HD **LER: LEAF ENERGY'S LOW COST, LOW POLLUTION AND PROVEN PLATFORM TECHNOLOGY TURNS WASTE PLANT MATERIAL INTO CELLULOSE, A THRIVING INDUSTRY WITH A HUGE FUTURE IN SEVERAL APPLICATIONS. LER HAS KNOWLEDGEABLE**

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Leaf **Energy** Ltd listed in the shell of Aquacarotene after merging with Queensland based **company** Farmacule BioIndustries Pty Ltd in 2010.

The **company**'s wholly owned technology (patent applied for) turns waste plant matter into cellulose as well as lignin and hemicellulose using the cheap, abundant and recyclable product glycerol (patent for process applied for), via low cost, low pollution technology.

The huge and growing demand for cellulose

A report dated June 23 2014 by Grand View Research Inc stated, "The global market for cellulose fibers is expected to reach $US 29,611.1 **million** by 2020. Low prices of raw material coupled with regulatory supports offered by various countries are expected to be key driving factors for the market. In addition, the augmented demand for clothing and apparel in emerging economies is also expected boost the demand for cellulose fibers. However, fluctuating prices of raw material is expected to be a key challenge for market growth.

*Clothing emerged as the leading application segment for cellulose fiber and accounted for 61.3% of total market volume in 2013. It is also expected to be the fastest growing application segment, at an estimated CAGR of 8.2% from 2014 to 2020.

Further key findings from the study suggest:

• The global demand for cellulose fibers was 5,400.1kilo tons in 2013 and is expected to reach 9,202.8kilo tons by 2020, growing at a CAGR of 8.1% from 2014 to 2020.

• Cellulose fiber demand for spun yarn applications segment is expected to grow at an estimated CAGR of 9.9% from 2014 to 2020, in terms of revenue.

• Asia Pacific continued its dominance in the global cellulose fibers market and accounted for 45.5% of total market volume in 2013 to become the leading cellulose fiber consuming region. Asia Pacific, along with being the largest market is also expected to be the fastest growing market for cellulose fibers, at an estimated CAGR of 8.6% from 2014 to 2020. Clothing segment dominated Asia Pacific market in terms of revenue and accounted for around 60% of the total market share.

• Asia Pacific market was followed by Europe owing to various government regulations supporting the use of biodegradable fabrics. North America contributed around 14% in the global market for cellulose fibers in terms of volume.

• The global market for cellulose fibers is fragmented within many companies including Thai Rayon, Aoyang, Tangshan, Fulida, Sateri, Grasim Industries, Lenzing, Helon and Indo Bharat, with Lenzing dominating the overall market with a market share of 17.5% of the total market volume.

(i) Why Cellulose will replace cotton fibre

"The Cellulose Gap", a scholarly report by Franz Martin Hammerle, June 2011, looks at cellulose fibre as a substitute for cotton. He said in the report, "Within the next two decades the world population will grow by 1.4 **billion** and is moving up the food chain. By 2030 we will have an additional demand for food of 43 %. On the other hand arable land is limited and the cropland area per person will shrink. This situation will result in a food crisis.

"Also the demand for textile fibres (natural as well as man-made) will increase by 84 %. But in the future cotton production will be stagnant because of the limited availability of arable land.

The experience shows that approximately one third of textile fibres have to be cellulosic fibres because of certain properties like absorbency and moisture management. This will result in a disproportionately high demand for man-made cellulosic fibres in the coming years. The substitution of cotton by man-made cellulose fibres is also a contribution to the environment ..

"Man-made cellulose fibres are extremely sustainable fibres. In comparison to cotton they have some important assets - No arable land is necessary, less water consumption (the Aral Sea has all but disappeared because of cotton production), no input of pesticides and fertilizers'.

(ii) The need for plant derived Cellulose to replace petro chemical plastic packaging

A US 2011 report revealed between 100 and 200 **billion** pounds of plastic is manufactured annually. An estimated 10% of plastic ends up in the oceans every year. About 20% comes from ships and platforms in the sea. The remaining 80% comes from the land – garbage that travels through storm drains or watersheds and accumulates in streams, rivers, and bays. Eventually this plastic garbage finds its way to into the oceans, where ocean winds and the earth's rotation create "gyres' — massive, slow rotating whirlpools in which plastic trash can accumulate.

