

Cleantech Forum Asia

Singapore | November 13-14, 2018



PART 1 Waste to Value: In search of the circular economy



PART 1 Waste to Value



ALLMENDINGER Director Of Research, **Cleantech Group** Chairman and CEO, Anaergia

Development and Promotion, National **Environment Agency** Singapore, Energy Institute

Director, Head Of Clean Resources, **CLSA** Capital

Partners

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PART 2 Waste to Value: In search of the circular economy



PART 2 Waste to Value



JOCELYN DOUCET CEO and Co-Founder, Pyrowave







A new era in plastic recycling

JOCELYN DOUCET, P. Eng., Ph. D.

Founder/CEO jdoucet@pyrowave.com

The team

EXECUTIVE TEAM



Jocelyn Doucet, P. Eng. Ph. D Co-founder & CEO

- As founder of Kengtek Consulting, advised Kraft, Danone, Lallemand, Kruger, Shell, Diageo, Total Group and several start-ups on process engineering and scaling up processes to the industrial level.
- Ph. D. in Chemical Engineering from Polytechnique; also serves as Adjunct Professor

Jean-Philippe Laviolette, eng., Ph. D. Co-founder and Director of Engineering

- Ph.D. in Chemical Engineering (Polytechnique)
- Engineering experience at Rolls-Royce, NASA, Total, E.I. du Pont de Nemours, Grace, Sasol, Total.

Sophie Morin, CPA, CMA Vice-president Finance

- 25 years of experience in Finance and Operations
- Director of finance at Kraft, Casino de Montreal and Farinart



BOARD OF DIRECTORS





Josko Bobanovic Sofinnova Partners



Johanne Sevigny Ecofuel

Problem

The current plastic ecosystem is an open value chain



Our use of plastics will increase

Open loop production depletes resources and creates a global problem



Geyer R, Jambeck JR, Law KL. Production, use, and fate of all plastics ever made. Science Advances. 2017;3(7):e1700782.

Solution

Pyrowave bridges the two ends of the value chain



The technology

Pyrowave CMD Series 600 microwave systems



Market segments

Initial segment for CMD 600 focuses on polystyrene (#6)



Commercial traction

Leading the North-American Closed-Loop polystyrene packaging consortium



Why Asia matters for us

95% of river-borne plastic comes from just 10 rivers



Schmidt et al., in Environmental Science & Technology, Vol. 51, No. 21; November 7, 2017

Looking for partners

We need operators to source material and operate the equipment



Looking for operating partners

We need operators to source material and operate the equipment







A new era in plastic recycling



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Founder/CEO jdoucet@pyrowave.com



PART 2 Waste to Value



JASON HERBERT Business Development, MINT Innovation



innovation

Cyanide-free gold recovery



109000 Tonnes

31

No Laws

Baldé, C.P., Forti V., Gray, V., Kuehr, R., Stegmann, P. : The Global E-waste Monitor – 2017, United Nations University (UNU), International Telecommunication Union (ITU) & International Solid Waste Association (ISWA), Bonn/Geneva/Vienna.

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Biometallurgy 101

...processes that involve interactions between microorganisms and metals or metal-bearing minerals"

Zhuang, W.-Q. et al. (2015) Recovery of critical metals using biometallurgy. Current Opinion in Biotechnology 33, 327-335.









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Using microbes as metal scavengers



- Concentrating ppm Au to parts per hundred
- Specific works in background of other metals
- Timely <1 week end-to-end
- Renewable just add sugar





Larger Regional Plant \$300m rev

Local Plant \$30m rev

Going Circular



The greatest threat to our planet is the belief that someone else will save it

Robert Swan, OBE

Contact: Jason V.M Herbert jason@mintinnovation.co | +64 27 774 4258





PART 2 Waste to Value



KEVIN HOUSTON Co-Founder, Carbon Masters India

Cleantech. Group

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Clean Energy for a Clean India

CARBON

MAST



www.carbonlites.com | www.carbonmasters.co.in



To help accelerate the world's transition to a low carbon circular economy by:



Building Carbonlites into *the* leading Bio-CNG and organic fertilizer brand- First in India and then globally



"If implemented globally Carbonlites technology can reduce GHG emissions by 28 million tons by 2027"- WWF Climate solver award citation 2017

3 big problems impacting India and the developing World today

$\mathbf{\Phi}$ carbonlites



Rapid Urbanization

- 11.2 billion tonnes of waste is dumped in landfills annually releasing Methane, a toxic GHG (GWP 32 x CO₂)
- Methane emissions from landfill represent over 12% of all methane emissions.

