₹100 $5 €3

www.energynext.in

Energy Next

Volume 3 Issue 7 May 2013 Hyderabad

Your guide to Renewable Energy

Target 2017: Racing against time

The growing need for low-carbon transport fuel is making biofuel an increasingly sought-after source. The challenge before India is to make clean fuel available and popular without threatening the food supply

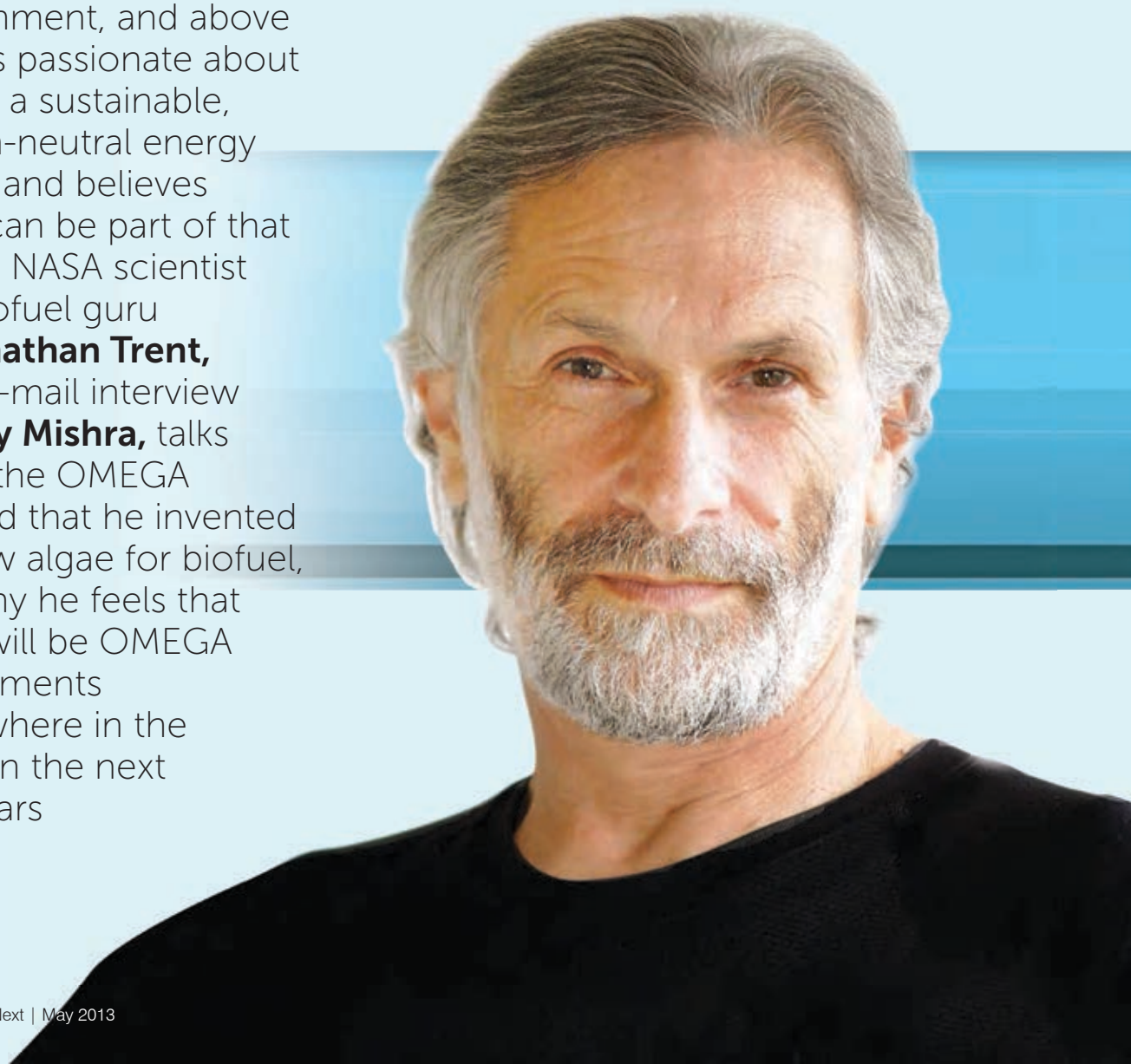
Supported by

इरेडा IREDA

IS/ISO 9001 - 2008 CERTIFIED

India has great potential for developing OMEGA systems

He's passionate about algae, he's passionate about the oceans, he's passionate about the environment, and above all, he's passionate about finding a sustainable, carbon-neutral energy supply and believes algae can be part of that supply. NASA scientist and biofuel guru **Dr Jonathan Trent,** in an e-mail interview to **Rosy Mishra,** talks about the OMEGA method that he invented to grow algae for biofuel, and why he feels that there will be OMEGA deployments somewhere in the world in the next few years



Amid growing scepticism about the viability of biofuels as a long-term alternative to fossil fuels, how can we make a convincing case for algal bio-fuels and persuade governments around the world to spend more on R&D projects like OMEGA?

There is no doubt that biofuels could be a long-term, even sustainable, alternative to fossil fuels, if they can be produced in sufficient quantities to meet the demand. In fact, I think it's this issue of scale combined with the question of economics that are at the root of the growing scepticism about biofuels. (There are also some people who worry about the issue of "food vs. fuel," but that is at the root of a kind of cynicism rather than scepticism).

Algae or rather microalgae are the best producers of oil and among the fastest growing plants for biomass production. Furthermore, they can be grown on wastewater from cities to avoid competing with agriculture for water and fertilizer. Although algae may produce as much as 100x more oil per hectare than soya, we still need to grow millions of hectares of algae to meet the current demand. If you do the calculations of energy returned on energy invested, taking into account the amount of solar energy that reaches the Earth and photosynthetic efficiency, it's clear that to produce more energy than is needed to grow the algae, the system has to be energy efficient and it will not be possible to pump water great distances. In other words, if wastewater is going to be used, the algae cultivation system must be close to the wastewater treatment plant. The problem is that most treatment plants are surrounded by urban infrastructure and it's impossible to build typical algae-growing ponds around existing treatment plants and it's impractical to build new plants. I developed OMEGA as the solution for coastal cities, which dump their wastewater offshore.

