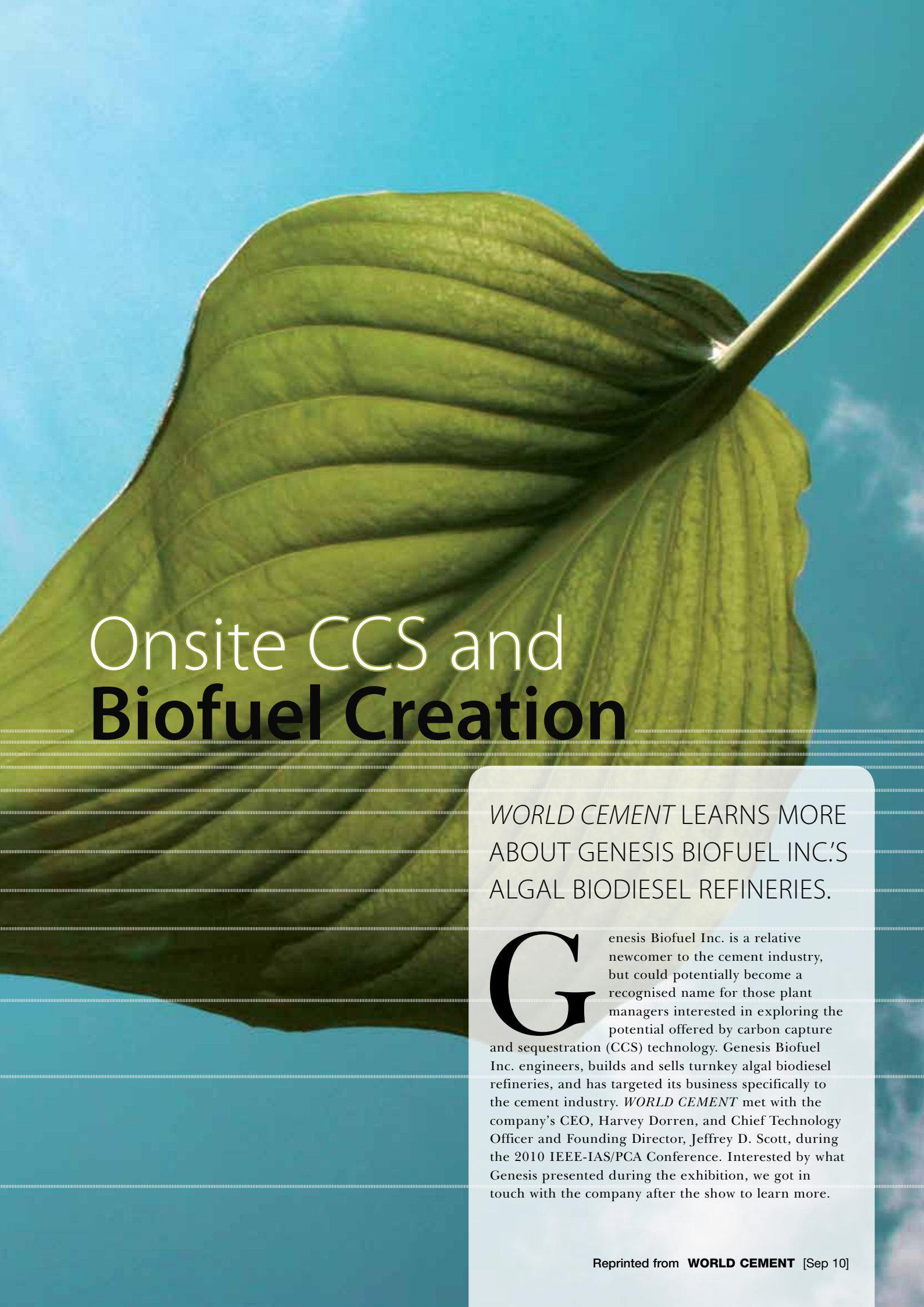

Onsite CCS and **Biofuel Creation**

WORLD CEMENT LEARNS MORE ABOUT GENESIS BIOFUEL INC.'S ALGAL BIODIESEL REFINERIES.