The North Pacific Subtropical Gyre is an area that traditionally supported plankton and small sea life, but now the plastic in some parts of this Gyre outweighs the plankton by a ratio of six to one.

This Gyre is the home of two massive ocean garbage collections – the Western and Eastern Pacific Garbage Patches. The Western Garbage Patch circulates between California and Hawaii and, according to an article in the LA Times, is estimated to be twice the size of Texas. The Eastern Garbage Patch circulates between Hawaii and Japan.

Other major gyres exist in the South Pacific, North and South Atlantic, and Indian Oceans. Smaller gyres have been discovered near Alaska and Antarctica. Moore estimates that bits of plastic now outnumber plankton in many parts of world's seas.

Roughly 44% of all seabird species, 22% of cetaceans, all species of sea turtles and many species of fish have been documented with plastic in or wrapped around their bodies.

(iii) Cellulosic sugars - work under way by several companies including Coca-Cola

Doris De Guzman writing in Tecnon OrbChem on December 27 2013 said in news on cellulosic sugars, "Recent cellulosic sugars activities especially from Renmatix, Proterro and Sweetwater... "Let’s start with Renmatix, which recently announced two big-time partnerships this month — BASF and Virent/Coca-Cola.

"The partnership of Virent/Coca-Cola and Renmatix is targeting the use of cellulosic sugar in the production of bio-based paraxylene, a raw material used in the manufacture of purified terephthalic acid (PTA), which is a major chemical component in the production of PET bottles or fibers. Virent and Coca-Cola are currently working to developed a drop-in bio-based PX for Coca-Cola to be able to soon offer a 100% bio-based PET bottle under its PlantBottle packaging. Virent’s bio-based PX product will be marketed under the trademark BioFormPX.

"Right now, Coca-Cola’s PlantBottle is made from sugarcane ethanol-based monoethylene glycol or MEG (the other component of PET) and petro-based PTA. Bio-based MEG has an average 40% premium, according to Tecnon OrbiChem’s Bio-Materials report. It will be difficult for Coca-Cola (and for those of Coca-Cola’s partners who are working towards bio-based PTA or other alternatives) to absorb more bio-based premiums in order to manufacture a 100% bio-based PET bottle. Coca-Cola’s partners have to think about sourcing lower feedstock costs at this early stage to be able to satisfy Coca-Cola’s sustainability demands.

"This is where cellulosic sugars are trying to come in in addition to being a non-food feedstock. Renmatix said its Plantrose platform will be evaluated and potentially optimized to provide an affordable sugar streams for Virent’s Bioforming process for large-scale production of bio-based PX. The Plantrose process

reportedly produces affordable cellulosic sugars, C5 (xylose) and C6 (glucose) using water-based method called supercritical hydrolysis in lieu of more expensive chemical and enzymatic routes to cellulosic sugars used today".

(iii) Among other uses for cellulose ..

Cellulose has versatile uses in many industries such as veterinary foods, wood and paper and products for human consumption - it produces thick and creamy food items without the use of as much fat. It is used in cosmetics.

Glycerol as a sugar substitute

Glycerol, the reagent used by Leaf **Energy** (patent applied for) in converting biomass to cellulose, is also used in food and beverages where it serves as a humectant, solvent, and sweetener, and may help preserve foods. It is also used as filler in commercially prepared low-fat foods (e.g., cookies), and as a thickening agent in liqueurs. Glycerol and water are used to preserve certain types of leaves

As a sugar substitute, it has approximately 27 kilocalories per teaspoon (sugar has 20) and is 60% as sweet as sucrose. It does not feed the bacteria that form plaques and cause dental cavities. As a food additive, glycerol is labelled as E number E422. It is added to icing (frosting) to prevent it setting too hard.

