	Expanding manufacturing facility to 5–7 systems/year	plant sales
Quantafuel	rotary kiln	waste plastic	Ramping up to 20,000 tonnes/year at Skive, Denmark. Offtake agreement with BASF	plant operation
Recycling Technologies		plastic waste	First commercial scale plant to be installed in Perth, Scotland	plant sales
Scandinavian Enviro Systems	batch oven	used tyres	Agreement signed with Michelin for <30,000 tonne/year plant in Chile.	plant operation.
Standard Gas		biomass, mixed waste	Not commercial yet	plant sales

Source: Edison Investment Research. Note: RDF, refuse-derived fuel.

Management

The composition of the executive board is as follows:

Pascal Klein: chairperson, CEO, CFO and COO. Mr Klein received a bachelor's degree in international management at ISEG Strasbourg in 2006 and an MBA at ISM Paris and St. John's University New York in 2008. The same year he became one of the founding members of Pyrum, holding the role of general director. He moved to his current role when Pyrum changed its legal status from GmbH to AG in 2018.

Michael Kapf: CIO and Head of HR. Mr Kapf received a degree as computer science expert at Deutsche Telekom AG/Saarbrücken in 2007. He had previously worked as a consultant in the European area for the company Hartech KG/Rehlingen-Siersburg. He is also one of Pyrum's founding members.

Kai Winkelmann: head of business administration. Mr Winkelmann graduated from the Banking academy in Hamburg in 1997. From 1997 to 2003 he worked as an equity and bond trader. He became a member of the executive board and the general manager at equinet Bank in 2003. From 2018 to December 2019, he was head of trading Germany for Pareto Securities. He joined Pyrum in February 2021.

Shareholders

Exhibit 6: Top shareholders	
Name	Holding
Founding partners (Pascal Klein, Michael Kapf, Amel Holding S.A.)	20.5%
BASF	7.9%
Benifin Vermögensverwaltungs- und Beteiligungsgesellschaft mbH	7.1%
The Capital Group Companies Inc.	3.9%
BlackRock Investment Management	2.3%
Others	58.3%
Source: Pyrum Innovations data	

Financials

Reported results

During H121 Pyrum focused on preparing for commercial roll-outs and series production of pyrolysis plants for self-operation and for customers. Total revenues increased by 21% year-on-year to €398k, with revenues from the operation of the recycling plant jumping by 45% to €392k. Revenue development was held back between May and July by a temporary fault in one of the two CHP systems, which has been remedied. Revenues reached €315k in Q321. Losses before tax widened by €1.6m to €3.2m, reflecting an increase in personnel expenses (by €0.7m to €1.5m) as Pyrum strengthened its workforce in all areas in preparation for the transition to serial production and in other operating expenses (by €1.7m to €2.2m). €0.7m of the other operating expenses related to the cost of the placing in Q321.

Net cash decreased by €2.9m during H121 to €5.8m at the period end. The main elements of this movement were the operating loss and €0.7m investment in capital equipment primarily on gas filtration, compared with €0.1m in H120. Other liabilities at the end of H121 included a €1.9m tranche of the €6.6m convertible loan agreed with BASF in September 2020. The loan bears interest at 3% per annum and is paid out in tranches when certain milestones are reached. Each tranche has a term of 10 years and repayment begins at the beginning of the third year after it is

granted. It is not materially dilutive as BASF can only exercise the shares in the event of a default on the loan.

Outlook

There are no consensus estimates available. In September 2021 management stated that it expected to increase sales to €1.3m in 2021, generating an EBITDA loss of €3m excluding the costs associated with the placing and admission to Euronext, and resulting in a free cash outflow of €18m. Significant items of capital expenditure during the year included the purchase of the building site next to its existing plant in Dillingen to support the planned capacity expansion (€0.8m excluding taxes) and a machine to turn powered recovered carbon black into pellets (€1.2m). In Q122 Pyrum purchased the property in Dillingen where the offices, laboratory and existing plant are located for c €2.8m. In October 2021 management noted that it expected revenues to increase in Q122 following the commissioning of the pelleting plant for recovered carbon black, which should enable the company to achieve better prices for its pyrolysis carbon. Based on the roll-out plan in Exhibit 3 and noting construction costs of €18–20m for each plant (see below), Pyrum plans to invest €12–40m in capex annually.

