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biofuelwatch

MASCOMA: THE BIGGEST MIS-SPENDING OF PUBLIC FUNDS FOR CELLULOSIC BIOFUELS EVER?

EXECUTIVE SUMMARY

This is an investigation of Mascoma Corporation, a start-up biofuels company which may have misspent more public funds intended for building advanced biofuels refineries than any other company in North America.

Mascoma took at least $100m and possibly over $155m in public funding intended for building integrated biorefineries. Their biggest donor was the US Department of Energy (DoE), including the DoE funded BioenergyScience Center. They also received $14.8 million from New York State, at least $20 million from the State of Michigan, around $1 million from the State of Minnesota, and over C$1m in total from Alberta Province and the National Research Council of Canada.

The $14.8 million from New York State was for a cellulosic ethanol plant that Mascoma did build, but which has never sold any ethanol. The plant has since been closed down and sold to a biotech company that intends to use it for a different purpose.

The vast majority of the grants received by Mascoma were intended for commercial-scale cellulosic ethanol refineries which were never built at all. Mascoma announced and then abandoned a series of such plants in Tennessee, Minnesota, Michigan and Alberta, but nonetheless spent grant funding that had been earmarked for them.

Biofuelwatch's investigation shows that:

1. Links between Mascoma and their academic 'partners', namely Dartmouth College, went well beyond ordinary collaboration: Mascoma was co-founded by leading synthetic biologists at Dartmouth College and co-founder Lee Lynd used his simultaneous positions in the company and at Dartmouth College to attract millions of dollars of public funds, which were paid to Mascoma but transferred to Dartmouth's synthetic biology laboratory. Financial agreements between the company and Dartmouth College extended to Mascoma obtaining a licence not just for Dartmouth's existing intellectual property rights, but ones which the university might obtain in future. Dartmouth College, in exchange, obtained an equity interest as a co-founder of Mascoma;

2. Mascoma's co-founder Lee Lynd continues to occupy a position on the management team of the BioenergyScience Center (BESC), set up and funded by the DoE, which would have put him in a prime position to attract funding via the BESC itself and, likely, for persuading the DoE to make the much larger grants for Mascoma's proposed biofuel refineries available;

3. Mascoma's failure to build any commercial cellulosic refineries cannot be explained by economic problems. According to the figures published by Mascoma, they had sufficient finance to build at least one if not two of their proposed commercial plants;

4. Mascoma's business model relied on a proposed cellulosic ethanol technology called Consolidated Bioprocessing (CBP). Mascoma co-founder and director Lee Lynd acknowledged in a scientific review he co-authored in 2011 that there were major hurdles to be overcome and that years of fundamental research into CBP were still needed. This strongly indicates that Lee Lynd at least was well aware that the technology was not commercially viable at the time;

5. There is a serious lack of transparency on the part of the grant-giving authorities, especially the DoE. This makes it impossible to ascertain whether Mascoma broke any terms of the grant agreements, or whether those terms were worded so weakly that they could not be used to force Mascoma to either build the

proposed plants or repay the money. It is clear however that there was a serious lack of due diligence on the part of all of the public authorities that gave grants to Mascoma, with the possible exception of New York State.

Biofuelwatch believes that a full investigation, with disclosure of all relevant public documents, is vital to understand how such large sums of money could have been misspent on biofuels plants that were never built, and what the implications for the DoE's overall funding programme for industrial biorefineries are. Biofuelwatch believes that such funds should instead be spent on measures proven to reduce greenhouse gas emissions, such as sustainable solar energy or home insulation.

INTRODUCTION

There have been several high-profile failures of US cellulosic biofuel refineries which were built partly with public funds and which have failed and been shut down. In one case (Cello Energy), a court awarded punitive damages for defrauding investors against a company which had built a cellulosic biofuel plant. And another company (KiOR) is currently being sued for fraud. Other cellulosic biofuel companies (e.g. Range Fuels) have been bankrupted without being sued for fraud.