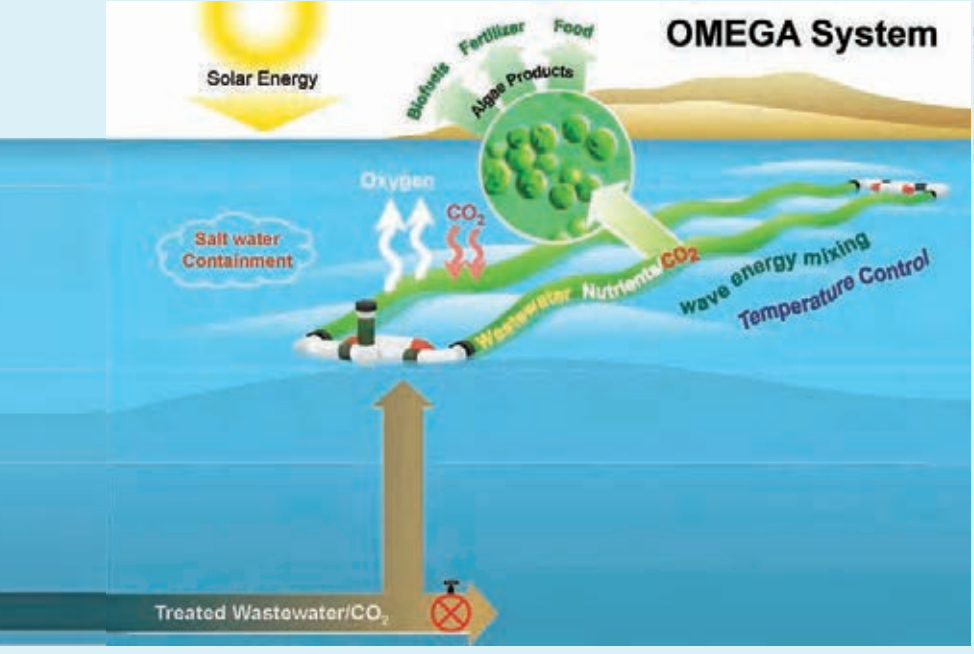


Image by T. Exposito and J. Trent

The OMEGA system consists of flexible plastic tubes floating offshore, filled with wastewater and CO2 from near-shore sources that provide nutrients for microalgae, which produce biofuels, fertilizer, and food. The surrounding seawater assists with mixing and controls temperature of the algae culture. The algae in wastewater are freshwater algae, which means the surrounding salt water provides containment, i.e., the algae that escape from the OMEGA system do not thrive in salt water and will not become invasive species in coastal waters.

OMEGA is an acronym for Offshore Membrane Enclosures for Growing Algae. There are a lot of other benefits from the OMEGA system that I present in my TED talk (http://www.ted.com/talks/jonathan_trent_energy_from_floating_algae_pods.html) and in previous publications (http://www.future-science.com/doi/abs/10.4155/bfs.12.53). There is technical information about the OMEGA system we built in an open access paper "Wiley et al." at: http://www.scirp.org/journal/jsbs/.

I appreciate the opportunity to introduce your readers to the OMEGA concept and I hope they will investigate it further. We need as many people working on OMEGA as possible, because I don't think it will be an easy way to produce all the fuels we need, but I do think it is the best system for making liquid fuels that is truly scalable, sustainable, and environmentally responsible.

Microalgae offer great potential for the production of biofuel, but the process is still said to be some way from being carbon-neutral or commercially viable. How is the OMEGA system poised to deal with these issues?

The question is how can we make algae biofuels carbon-neutral or better still, carbon negative and commercially viable?

Algae use carbon dioxide along with sunlight, water, and nutrients to grow, which means algae are a sink for carbon. Keep in mind that the fossil oil we are burning today was formed by algae that lived millions of years ago. The question of "carbon neutral" or "carbon negative" has to do with the rates of carbon capture by algae and other plants versus the rate we burn those plants or their by-products and turn them into green-house gas.

If we make biofuel from the oil produced by algae grown last month and burn that oil, that would be