In India 62.1 million tonnes of MSW from over 4,000 cities are sent to landfills causing health and environmental problems



Rapid Consumption Growth

- India is the 2nd largest LPG market in the world but imports 39% of its LPG requirements
- Minister of Petroleum announces major SATAT programme to use bottled Bio-CNG to provide a low Carbon transport fuel
- Targets 5,000 Biogas plants to be built by 2025



Declining soil carbon

Indiscriminate and imbalanced use of chemical fertilizers and low addition of organic matter is reducing soil health impacting crop yields and farmers income

- Indian market for chemical fertilizers is \$ 27million (Subsidy is \$ 9 billion mostly on Urea)
- PM Modi wants India to cut Urea consumption in half by 2022

Carbonlites: Enabling the Circular Economy



Usage



CL displaces LPG in restaurants and to run vehicles. Manure is used in farming.

Distribution



Carbonlites and CL Fertilizer are distributed to consumers at their doorstep

Waste undergoes anaerobic digestion to produce methane and organic slurry. The gas is purified, compressed & bottled into Carbonlites. Slurry is treated to produce organic manure.

Production

Carbonlites Bio-Gas Plant **Waste Generation**



Organic waste is generated at households, farms, restaurants and offices

Waste Collection



Segregated waste is collected in our smart bins & transported by trucks running on bio-CNG



WHAT IS CARBONLITES?

Carbon mitigation in a bottle and a bag ! Saves costs and carbon emissions





SMART BINS

Waste pickup from IT parks and restaurants in Carbonlites Smart Bins and Bio-CNG trucks





BOTTLED BIO CNG

Carbonlites bottled bio gas is used in commercial kitchens as a replacement for LPG. It is also used as a transport fuel in CNG vehicles.



8 to 10% vs LPG

bonlites

Saves carbon Emissions **

ORGANIC FERTILIZERS

The digestate is combined with biomass, enriched and used to manufacture high quality organic manure



Returns carbon and useful micro nutrients back to the soli (e.g Zn)

** CO₂ emissions from burning Carbonlites are biogenic and do not add to carbon stocks

1. End to end mastery of the Carbonlites waste to Value Chain



3

carbonlites

(j)
Carbonlites: End to end process technology enabled

\mathbf{G} carbonlites













Purification Unit







Gas Delivery &

Fertilizer Sales

0

carbonites





Ç carbonlites	
P corb	onlites

Fertilizer sales via dealers





2. Innovative business models to scale rapidly with Partners





4 revenue streams for Carbon Masters

Carbonlites gas sales Carbonlites organic fertilizer sales Business services revenueconsulting, operational fees, waste processing fees Engineering services revenuesale of infrastructure i.e Cylinders and cascades

2. Innovative business models to scale rapidly with Partners

 $\mathbf{\hat{\mathbf{G}}}$ carbonlites

Model 2: Asset Lite Business Model with Municipal authorities (PPP)



3 revenue streams for Carbon Masters

CL organic fertilizer sales Engineering services : provision of biogas infrastructure



India could (again) lead the world in biogas production creating a new decentralized clean energy industry.

India capacity for Biogas production from feed stocks

Source of FeedstockBiogas Potential (m³/ year)Agri/ Crop Residue438,382 million	BUSINESS MARKET POTENTIAL CHANNEL (in \$)
Distilleries 1,500 million	Annual Bio-CNG sales for 2bn commercial cooking displacing LPG
Poultry 160 million	Bio-CNG sales for transport displacing Diesel and Petrol 9bn
Dairy Industries 80 million	
Sugar Industry (Press Mud) 2.9 million	Organic fertilizer sales 13.5bn
MSW 2,680 million	

Annual Capacity 4,42,805 million

4 0

Journey so far











Seed Investment of 4 crores(\$574,000) achieved in July 2017 from Indian Angle network and VC Sangam Ventures





4



Impact of Carbonlites





Carbonlites helps tackle the effects of global warming. Every ton of Carbonlites used stops 35 tons of CO2e from entering the atmosphere (avoided methane emissions from landfills and displaced LPG).