Mascoma has never faced fraud or bankruptcy proceedings, yet this company's story appears in many ways far more remarkable and concerning than that of Cello Energy, KiOR or Range Fuels.

Firstly, Mascoma spent more public funds than any of these companies: Overall, They spent least $100m and possibly over $155m of public funds. And secondly, the other companies used public funds to build commercial-scale cellulosic biofuel refineries, but failed to achieved the promised yields and volumes of biofuels. Mascoma, on the other hand spent government money earmarked for commercial cellulosic biofuel refineries, which they never even started to build.

Also remarkable is the fact that Mascoma succeeded in funnelling millions of dollars' worth of public funds into Dartmouth's synthetic biology work. Dartmouth College's synthetic biology team, chaired by Mascoma's co-founder, Lee Lynd, was a major beneficiary of the company's actions.

Instead of facing fraud, or even bankruptcy proceedings, Mascoma has simply changed its name to Enchi Corporation, after selling off most of its assets, as well as its name, to a Canadian biotech company called Lallemand.

The Mascoma story provides a fascinating glimpse into the cosy relations and complex personal links between the US Department of Energy, synthetic biology academics and start-up companies. It reveals an astounding lack of due diligence carried out by public grant-giving bodies in the US and, to a lesser extent, Canada, and a remarkable lack of transparency or accountability over the fate of public funds.

Range Fuels refinery in Broomfield, Colorado. USDA/Flickr

MASCOMA'S TECHNOLOGY: CONSOLIDATED BIOPROCESSING, THE HOLY GRAIL FOR CELLULOSIC ETHANOL PRODUCTION?

Conventional ethanol is made either from sugars that are derived from sugar cane or beet, or from the starch in grains such as corn. Ethanol production from sugar cane or beet is most straightforward: Those sugars can be easily fermented to ethanol using ordinary baker's yeast. Making ethanol from corn or other grains is slightly more complicated: energy and at least two different enzymes are needed to break up the starch into sugars, which can then be fermented. Making cellulosic ethanol, on the other hand, is far more difficult.

This is due to the fact that the cell walls of plants contain different types of sugars which are embedded in complex and very recalcitrant structures. Cellulosic ethanol production involves three different steps:

1) Pre-treating biomass so that the molecules which contain different sugars can be easily accessed. This might involve milling biomass into small particles, exposing it to heat and high pressure which is then suddenly reduced, and/or treating it with sulphuric acid;

2) Hydrolysis: This involves breaking up the different types of molecules which contain long chains of sugars;

3) Fermentation: efficient cellulosic ethanol production requires all or most of the sugars in the biomass to be fermented. However, no microorganism has been found that can efficiently ferment the whole range of such sugars Engineering such an organism is one focus of synthetic biology.

The second stage, i.e. hydrolysis, is particularly challenging. It can be done using acids which are cheap, but there are serious problems with this approach: Sugar yields are relatively low, expensive materials are needed to prevent corrosion caused by the acids, and the process results in byproducts which then hamper ethanol fermentation.

The more popular alternative is to use enzymes (produced by microorganisms which are cultured elsewhere),instead of acids. This has several advantages: Sugar yields are higher, corrosion is not a problem, and no byproducts which could inhibit fermentation are formed. Yet this approach has its own problems: It requires many different expensive enzymes, which tend to be produced by a variety of genetically engineered microbes. The process takes days rather than seconds or minutes (as for acid hydrolysis). The enzyme mixture can be easily contaminated by unwanted microbes which disrupt the whole process. And – most problematically - sugars which are released during hydrolysis can stop some of the enzymes from working effectively.

Much recent research into cellulosic ethanol has focussed on how to stop enzymes being inhibited by the sugars which the hydrolysis process is meant to release. Researchers and companies have been trying to avoid this problem by finding ways of combining hydrolysis and fermentation in one single step. If this could be done then there would never be enough 'free' sugar to stop enzymes from working well, because those sugars would immediately be fermented to ethanol. Such 'single stage' processing overcomes one major problem but creates another: It requires a temperature that is less than optimal for both hydrolysis and fermentation and thus reduces the efficiency of the whole process.