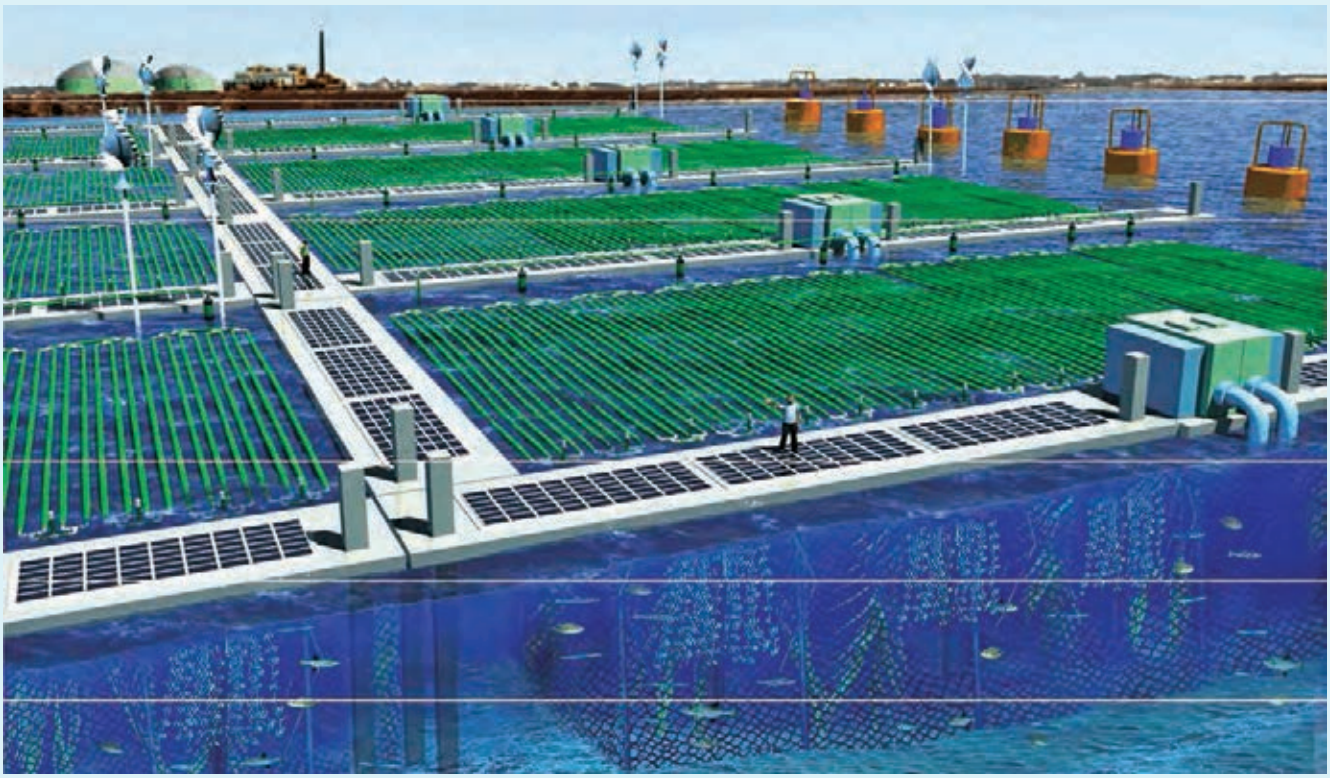


Image by T. Exposito and J. Trent

An artist's conception of the OMEGA system with the green algae in floating photobioreactor tubes, the offshore infrastructure with photo-voltaic cells provides access to wave and wind generators, as well as aquaculture underwater (foreground).

carbon-neutral because we capture the carbon in algae and then put it back into the atmosphere in a short cycle; assuming we don't use a lot of other carbon-based energy to grow the algae. Better still, if the algae oil is 40 per cent of the algae biomass and we turn the other 60 per cent of the algae biomass into a stable form of carbon, such as biochar, then we can make the algae system carbon negative. This is true for all biofuels systems, not just OMEGA.

I address the question of economics in the next question.

Q Can the OMEGA system be connected with renewable energy infrastructure such as wind or solar to improve its financial viability?

My graduate student, Brandi McKuin, has been doing a techno-economic analysis of the OMEGA system and the economics for OMEGA improve considerably if it's combined with solar and wind, as well as wave energy generation and aquaculture. Here's an example, of her calculations, using the San Francisco Southeast Wastewater Treatment Plant in her techno-economic model and assuming a 10 per cent profit margin. An OMEGA system making only renewable biofuels would produce fuel at a cost of $6.67/L. If however, the OMEGA system makes biofuels and simultaneously treats wastewater, the cost of biofuels would be reduced 13 per cent to $5.80/L. If the system makes biofuel, treats wastewater, and produces renewable electricity from solar, wind, and wave energy, the cost of biofuel would be reduced 24 per cent to $4.20/L. If the system does all of the above and the OMEGA offshore infrastructure is used for aquaculture (e.g., growing mussels), the cost of biofuels would be reduced 41 per cent to $1.43/L. In other words, if OMEGA is integrated into a system that takes advantage of associated services and products, its financial viable improves considerably. This "ecology or technologies" is an obvious way to make OMEGA competitive with even a seemingly inexpensive commodity like petroleum. Fossil petroleum is not really inexpensive, if we consider its true costs, which in my mind include government subsidies in various forms (such as waging wars to protect access to oil fields), and the environmental consequences of its continued use (such as global warming and sea level rise).