Helps farmers access low-cost organic manure that improves soil health and replaces imported chemical fertilizers. Landfills adversely affect communities around them and pollute groundwater tables. Carbonlites initiative prevents waste from entering these landfills.





India today imports c39% of its LPG requirement. Carbonlites reduces dependence on imports and increases energy security of the nation.





Every new project helps us generate several green jobs for India's youth.



How do you cook a Carbon Neutral Paneer Butter Masala?



PART 2 Waste to Value



MARKO KARKKAINEN President Asia Pacific, Ductor



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THE WORLD

The Ductor Mission and Vision



and energy production based on

one of the most important renewable

SOLVING GLOBAL CHALLENGES THROUGH BIOTECH

OUR GROUNDBREAKING TECHNOLOGY REVOLUTIONIZES THE BIOGAS INDUSTRY WHILE ADDRESSING MAJOR GLOBAL ISSUES SURROUNDING WASTE MANAGEMENT, INCREASED FOOD DEMAND AND CLEAN ENERGY NEEDS.



FOOD DEMAND

Ductor technology enables underutilized organic waste to be effectively converted to fertilizer for enhanced crop productivity to meet the rising demand for food.



7

ENERGY PRODUCTION

Ductor technology enables organic waste with high nitrogen content to be used for efficient and game-changing biogas production.

WASTE ACCUMULATION

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Ductor technology turns problem waste into profitable recyclable goods resulting in enormous social, environmental and economic benefits.

HOW DUCTOR BRINGS MORE VALUE

DUCTOR'S PATENTED MICROBIAL PROCESS MEANS THAT HIGH NITROGEN-CONTAINING WASTE MATERIAL CAN BE USED IN BIOGAS PRODUCTION AND THE NUTRIENTS USED AS FERTILIZERS MUCH MORE EFFECTIVELY THAN TODAY.

DUCTOR ENABLES GAME-CHANGING ECONOMICS IN BIOGAS PRODUCTION, INCREASING COMPETITIVENESS VERSUS OTHER RENEWABLE ENERGY SOURCES, WHILE ALSO PLAYING A CRUCIAL ROLE IN THE CIRCULAR ECONOMY.



DUCTOR® FROM WASTE TO PROFITS





Approximately 400 kg of solid organic phosphorus fertilizer can be produced from every ton of poultry manure.



About 80 kg of ammonium sulfate can be produced from every ton of poultry manure.



Ductor's water purification system produces nonpotable water for irrigation or discharge to nature.

BENEFITS FOR CLIENTS

WHY DUCTOR IS REVOLUTIONARY

Ductor's technology improves the economics of biogas production by:

- Allowing the use of cheap and abundant raw materials.
- 3 Creating new revenue streams.

5 Reducing greenhouse gas emissions.

2 Increasing yield and the capacity of the plant.

4 Reducing wastewater treatment costs.

THE SUBSTANTIAL COST SAVINGS AND INCREASED REVENUES FOR BIOGAS PRODUCERS WILL ENABLE A GAME-CHANGING IMPROVEMENT IN THE ECONOMICS OF BIOGAS PRODUCTION.

THIS IS WHAT OUR CLIENTS GET

MATERIAL COST SAVINGS

Up to 80% raw material cost savings can be achieved. With Ductor's technology, biogas producers can replace expensive maize silage with inexpensive poultry manure as biogas feedstock.

NEW REVENUES FROM AMMONIUM SULFATE

About 80 kg of ammonium sulfate can be produced from every ton of poultry manure. The ammonium sulfate from the nitrogen removal process is organic nitrogen fertilizer as such.

UTILIZATION OF NITROGEN-RICH BIOMASSES

Ductor's technology enables the removal of over 60% of the nitrogen contained in organic waste materials. Microbiological nitrogen removal process takes place before biogas production. This enables the utilization of high nitrogen content organic wastes as feedstock.