This is where Mascoma's proposed technology, called Consolidated Bioprocessing (CBP), comes in. It involves creating a GE super-microbe or, more likely, a community of (GE) microbes which produce the enzymes that free up all of the different sugars in biomass and, at the same time, ferment all of them to ethanol, all simultaneously and in one single vessel. The DoE has called it a "a game-changing, one-step strategy". Developing and operating an effective CBP system would mean overcoming virtually all of the challenges of cellulosic ethanol production, including that of high production costs, because there would no longer be a need to buy expensive enzymes.

Yet such a breakthrough remains a long way off. This was concluded in a scientific review published in 2007, and it was even admitted in a scientific review published in 2011 that was sponsored by Mascoma and co-authored by their co-founder Lee Lynd. The language and conclusions of that review were fundamentally different from the confident promises made by Mascoma.

Thus, at the same time as Mascoma had been persuading public authorities to grant them large subsidies for commercialising CBP technology, Mascoma's researchers were admitting that major fundamental research was needed before CBP could become a proven technology.

SHIFTING PLANS AND BROKEN PROMISES: A CHRONOLOGY OF MASCOMA

Mascoma was founded in 2005 by two academics of Dartmouth's Thayer School of Engineering: Charles Wyman and Lee Lynd.

By 2006 the company already had attracted $35.25 million from venture capitalists and had bought another start-up company, which gave it access to proprietary cellulosic biofuel technology developed at Purdue University.

By the end of that year, Mascoma had been awarded $14.8 million from New York State for building a cellulosic ethanol demonstration plant in Rochester, NYS, in partnership with Danish biotech company, Danisco. [1] Danisco was to provide the enzymes needed to free up the sugars in biomass so that they could be fermented to ethanol. [2]

A year later, Mascoma started building a demonstration plant in Rome, NYS, instead of the Rochester facility, and was no longer in partnership with Danisco. Mascoma retained the $14.8 million grant for the Rome facility, and obtained further private investment in the Rome facility, which cost a total cost of $30 million to be built. At the ground breaking ceremony, Mascoma's CEO promised: "Cellulosic ethanol will become a commercial reality and the work done at this new facility will dramatically expedite the process."

According to the DoE, Mascoma's Rome plant started production in February of 2009 with a capacity of up to 200,000 gallons a year. Yet Mascoma never announced the sale of any ethanol made in the plant. They never even announced any successful test run of their biofuels by a car manufacturer. This is surprising since General Motors had invested in the company in 2008. Last year (2015), the plant was acquired by a biotech company called Renmatix, with very different plans and technologies, and also with no actual production so far.

The purpose of a demonstration plant such as the Rome facility which New York State funded Mascoma to build, is to test a technology at a scale large enough to find out how well it works and provide opportunity for refining and adjusting the process if necessary. New technologies require testing at this scale before they can be rolled out on a commercial scale. This would have been particularly vital for a technology such as Mascoma's, which had never been demonstrated outside the laboratory.

Mascoma wasn't going to wait. Nor was the DoE. Three months before Mascoma laid the first brick for their plant in Rome, NY, they had already entered into a partnership with the University of Tennessee to build a plant 25 times as large as the one in Rome, NY in the town of Vonore. Seven months later – and ten months before Mascoma's demonstration plant in Rome officially opened - the DoE jointly awarded Mascoma and the University of Tennessee $26 million for building the much larger plant. Then Secretary of Energy, Sam Bodman, enthused: "This funding will further President Bush's goal of making cellulosic ethanol cost-competitive by 2012...These projects [including Mascoma's] will help pioneer the next generation of non-food based biofuels that will power our cars and trucks and help meet President Bush's goal to stop greenhouse gas emissions growth by 2025." The university estimated a cost of over $100m. Mascoma raised $71 million in private investment during 2008, including $10m from Marathon Oil and General Motors. The University of Tennessee had pledged $40 million towards the plant. And the State of Tennessee had promised $70.5 million. According to the DoE "Project Partners and the State of Tennessee, together with the DOE have committed the full amount required to build and operate the project."