Q What are the biggest obstacles you have been dealing with in getting the OMEGA system into full deployment?

There are a lot of technical and social "obstacles" and the "biggest" one is the one I'm confronting at any given time. The good news is that technically OMEGA is not breaking any laws of physics or chemistry; i.e., OMEGA has no fundamental problems to overcome like, for example, cold fusion. Some of the social obstacles, like getting permits for offshore deployments or raising money, seem pretty daunting. (You know the old saying: "People want everything to stay the same and get

better"). These social problems are site-specific and time-dependent and I think they are all tractable with patience and perseverance.

Basically, it seems to me that OMEGA is an idea whose time has come. I predict that there will be OMEGA deployments somewhere in the world in the next few years; whether I'm involved in the deployment or not.

Are you in talks with any organisation to assist you in a scaled-up demonstration of the system?

I have just completed a $10.8 million feasibility study funded by NASA and the California Energy Commission and I'm working on a series of technical papers to share the results with everyone interested. There is not currently any organization funding my interest in doing a scaled-up demonstration of an OMEGA system, but I'm talking to lots of people in various countries and I'm optimistic that I may be part of further developments in OMEGA. What's important is that someone starts, somewhere, so others will have a model to follow!

What would you say are the major improvements needed to make this system a more refined and effective solution?

It's hard to say what universal "improvements" will be needed for OMEGA because each deployment site will have its own challenges and advantages. OMEGA and large-scale algae production in general, would benefit from developments in algae-strains, culturing techniques, photobioreactor materials, pump efficiency, fluid dynamics, monitoring and control systems, and most importantly significant developments in people's respect for planet Earth and support for sustainable systems.

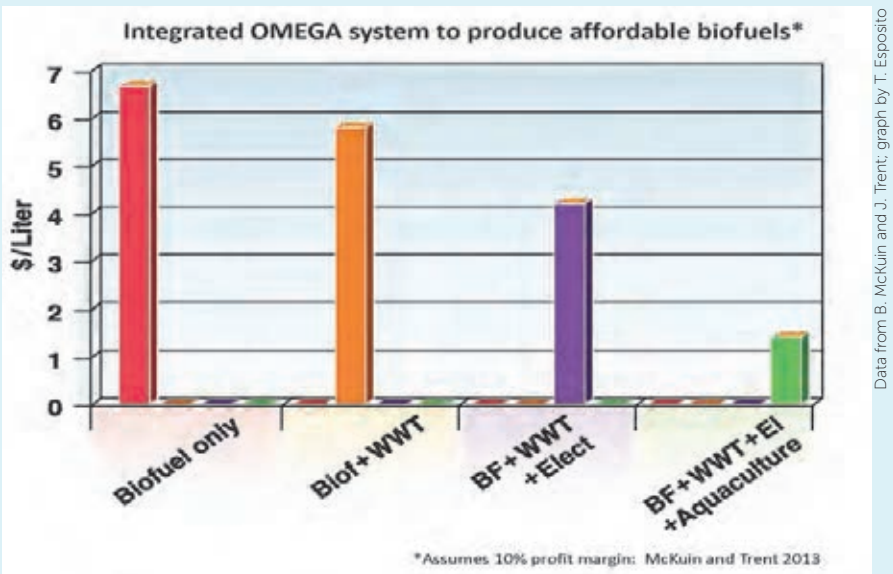
When do you expect to have the perfect system with you?

We now know how to make functional OMEGA systems. What we need to "perfect" the systems is to start building them in various locations to find out what we don't know that we didn't know. Once we build systems in various sites, each system will evolve and quickly adapt and improve. The world is so inter-connected now that technology develops fast. I'm optimistic that fully diversified OMEGA systems producing biofuels, electricity from solar or wind or waves, and producing food from aquaculture, will be in full operation before 2020.