NEW REVENUES FROM PHOSPHORUS FERTILIZER

Approximately 400 kg of solid organic phosphorus fertilizer (which contains 17 kg P2O5 and 13 kg K2O) can be produced from every ton of poultry manure. The potassium-phosphorus fertilizer is pelleted and thus soil friendly.

Innovation Driven As a cleantech company, continuous innovation and R&D are pillars of our Mission.

We work with commercial partners in renewable energy, waste management, agriculture, and food production, as well as leading research and government institutions around the globe.

Together with our partners, we will play a major role in the circular economy of food production - waste reuse - energy generation.













DUCTOR TIMELINE

2018

Orders signed for 27m€. Project funnel in different stages in Europe, Asia and the Americas exceeds 300€ million. Ductor's HQ is located in Helsinki, Finland with regional offices in Germany, Switzerland, Singapore, the US, and Italy.

2015

First biogas plant equipped with Ductor's nitrogen and phosphorus recovery technology was constructed in Tuorla, Finland. Commercial activities kicked off in Germany where sales organization was established and a number of sales contracts were signed.

2009-2011

2009–2011 pre-study face in the laboratory on biological fermentation process.

2011-2013

2016

Technology for extraction of nitrogen was developed and a groundbreaking solution was proved in a laboratory in Helsinki.

2014

First pilot plant was constructed in Helsinki.

Ductor was founded in 2009 in Helsinki, Finland. Today, we operate globally in Americas, Europe, and Asia. One day, we'll be everywhere.

2009

Startup Company Ductor's revolutionary story started in Helsinki, Finland



Our Management Team





ARI KETOLA Chief Executive Officer

JOONAS KETTUNEN Chief Financial Officer

JENNIFER BARBER President, Ductor Americas

MARKO KÄRKKÄINEN President, Ductor APAC



DEBORAH LANGIER Interim General Counsel

MATTI JÄRVINEN Chief Operating Officer

TED NIBLOCK Chief Development Officer

RIKU MÄKINEN President, Ductor EMEA

Asia Pacific



Partners and Customers Network. We are actively looking for new energy projects.

- CP Food Group
- Marubeni
- AIIB (funding)
- Green Climate Fund (funding)
- Urbaser
- State of Johor, Malaysia
- City of Semarang
- Endeavour Group
- BTD Environmental Solutions
- Sagacity Environment
- Nusa Suriamas



MSW Potential in Thailand





MSW Potential in Indonesia





MSW Potential in Malaysia







PART 2 Waste to Value



CRAIG VINTON BD Manager, Avertana



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Generating Value from Industrial Waste

Cleantech | November 2018

The Cost





Finite Resources





Resource Maximisation and the Circular Economy









The Avertana Process





Multi-product, Multi-market





Avertana's technology converts industrial waste





Global Opportunities

100's of millions of tonnes of titanium rich slag globally



Pre-commercial Plant Operating



Pre-commercial plant testing scale up of novel process steps in vendor supplied equipment.



Commercial Metrics




Key Benefits of Avertana Process

Low 'total' cost route to produce TiO₂ + aluminium sulphate

Displace mining with above-ground waste as feedstock

- Low, fixed-cost feedstock
- Back integration to readily available resource
- Low carbon footprint for raw material extraction

Objective to produce no solid waste

- Total conversion to saleable products/co-products
- No disposal/storage costs
- Significantly reduced overall carbon footprint



Development Roadmap

Technology Readiness

	Proof of Concept				Те	chnical Via	Tecl	Technology License/Sale/JV Execution Phase		
Teo	chnical D	evelop	ment a	nd Scale	e Up					
	Concept Development	Laboratory		Pilot plan	t 🔪	Pre-cor	nmercial	\rangle	Commercial	
2012 I	2013 I	2014 	2015	2016 I	2017 I	2018 	2019 I	2020	2021 I	2022





- Vertically integrated
 - World scale
 - Low cost
- Fundamental economic and
- environmental sustainability



NETWORKING BREAK 3:40pm - 4:00pm