Yet in February 2009, the same month in which the demonstration plant in NYS officially opened, Mascoma pulled out of the project in Tennessee. They blamed the University of Tennessee for having reduced the size of the project, while the university claimed to have been left with no choice because Mascoma had failed to raise sufficient funds – a very questionable claim, as the figures cited above show. [3]

What seemed to stand in the way of this project – other than fact that the technology remained unproven – were

[1] The partnership was between Mascoma and Genencor, a fully-owned subsidiary of Danisco A/S. Danisco has since been acquired by the multinational agrochemical and biotech corporation DuPont.

[2] The grant was specifically awarded for using Consolidated Bioprocessing which, as we have seen above, should mean that all the enzymes would be produced by microorganisms inside the refinery and that none would need to be bought. So it is not clear why Genencor was to supply enzymes.

[3] The University of Tennessee subsequently entered into a partnership with DuPont and Danisco and a much smaller cellulosic ethanol demonstration plant was built on the same site, though it has since been closed down. The $70.5m state grant was transferred to and paid for this plant.

the company's even grander ambitions. They had already announced in July 2007 that they would build another refinery in Kinross, Michigan. Initially, this scheme was reported to be planned at the same scale as that in Tennessee, but by October 2008, Mascoma were promoting a capacity of 40 million gallons a year for their Michigan plant - 200 times the size of their recently opened demonstration plant in Rome from which they had not actually sold any ethanol.

That same month, month, the State of Michigan awarded Mascoma a $23.5 million grant for the Kinross project. Governor Granholm praised Mascoma's plans: "This company and their partners will create jobs in Michigan as they develop the next generation of cellulosic ethanol that will reduce our dependence on foreign oil and make fuel more affordable for our families." Mascoma spent at least $20m of those state funds without building anything. Public documentation about the DoE grant(s) is sketchy but it seems that the DoE allowed Mascoma to transfer the $26 million that had been awarded to them and the University of Tennessee for the joint Vonore project and spend it on the Michigan plant instead. Sometime between then and January 2010, the DoE increased the grant award to $32 million. This figure was to eventually go up to $100 million.

In February 2011 the DoE conducted a 'peer-review' into the progress of Mascoma's Michigan project. [4] Mascoma's presentation offered a glowing image of their project, which, up until then, had consisted of test-runs in their existing demonstration plant in Rome, NY. The technology, they claimed, was 'low cost' and for most processes 'mature', risks were 'minimal', and returns would be high 'compared to other biofuel opportunities', and the plant would be up and running in 2013. Important technical milestones had been reached: Mascoma had managed to operate a 1,000 gallon and for the first time also a 5,000 gallon fermentation tank in the Rome, NY plant, and they had demonstrated the recovery of xylose, a sugar contained in plant walls which is very different from the sugars fermented in conventional ethanol refineries. Fermenting a range of different sugars is vital for making cellulosic ethanol efficient enough for commercial production.

Mascoma was supposed to have tested an even larger 25,000 gallon fermenter, too, but had abandoned that plan. The DoE was nonetheless impressed. So much so that they increased their total grant for Mascoma's project in Kinross, Michigan to $100 million.

Yet Mascoma's presentation to the DoE raises three obvious questions: If they used millions from this DoE grant for testing their technology in Rome, NY, then what exactly had they used the previous NY state grant and the private investment for that plant for? What had that plant been producing since it 'started production' in February 2009? And how could the claims made to the DoE be reconciled with the above-mentioned scientific review funded by Mascoma which was also published in 2011, but which concluded that the Consolidated Bioprocessing, i.e. the company's technology, required significant further fundamental research.