Algae or rather microalgae are the best producers of oil and among the fastest growing plants for biomass production. Furthermore, they can be grown on wastewater from cities to avoid competing with agriculture for water and fertilizer

What do you think of the current efforts around the world to replace fossil fuels with clean and sustainable fuels? Are we going about it as seriously as we should? Can we bring the much-needed change in the next 5 to 10 years?

Most people are focused on their day-to-day problems and not paying attention to the big-picture—5 to 10 years ahead. This is understandable for the general population, but I'm disappointed the scientific community is not mobilizing itself more effectively. We have plenty of people pointing to the current predicament (there is a good video on the Internet that summarizes the situation at: http://vimeo.com/39048998); what we obviously need now is a lot more scientists and engineers turning their attention to basic problems of food, clean water, and environmentally compatible energy supplies. Our children and the "children" of many species are dependent on our role in the development of sustainable and acceptable human lifestyles.



Data from B. McKuin and J. Trent; graph by T. Esposito

The cost of biofuels (US$/litre) decreases as the OMEGA system includes revenue from wastewater treatment (WWT), electricity generation (Elect) from solar PV, wind turbines, and wave generators; and aquaculture.

Photo by J. Trent

Prototype OMEGA system in seawater tank at the San Fransisco Southeast Wastewater Treatment Facility. The algae in wastewater circulate through the floating tubes with dissolved gas and pH controlled by the partially submerged column to the left of the people (for details see: Wiley et al. http://www.scirp.org/journal/jsbs/).

Of all the known renewable energy resources, which one would you describe as the most promising solution to the looming global energy crisis?

From an energy perspective, I don't believe there is "one" technical solution to the "looming global energy crisis;" there are many solutions. They start with conservation, and depending on the location, they can include solar PV, wind, and various forms of waste conversion with OMEGA being one of them. At some point we have to realize that "waste" is ONLY A VERB and that most of what we now consider "wastes" are resources that we are currently wasting. You already know this in India, but what scares me is that people in India are trying to emulate the lifestyle in the USA. This is scary because the USA represents only about 4 per cent of the world's population that uses over 20 per cent of the world's resources. If everyone in India (17 per cent of the world's population) lived like people live in the USA, India alone would use 85 per cent of the world's resources; if India and China did this, it would require the resources of 1.8 planet Earths! The key to sustainability is to develop a lifestyle that combines the best features of different cultures that is sensitive to the needs of future generations.

In my opinion, one of the most important things we have learned from space exploration is the kind of radical parsimony that the world needs to consider seriously. Think about putting people on Mars or on the Moon or in outer space, you have to think hard about how to cope with very limited resources to maintain what's called "life-support systems." These places off Earth are alien, desolate, and dangerous. In outer space there are none of the life-supporting resources that we take for granted on Earth—like air or water or food or gravity. Thinking about going to such inhospitable places makes us think hard about everything we need, everything we use, and everything the local environment can provide... The OMEGA system emerged from that kind of thinking. We looked at cities on Spaceship Earth and thought about waste-streams, under-utilized spaces, all conceivable energy sources; we thought about how to optimize and integrate activities and resources. We even considered how OMEGA could take advantage of future sea-level rise.

> *What we obviously need now is a lot more scientists and engineers turning their attention to basic problems of food, clean water, and environmentally compatible energy supplies. Our children and the "children" of many species are dependent on our role in the development of sustainable and acceptable human lifestyles*

I think India has great potential for developing OMEGA systems and I want to encourage your readers to consider this technology, keeping in mind that "we are not passengers on Spaceship Earth, we are the crew!"

(The views expressed here are solely those of Dr Jonathan Trent in his personal capacity as a scientist and professor and do not in any way reflect the views of NASA or the US government.)