Exhibit 7: Financial summary					
	€'000s	2019	2020	H120	H121
Year end 31 December		German GAAP	German GAAP	unaudited	unaudited
Income Statement					
Revenue		169.7	662.7	327.6	397.9
Profit Before Tax (as reported)		(1,783.4)	(3,571.3)	(1,569.3)	(3,136.2)
Net income (as reported)		(1,786.7)	(3,575.0)	(1,570.0)	(3,136.9)
Balance Sheet					
Total non current assets		6,402.3	6,509.4		7,295.3
Total current assets		937.3	9,980.6		7,351.1
Deferred expenses		2.7	29.3		50.4
Total assets		7,342.3	16,519.2		14,696.8
Shareholder equity		1,958.2	6,883.2		3,746.3
Provisions and accrued Liabilities		2,127.1	2,118.2		3,206.8
Total liabilities		3,257.0	7,517.8		7,743.8
Total liabilities and equity		7,342.3	16,519.2		14,696.8
Cashflow					
Net cash from operating activities		(1,619.0)	(2,170.9)	(752.5)	(2,036.7)
Net cash from investing activities		(1,009.9)	(1,313.0)	(59.3)	(652.0)
Net Cash from financing activities		2,622.4	12,614.3	1,020.3	(261.7)
Net Cash Flow		(6.5)	9,130.5	208.5	(2,950.5)
Cash & cash equivalents end of year		401.1	9,531.6	609.6	6,581.1
Net cash/(debt)		176.5	8,718.8		5,847.3

Source: Pyrum Innovations accounts

Valuation

There are no consensus estimates, which precludes the use of peer-based multiples to conduct a formal valuation analysis. However, management has provided information on the potential revenues and profit from the operation and sales of pyrolysis plants, as well as its roll-out plans. Combining these gives a view of what potential revenues and profits could look like if Pyrum is successful in executing its strategy. This guidance is based on gate fees for used tyres of €105/tonne compared with the €116/tonne received at present, €250/tonne for pyrolysis oil, which is based on the 10-year average for low sulphur fuel oil, and €680/tonne for carbon black, based on existing off-take agreements. Guidance for each of the three business models is as follows:

- **Build, own, operate (BOO) model:** management estimates that a pyrolysis plant with a capacity of 20,000 tonnes can generate revenues of c €9.0m and an EBITDA of c €6.9m. Based on construction costs of €18–20m, this equates to a payback time of 2.8 years.

- **Plant sales model:** management expects that the sales price for a pyrolysis plant with a capacity of 20,000 tonnes will be in a range of €25–27m, depending on the plant specification and property costs. Pyrum will receive advance payments for plant sales: 30% at the signing of contracts; 30% at the end of the engineering phase; 30% on delivery and 10% once pyrolysis ramp up has completed. Given the construction costs noted above, management estimates a profit of c €6–7m per plant sold.
- **SPV model:** as the sales price for a plant with a capacity of 20,000 tonnes in an SPV-model will be the same as the sales price when selling a plant to a third-party, management expects the profit from a plant sale to stay the same in this business model (ie c €6–7m). In addition to revenues from the sale, management estimates that Pyrum will receive annual maintenance fees of c €0.3m and a share of net dividend of c €0.6m. These annual recurring fees would be offset by the cost of financing the equity stake of the 15–30% share in the SPV (c €3.0m), which management expects to fund via a debt drawdown at 3% interest per annum.