At some point, probably in 2011, the Kinross, Michigan, plans were scaled back to half the proposed size, at least 'initially'. This was still one hundred times larger than the Rome, NY plant. The Michigan Chapter of the Sierra Club backed a local resident's court action against the DoE's grant award. They were deeply concerned about the effects that a 20-40 million gallon cellulosic ethanol plant would have on Michigan's forests. Sierra Club finally lost the case in the Court of Appeals in May 2014. But by that time, a major investor in this plant, the oil company Valero, had pulled out and the project had effectively died.

Soon after the Court of Appeals judgement was handed down, Mascoma's CEO, Bill Brady, admitted to the media that "Kinross, itself, is unlikely to happen." Instead, Mascoma was going to focus on selling its ethanol refining technology to other cellulosic ethanol companies, though they were still trying to get finance for building their own cellulosic ethanol plant – this time in Alberta. By then, Mascoma had spent at least $20m of grant funding from Michigan State and tens of millions of DoE funds that had been earmarked for the plant in Kinross.

They spent public funds on two further projects both of which failed to result in any construction, let alone production:

As early as November 2007, i.e. well before Mascoma opened its demonstration plant in Rome, NY, the company appointed a managing director for developments in Canada. By July 2009, Mascoma had obtained C$810,506 (U$771,176) from the National Research Council Canada and the following year they were granted $0.8 million by Alberta Province for developing a cellulosic ethanol plant in Alberta's Drayton Valley. In 2013, the Canadian federal government pledged C$75 million (US$ 59 million) for this

[4] Demonstration of Integrated Biorefinery Operations for Producing Biofuels and Chemical / Materials Product s Mascoma MAS10BIO5, Feb 1, 2011 Office of the Biomass Program Integrated Biorefinery Peer Review ,Michael Ladisch, PI Todd Polanowicz, Justin van Rooyen Mascoma Corporation.

plant, which was to have a capacity of 18 million litres. There is no published evidence that any of these C$75 million were in fact paid to Mascoma. However, there is little transparency regarding any the Canadian funds for Mascoma, too: Neither of National Research Council Canada nor the Province of Alberta mention grants to Mascoma on their websites, even though both had in fact paid the company substantial sums of money.

Mascoma's subsidiary in Alberta was formally dissolved in 2015, having built nothing in that province either.

There was yet another loser from Mascoma's abandoned ethanol projects: the State of Minnesota. In 2010, Mascoma acquired the biotech/biofuel subsidiary of the Canadian food and minerals company SunOpta. That subsidiary, SunOpta BioProcess Inc., had been given nearly $1 million from the Minnesota Department of Agriculture and $100,000 from Minnesota's Agricultural Utilization Research Institute to build a cellulosic ethanol plant in Little Falls. Mascoma promised to develop and build the plant but in 2011, having used up all but $48,000 of the grants, they announced that they had changed their plans and were abandoning the project. None of the money was ever recovered.

MASCOMA FAILS TO DELIVER CELLULOSIC FUELS, BUT BOOSTS SYNTHETIC BIOLOGY APPLICATIONS IN CORN ETHANOL REFINING?

In 2012, Mascoma finally began to sell a product – but not one related to cellulosic ethanol, i.e. to any activities for which they had obtained all of their public grants and most of their private investment. Instead, they had entered into an agreement under which the Canadian biotech firm Lallemand would commercialise yeast which Mascoma had genetically engineered to produce an enzyme that is needed in order to break down starch, for example from corn, into sugars which can be fermented to ethanol. Their first large customer was Pacific Ethanol, an important corn ethanol producer in the US. Mascoma and Lallemand later commercialised another genetically engineered yeast, this time one which not only produced an enzyme needed for breaking down starch but which also, according to Mascoma and Lallemand, increased ethanol yields by 2.4% on average by turning less of the sugars into glycerol. Glycerol is a byproduct of ethanol fermentation. According to Enchi Corporation, Mascoma's (partial) successors, those yeasts had been used to produce 3 billion gallons of ethanol by the time Mascoma's yeast business was bought up by Lallemand in 2014.