Genesis Biofuel Inc. is a relative newcomer to the cement industry, but could potentially become a recognised name for those plant managers interested in exploring the potential offered by carbon capture and sequestration (CCS) technology. Genesis Biofuel Inc. engineers, builds and sells turnkey algal biodiesel refineries, and has targeted its business specifically to the cement industry. *WORLD CEMENT* met with the company's CEO, Harvey Dorren, and Chief Technology Officer and Founding Director, Jeffrey D. Scott, during the 2010 IEEE-IAS/PCA Conference. Interested by what Genesis presented during the exhibition, we got in touch with the company after the show to learn more.

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Harvey Dorren, CEO

Jeffrey Scott, CTO

Although the company was founded as recently as 2008, Scott has spent the last four years designing and engineering the company's refinery, incorporating R&D from National Renewable Energy Laboratory (NREL) and The Colorado Center for Biorefining and Biofuels (C2B2), a research centre of the Colorado Renewable Energy Collaboratory of which Genesis is a sponsoring member. Scott's past ventures include CA Solar, where he designed a wind turbine/PV energy system, a biogas plant and water catchment systems.

CCS and cement

CCS is making waves across many industries, so we had to ask: why the cement industry?

The answer is a practical one. "The volume of GHG emissions from cement plants fits with the size and configuration of Genesis refineries very well. It is a market that few companies are pursuing and Genesis specialises in this industry." While other players in this market are looking at large-scale projects working alongside, for example, coal-fired power plants producing 75 – 100 million tpd of CO_2, the Genesis system works on a smaller scale, making it much simpler for the company to scale up its R&D model for a real life application. A smaller line is also more flexible, enabling the company to adapt to the differing requirements of its customers.

Genesis was inspired to create an effective CCS solution by its customers. "When communicating with leaders in the industry, they were very specific about what their present and future needs are in regard to the reduction of GhGs and specifically carbon dioxide. While Genesis refineries produce high quality biofuel and low carbon biomass, future costs related to emissions are the industry's highest concern," says Dorren. Genesis's primary mission is to eliminate carbon taxes and create carbon tax credits for its customers who are potentially subject to hundreds of millions in carbon penalties annually.

It is size and efficiency that make the technology work for the cement industry. Dorren illustrates: "(1) The footprint of a refinery built symbiotically with an average size cement plant is relatively small. (2) As the system uses concentrated solar power to heat and cool the bioreactors and the physical plant it is very energy efficient. (3) Water consumption is very low, as there is very little evaporation; also, as we are collecting condensate from the flue gas cooling process the plant can actually provide surplus water. (4) The production of high quality B100 provides for all the internal needs of the cement plant vehicles and equipment. This reduces the vehicle carbon footprint while generating a large surplus of biofuel that can be sold on the open market. (5) The biomass co-product substitutes low carbon fuel (pelleted cellulose) for high carbon fuel (coal or coke), thus reducing the cost of fuel while reducing the carbon footprint of the cement process. It is basically free fuel for the kiln. (6) The refinery is carbon negative."

From sequestration to biofuel

So, how does this model of CCS work and why use algae?

Genesis refineries use algae for the following reasons:

- It is one of the fastest growing organisms on earth, reproducing in nature at a rate of 200% its mass in a single day. In a controlled environment that growth can be accelerated by 350% or more.
- Unlike seasonal crops, algae can be grown year round.
- It is consistent in quality compared to other feed crops that vary year to year.

> Each cement plant is different and we must come on site and perform evaluations to be precise on the cost and profitability of a refinery.
> *Harvey Dorren, CEO, Genesis*

Genesis Biofuel & Titan America sign collaborative agreement

Genesis Biofuel, Inc. and Titan America have signed a formal Collaborative Agreement. In this agreement Titan America and Genesis Biofuel agree to a complete exchange of processes and technology. Titan agrees to allow Genesis personnel access to their facilities as well as their engineering and production personnel. This agreement is a prelude to a Memorandum of Understanding and the construction of Genesis refineries at their US facilities and soon after in Europe.