Management's mid-term target is to increase capacity to c 130,000 tonnes from SPVs and Pyrum's own operated plants (ie seven plants in total). If we assume that three of these are operated by Pyrum and four are operated by an SPV in which Pyrum has a 15% stake as per the road map in Exhibit 3, this gives annual revenues of €27m and EBITDA of €24m. If in addition Pyrum sells one plant to a customer, this would take total annual revenues to €53m and EBITDA to €30m. Pyrum would be reinvesting this cash back into new self-operated plants at this point, thus operating at around cash break-even.

Management's long-term target for the company is to increase capacity to c 450,000 tonnes, or 23 plants, some of which would be owned by third parties. If we assume that 11 of these are operated by Pyrum, five on an SPV model and seven by third parties, this gives annual revenues of €99m and EBITDA of €80m. If in addition, Pyrum sells one plant to a customer, this would take total annual revenues to €125m and EBITDA to €86m. Depending on the rate at which management continues to roll-out new self-owned plants, this could represent free cash flow of €40–50m a year. This capacity would output 150,000 tonnes of recovered carbon black annually, which is c 1% of the global market.

Sensitivities

- **Regulatory impact:** the EU Waste Framework Directive is beneficial for Pyrum as the legislation makes it more economically attractive for businesses to use waste to produce energy rather than sending it to landfill. Moreover, it also favours recycling materials such as rubber, rather than recovering the energy content from the material.
- **Permitting:** the operating licences for pyrolysis plants require them to be fully compliant with the emission levels set by legislation in different countries. Pyrum has already demonstrated that it is able to gain a licence for operating a plant deploying its patented pyrolysis process in Germany, which has one of the strictest regimes regarding environmental protection globally.
- **Availability of finance for new technologies:** the rate of roll-out of Pyrum's pyrolysis plants is partly dependent on the ability of potential SPV partners to secure financing for projects. This is more difficult for new technologies where there are limited historic data to support the likely rate of return on investments.
- **Availability of waste:** part of the economic case for Pyrum's technology depends on being able to secure sufficient quantities of waste material, currently used tyres, of suitable quality and the level of gate fees paid by suppliers for disposing of the material. Pyrum has agreements with recycling companies, tyre manufacturers and others at agreed prices and has made sure that there are sufficient alternative suppliers if there is a lack of supply. However, if the market for feedstock should grow because of competitors entering the pyrolysis market or new technologies emerging that require material volumes of the same feedstock as Pyrum, then the gate fees could decrease.

- **Dependence on customers to off-take output:** part of the economic case for Pyrum's technology depends on the volume of output taken by customers and the price paid per tonne. The company is currently highly dependent on BASF, which is the sole customer purchasing its pyrolysis oil. In March 2020 Pyrum signed a framework agreement with BASF to deliver 2,500 tonnes of oil annually, or the maximum quantity that Pyrum can produce if less than that. This includes off-take agreements for the plants operated by Pyrum and those in which Pyrum has a share, though in the latter case, the detailed terms are subject to final agreement between the relevant parties so the price that the company will receive for its products may vary from contract to contract and will be related to the price of low sulphur fuel oil. BASF is keen for Pyrum to increase oil deliveries to 100,000 tonnes/year by 2025 and, under a co-operation agreement with Pyrum, has agreed to provide financing for future SPVs. There are multiple potential customers for Pyrum's recovered carbon black.
- **Supply chain issues:** Pyrum is affected by steep increases in the price of steel, which are affecting the cost of completing the Dillingen expansion.
- **Energy prices:** Pyrum has little exposure to rising energy prices because a complete plant, excluding pre-treatment of waste, is self-sufficient with regards to energy. Electricity generated from the pyrolysis gas is used to power the reactor and the associated activities, including a small proportion of the energy used in shredding the used tyres.
- **IP protection:** Pyrum has filed two patents. It has an international patent extending to 2031, which covers the thermal reactor itself. This patent is supplemented with operational know-how that could form the basis of a follow-on patent. It also has a European patent covering the pyrolysis process, which expires in 2029, which it does not consider critical.

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