Mascoma thus played a pivotal role in commercialising yeast engineered through synthetic biology into US corn ethanol production on a large scale. This GE yeast has been used inside commercial ethanol refineries. Such refineries are operated by companies that have no specialist background at all in biotechnology and thus in biosafety, i.e. no expertise in preventing the accidental release of genetically engineered yeast cells.

Neither of Mascoma's two commercialised GE yeast strains would be of use for making cellulosic ethanol: Cellulosic ethanol involves isolating, breaking down and fermenting sugars contained in plant cell walls, rather than in starch. Their GE yeast only helps to break down starch.

A LUCRATIVE BUSINESS FOR DARTMOUTH COLLEGE'S SYNTHETIC BIOLOGY LAB

Mascoma Corporation, as discussed above, was founded by two Dartmouth College researchers. There is nothing unusual about this: other synthetic biology companies, too, have been founded by academics trying to commercialise the results of their work. In fact, a synthetic biology company that does not collaborate closely with research institutes stands little chance of financial success.

Yet the financial transactions between Mascoma and Dartmouth College, described in detail in Appendix A, went far beyond usual collaborations between universities and companies, involving for example an agreement by which Mascoma had free access not just to the results of past but also of future university synthetic biology research. At the end of 2013, Lee Lynd gave a presentation to the DoE's Advanced Research Projects Agency, in which he reflected on what he called an 'unusual agreement between Dartmouth and Mascoma". According to Lynd, "university and company interests [were] aligned", though possibly less so with royalties. The arrangement, he said, was good for the technology and good for himself as a researcher since it *"preserved [his] opportunities to do important things"*.

REFLECTIONS: HOW COULD A COMPANY LOSE TENS OF MILLIONS OF PUBLIC FUNDS ON UNDELIVERED PROJECTS AND GET AWAY WITH IT?

In his 2013 presentation to the DoE's Advanced Research Projects Agency, Lee Lynd described Mascoma as having initially had *"a build-own-operate business model, but [having] pivoted to being a technology provider to the renewable fuel industry (both corn and cellulosic)"*. He argued that "once a near-panacea, the climate for advanced biofuels became less favourable". At the time, Mascoma had only just been promised C$75 million by the Canadian government for building their proposed refinery in Alberta, and the DoE was still defending their Michigan proposal against the Sierra Club in the Court of Appeals.

Yet here was Mascoma's Chief Science Officer Lee Lynd already telling the DoE that they had given up on all their plans to build cellulosic ethanol refineries. They had already started supplying genetically engineered yeast to conventional corn ethanol refining, but there is no record of them or their successors (Mascoma LLC and Enchi Corp) having sold any technology to other cellulosic ethanol companies.

Blaming the a worsening 'climate for advanced biofuels' for abandoning their subsidised refinery projects seems disingenuous: Five commercial-scale cellulosic ethanol refineries have officially opened in the US since 2013, though one of these has closed down and the others have been producing very little ethanol. The DoE has continued to make generous grants available for such projects.

Mascoma's total public and private funds would not have been enough to enable them to build all of the four commercial-scale cellulosic ethanol refineries they had announced. But they would clearly have been enough to build one or even two. The Tennessee project had reached financial closures by the time Mascoma pulled out. Of course the technology had never been proven at scale – but Mascoma knew this very well at the time they announced their commercial ethanol plans. As shown above, their own co-founder, Lee Lynd had argued in a scientific paper that years of fundamental research would be needed to develop a viable CBP technology, yet at the same time had convinced public grant-makers to part with at over $100 million for the commercial use of that very same technology.

Ethically, those choices appear highly questionable indeed. However, the documents signed between Mascoma and their public grant giving bodies are not in the public domain, and the DoE failed to publish any further reports about Mascoma's Michigan project after increasing their grant to $100 million. We thus do not know whether Mascoma failed to fulfil their legal commitments or whether the grant conditions had been so full of loopholes that they had not actually been required to actually build and operate any of the proposed refineries.