Glycerol has a caloric density similar to table sugar, but a lower glycemic index and different metabolic pathway within the body, so some dietary advocates accept glycerol as a sweetener compatible with low carbohydrate diets.

For human consumption, glycerol is classified by the U.S. FDA among the sugar alcohols as a caloric macronutrient.

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Leaf **Energy**'s Glycerol technology, patent applied for, has comparatively lower capital cost, lower operating cost and faster processing times than other processes to convert biomaterial into cellulose.

Chairman Jay Hetzel was a co-founder of Catapult Genetics, sold to Pfizer. Ken Richards, managing director took Norgard Clohessy **Equity** Ltd from capitalisation of $60,000 to $50 **million**. He has managed several other companies, mostly in the environmentally sustainable field.

*Leaf **Energy** received the Judges Award at the Consensus Greentech Awards in June this year.

While Leaf **Energy** has yet to decide on the location for its plant (Australia and other countries are under consideration), the path to production, including establishment of its plant is expected to be about three years from now - or two years following a decision as to where to set up a manufacturing facility.

LEAF **ENERGY** LTD - A SNAPSHOT

Farmacule Bioindustries Pty Ltd was formed in 2001 with global exploitation rights from the Queensland University of Technology (QUT) for the patented INPACT technology which was developed by a QUT research team led by Farmacule's CSO Prof James Dale to provide a sophisticated proprietary gene switching and amplification technology to increase the express and yield in selected plants of novel proteins, enzymes and molecules of interest.

Farmacule signed a collaboration agreement with Swiss based global agribusiness **company**Syngenta Crop Protection AG and the Queensland University of Technology to produce bioethanol from sugar cane for global markets. Use of Farmacule's INPACT technology had the potential to significantly reduce the cost of enzymes needed to break down the waste biomass to allow it to be processed into ethanol.

In 2010 Farmacule Bioindustries came onto the boards via a merger with Aquacarotene.

AQL consolidated its shares on a 20 to 1 basis and issued 15 **million** post consolidation shares to Farmacule on certain milestones.

Aquacarotene changed its name to Leaf **Energy** Ltd on November 26 2010.

Aquacarotene, under Ken Richards (who is now the managing director of Leaf **Energy** Ltd) had sold its algae-farming assets in Western Australia to US **company**Aurora Biofuels for $2 **million**.

*Leaf **Energy** in 2012 had a worldwide exclusive license agreement with Texas A&**M** University to develop the marine yeast Debaryomyces, that complemented the technologies being developed through the Syngenta Centre for Sugarcane Biofuels Development by the Queensland University of Technology.

Leaf **Energy** today:

*Leaf **Energy**'s Glycerol process - patent application submitted

Earlier this month Leaf **Energy** submitted a patent application for its platform glycerol process.

Competitive Advantages of Leaf **Energy**'s Glycerol pre treatment process

Leaf's Glycerol Pretreatment Process uses a cheap, recyclable, abundant reagent, Glycerol, in a simple process, to break down plant matter into Lignin, Cellulose and Hemicellulose at low temperatures. These component parts are then available for further processing to sugars using enzymatic hydrolysis and those sugars can then be converted to biofuels, bioplastics and green chemicals.

The process has a lower capital cost because the process needs lower temperature and lower pressures than many other technologies and has faster processing times due to the efficiency of glycerol as the reagent.

The Glycerol Pretreatment Process has significant advantages over current pretreatments being

used such as steam explosion.

July 15 2014 - trials at Andritz facility, Ohio - conversion of cellulose to sugars opens up second income stream for Glycell process

Leaf **Energy** on July 15 announced continuous production trials at the Andritz pilot plant facility (that has focused on developing the Glycell process on industrially available equipment on several different biomass inputs) has received a report from Andritz on the component testing and conversion of cellulose to sugars for the second set of trials run in late January 2014:

Highlights included :

99% saccharification of cellulose to sugars in six hours from the Glycell process for pretreated sugar cane bagasse a significant new opportunity for Leaf **Energy**.

*Clean sugars were produced with negligible degradation of product.