Harvey A. Dorren, President & CEO of Genesis Biofuel, Inc. stated, "Titan America is a leader in cement production here in the United States and in Eastern Europe. They are dedicated to the environment and their position as an outstanding corporate citizen. We at Genesis Biofuel are thrilled to be working with Titan as we continue our endeavour to Save the Planet, One Cement Plant at a Time."

- Algae does not require agricultural land and does not compete with food crops for this resource.
- It grows in all climates, from the arctic to the equator, so local sources should always be available.
- There are over 350 000 known strains of algae on the planet, so strains can be selected according to each customer's need. Higher lipid algae would boost biofuel output, but decrease carbon sequestration. Lower lipid algae would maximise carbon sequestration but lower biofuel output.

Genesis grows algae in photo bioreactors (PBR), rather than in open ponds, because PBRs provide a clean controlled environment. PBRs are large clear tubes that contain water and a specific strain of algae and are linked together. A CO_2 delivery system is attached to the tubes. Once the algae is seeded, it is fed CO_2 from the cement plant, which in combination with sunlight causes algae to grow. Additional nutrients are injected to accelerate growth. Algae is harvested and collected in storage tanks using a continuous process. There are many conditions to monitor and manage through this process, including Ph and alkaline balance, temperature control, predator algae and bacteria. Genesis has an automated control system that enables the exact amount of carbon sequestered and the amount of oxygen released to be quantified.

From the PBRs, ultrasound is used to extract the oils from the solids, the algae is then centrifuged to separate water and biomass from oils. This process yields "green crude", which will be further refined to make biofuel, together with "biomass", which is very high in protein and while it can be used for high quality feedstock for animals, compressed into pellets for fish food, or applied directly to the soil for fertilizer, it can also be burned as biomass or used as feedstock for ethanol production. Customers could use all of this biomass to reduce the coal intake of their plants.

The conversion of "green crude" into biofuel is called transesterfication. The Genesis refinery employs a ShockWave reactor to convert green crude into raw biofuel. Methanol is removed from the raw biofuel and it is final filtered to produce pure raw B100 biofuel. This fuel is superior to its petroleum counterpart because it is biodegradable, performs better in diesel engines, ignites more easily, helps promote longer engine life because it has better lubrication qualities, produces 40% less pollution when burned, and is actually cheaper than petroleum diesel. Cement plants can use this biofuel to completely offset their fuel requirement for their trucking fleets and heavy equipment.

The entire refinery is carbon negative. Heat for the process is provided by a concentrated solar thermal system. All water used in the process is recycled. There is no waste. All products and byproducts are used by the cement plant and the excess has retail value for them on the open market.

Return on investment

As an international industry, it is important to know whether there is a real market for biofuels and whether this is true in all countries. Dorren confirms: "Yes, domestically with RFS2, the United States is required to offset petro fuels with alternative fuels with 36 billion gallons per year by 2020. There is not enough supply at this time to cover the needs and current requirements of that mandate and demand from consumers.

"Internationally, Europe and the rest of the world utilises more diesel powered vehicles than the US does. There has been an established market for biofuels globally for years." Genesis claims that each refinery will produce more biofuels than can be reused on site. Cement plants will be able to sell the surplus fuel, recouping the initial costs. With this in mind, we asked Mr Dorren the money question: What kind of investment is required and what return does the technology offer?

"Each cement plant is different and we must come on site and perform evaluations to be precise on the cost and profitability of a refinery," Dorren says. "That said, the cost of a refinery built next to a cement plant producing 6000 metric tonnes of clinker per day (thus an average of about 6000 metric tonnes of GHG) is in the US$100 million to 140 million range. Given reasonable carbon credits, sale of surplus biofuel, RINs, depreciation and offset of high carbon fuel with biomass, our projections reflect a payback of 24 to 36 months."