In September 2013, the DoE's Office of Inspector General published a highly critical follow-up audit of the DoE's grants for biorefineries, including cellulosic ethanol plants. That audit pointed out: *"Despite over 7 years of effort and the expenditure of about $603 million, the Department had not yet achieved its biorefinery development and production goals."* And it concluded: *"The Program's inability to achieve the EPAct mandate and the original 2014 production capacity goal occurred because selected projects were not at the level of technical readiness needed for commercial development, and, because of poor market and financial conditions."* The Office of Inspector General specifically criticised the DoE for having funded commercial-scale projects before the technology had been fully validated and tested in pilot or demonstration-scale facilities. This clearly applies to Mascoma, who were awarded $100 million by the DoE for a commercial cellulosic ethanol refinery in Michigan, without ever having had to demonstrate successful continuous operation of their demonstration plant in Rome, NY. The same criticism applies to Mascoma's other grant-givers, in Minnesota, Michigan and in Canada.

The audit report failed to mention what might well have been the key reason behind such a colossal misspending of public funds: The close relations between the DoE (through its Bioenergy Research Councils), academic 'partners', who may in fact include the company's own directors, and the recipient companies. Lee Lynd, who occupied key positions in Dartmouth College, on the DoE Bioenergy Research Council, and with Mascoma, appears to have seen nothing wrong with Mascoma's use of public funds. Lynd's interest in genetically engineering microorganisms to produce cellulosic biofuels goes back many decades. From his presentations, including a TEDx talk in 2010, Mascoma appears to have been just another stage his career as a synthetic biology/biofuel researcher. While Mascoma never produced any ethanol, Lynd's academic output has been impressive: He has authored 180 papers about cellulosic biofuels and/or synthetic biology. Neither Mascoma, nor Dartmouth College nor the DoE have ever acknowledged that tens of millions of taxpayers' dollars spent on cellulosic ethanol refineries ended up doing nothing more than furthering the work and careers of synthetic biologists and boosting GE microbe use in corn ethanol refining.

APPENDIX A: EVIDENCE OF THE LINKS BETWEEN MASCOMA, THE DOE, AND DARTMOUTH COLLEGE

Mascoma co-founder ***Charles Wyman*** now works for the University of California, Riverside. He remained with Mascoma as a Chief Development Officer for several years and has since founded another start-up company, Vertimass LLC. Vertimass seeks to convert ethanol into 'drop in fuels', i.e. fuels with identical qualities to petrol, diesel or kerosene. They have already attracted their first DoE grant of $2 million. Wyman also has a long history of combining senior positions in academic synthetic biology work and publicly-funded start-up companies.

Mascoma co-founder Lee Lynd continued as Director and Chief Science Officer of Mascoma Corporation until their partial sale and name change in 2014, and now holds this position for both Mascoma LLC (i.e. the part of Mascoma bought up by Lallemand) and Enchi Corporation (the re-named remainder of Mascoma). He also remains a Professor at Dartmouth College, where he leads a synbio research group named after himself, the Lynd Research Lab. What is more, he holds a position as a management team member of the Department of Energy's (DoE) BioenergyScience Center (BESC) which, according to Mascoma's financial report in 2012, had paid the company $6.4 million from DoE funds, nearly all of which went to Lee Lynd's own synthetic biology department at Dartmouth.

The ***BESC*** is one of three Bioenergy Research Centers established by the DoE in 2007 in order to accelerate the development of next generation biofuels. It is a partnership of 18 academic institutions, companies, and DoE laboratories, and partners include both Dartmouth College and Mascoma LLC. The BESC received $139.9m from the DoE between 2007 and 2011 and $25m a year from 2012 until 2017 to spend on research projects. Although the BESC does not decide on DoE grants paid for cellulosic biofuel refineries, its advice will no doubt be taken into account. Professor Lynd thus continues to hold key positions in Mascoma, in academic synthetic biology research and teaching (Dartmouth College) and in a DoE initiative that has dispersed funds to his own company.