The results were obtained from continuous production trials at the Andritz pilot plant facility in Springfield, Ohio (Andritz is a leading supplier of plant, equipment and services for pulp and paper and other industries).

Capital costs

In a Scoping Study on the Glycell process prepared by Dr Les Edye a principal of BioIndustry Partners at Queensland University of Technology and then independently reviewed by DWH Process Consulting led by Dr David Humbird in the US, released on July 7, the base plant and infrastructure capital costs for a plant was calculated at $32.8 **million** with an after tax internal rate of return of 42%.

Leaf **Energy** expects significantly lower capex and opex costs vs other methods of production due to lower temperatures required, lower enzyme loads and lower **energy** costs vs competing technologies.

A greenfields plant is expected to take two years to production, once a site is decided upon.

Significantly faster production can be achieved by retrofitting a plant to existing ethanol plants - eg, the 70 ethanol plants currently operating in India. This approach could also facilitate large carbon savings in multiple markets.

There are current ethanol plants in several countries including the US, Brazil, EU, **China**, Russia, Thailand, Canada, India, Colombia and Australia with some 22.35 **million** US liquid gallons per year of production.

Cellulosic ethanol from waste plant material forms a small but growing proportion of total cellulose production - and is far less environmentally costly - than ethanol developed from crops.

However, at some stage Leaf **Energy** expects to establish its own plant on a greenfields site.

(Leaf's Glycerol process uses existing "off the shelf" machinery).

In the pipeline

Dec 23 2013: Collaborative and royalty agreement with Actinogen

Under the terms of the agreement LER will fund further studies in ACW's bioethanol project in which the **Company** previously identified strains of actinomycetes capable of producing

cellulase(s) .

LEAF **ENERGY** LTD FINANCIALS

Code: LER

Last Traded price 4.7c.

Shares Issued 94.1m.

Market Cap 4.46m.

Directors:

Jay Hetzel, Chairman

Background in biotechnology, R&D and commercialisation. Co-founder of Catapult Genetics, sold to Pfizer. Numerous board/executive positions.

Ken Richards, Managing Director

Mr Richards has in excess of 25 years experience as a Managing Director in various listed and unlisted companies across agriculture and technology sectors. Ken's life as a public **company** CEO has seen him complete transactions (capital raisings, takeovers, assets sales etc) well in excess of $200,000,000. In 2007 Ken took on the role of Managing Director of Aquacarotene, a Micro Algae producer. Ken initiated the **sale** of the pond lease to Californian based Aurora Biofuels for $2,000,000. In 2010 Aquacarotene merged with Queensland based **Company** Farmacule BioIndustries Pty Ltd to form Leaf **Energy**. Ken holds a Bachelor of Commerce and a Master of Business Administration degree from the University of WA. Mr Richards is a fellow of the Australian Institute of **Company** Directors.

Alex Baker ,**B**.Sc., GDip.Biotech., MTM, MAICD, Chief Operating Officer

Mr Baker has 20 years of professional business experience including multi-sector experience in healthcare, life science and IT. He has worked in a range of **company** types including ASX listed companies QRxPharma Ltd (ASX:QRX), Progen Pharmaceuticals Ltd (ASX: PGL) and now Leaf **Energy** (ASX:LER). He has senior management experience including CEO for Maverick Biosciences. He adds additional skills and expertise in relationship management and business development. He holds tertiary qualifications include a Master of Technology Management, Graduate Diploma in Biotechnology and a Bachelor of Science plus other relevant continuing professional development. Mr Baker is a member of the Australian Institute of **Company** Directors.

Samantha Madden, **B**.Com, CA, Financial Controller

Mrs Madden has a business accounting and taxation background with a focus on small to medium business. She holds a Bachelor of Commerce from The University of Queensland and is a member of the Institute of Chartered Accountants in Australia. Her wide ranging experience was gained through positions with chartered accountancy firms and as Financial Controller for varied businesses in Brisbane.

Major shareholders:

Ken Richards 15.25%

Russell Charles Wilson 11%

Queensland University's QUTBLUEBOX Pty Ltd as trustee 5.9%.

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