Financial transactions between Mascoma and Dartmouth College revealed in Mascoma's financial report in March 2012 went far beyond ordinary collaborations. Not only had Lee Lynd, who continued as head of Dartmouth's synthetic biology 'Lynd Laboratories' taken more than a quarter of a million dollars from Mascoma in consultancy fees (as well as substantial stock option grants), but Mascoma had entered into a $1.8m two-year research agreement with Dartmouth College in 2006. That was in addition to paying for a license agreement which allowed the company to use technologies patented by Dartmouth. Between 2009 and 2011, Mascoma passed $6.3 million of funding from the DoE's BioenergyScience Council (BESC) to Dartmouth College for 'research' costs, with a further $1.94 pledged to Dartmouth, as well as Purdue University, during 2012-13. As a member of the BESC's management team and a project leader, Dartmouth's and Mascoma's Lee Lynd was perfectly placed for securing those public funds. When Mascoma was founded, Dartmouth College received equity as a co-founder of the company, and Mascoma obtained the right to use not just the (synthetic biology) technology already developed by Lynd's team but any that might be developed in future.

APPENDIX B: DETAILS OF MASCOMA'S FINANCES, INCLUDING THEIR PUBLIC GRANTS

Lack of transparency

Just how many millions of public funds were paid to Mascoma is impossible to ascertain through public records. The DoE's website has 50 different entries for Mascoma but none that showed how much money the department actually paid to the company. Companies only have to publish their full financial details if they are listed on the stock market or are planning to 'go public', i.e. to enter the stock market.

Mascoma's single financial report, published in 2012

Mascoma announced in 2011 that they were planning to go public but withdrew in 2013. During this time, they published one detailed financial report in respect of the period 2009 to early 2012. No evidence of their revenues and spending in previous or subsequent years is available.

According to Mascoma's financial report from 2012, 93% of the company's income during 2011 had come from government grants and awards. [5] The public grant income declared in the report consisted of:

- $2.9 million out of a $4.3m DoE grant for developing a genetically engineered microorganism that can convert solid biomass (i.e. lignocellulose) to ethanol;
- $18.9m out of an $80 million [and eventually $100 million] DoE grant for developing a cellulosic ethanol refinery in Kinross, Michigan, with a further $33m cleared for payment and another $55 million approved for 2012 and 2013;
- $20 million towards that same refinery from the State of Michigan;
- A $6.4 payment from the DoE's BioenergyScience Center (i.e. the same BESC on whose management team Mascoma's co-founder and Chief Science Officer was sitting);
- $13.8 out of a total $14.8 grant from New York State;
- $0.6m out of an approved $0.8 million granted by Alberta Province for a feasibility study for a cellulosic ethanol plant in Drayton Valley, Alberta;
- $33,333 received in 2008, out of a $100,000 grant from the State of Minnesota's Agricultural Utilization Research Institute for developing a cellulosic ethanol plant in Little Falls, Minnesota;
- $611,830 from another Minnesota state grant received in 2008 and 2009, with a further $298,161 due in 2010, also for the Little Falls Project;
- The equivalent of $771,176 from the National Research Council Canada

We assume that the $4.3 million DoE research grant will by now have been paid in full, since Mascoma's successors, Enchi Corporation, reported on the 'success' of the project in August 2015. We also assume that the $14.8 million New York State grant would have been paid in full since that demonstration plant was built and commissioned. And media reports suggest that Minnesota ended up paying the full $100,000 plus $910,000 grants and only received $48,000 back from Mascoma after the company abandoned the project. All of those grants add up to around $100 million.

We cannot ascertain how much of the total DoE grant award of $100m for the Kinross facility was paid to Mascoma, nor whether the DoE's BioenergyScience Center, or Alberta Province or the National Research Council Canada made any further payments.

Out of these $100 - $155+ million in subsidies, at least $73.5 million were earmarked for the development of commercial cellulosic ethanol refineries in Minnesota, Michigan, and Alberta.

[5] Although Mascoma's SEC report presents financial information for several years, it only gives a figure for the proportion of income derived from public funds for the year 2011.