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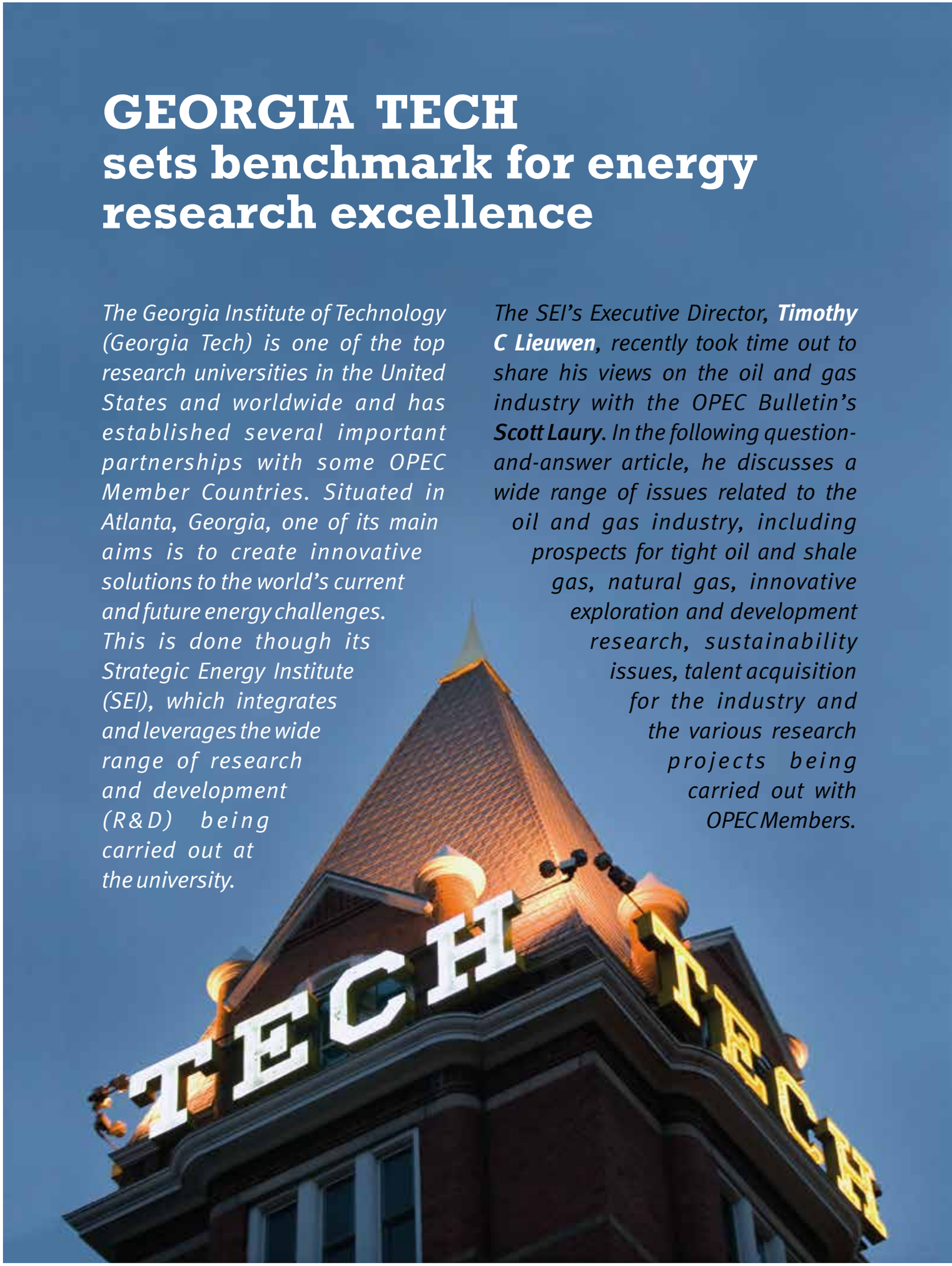
EU–OPEC Energy Dialogue

GEORGIA TECH sets benchmark for energy research excellence

The Georgia Institute of Technology (Georgia Tech) is one of the top research universities in the United States and worldwide and has established several important partnerships with some OPEC Member Countries. Situated in Atlanta, Georgia, one of its main aims is to create innovative solutions to the world's current and future energy challenges. This is done though its Strategic Energy Institute (SEI), which integrates and leverages the wide range of research and development (R&D) being carried out at the university.

The SEI's Executive Director, ***Timothy C Lieuwen****, recently took time out to share his views on the oil and gas industry with the OPEC Bulletin's* ***Scott Laury****. In the following question-and-answer article, he discusses a wide range of issues related to the oil and gas industry, including prospects for tight oil and shale gas, natural gas, innovative exploration and development research, sustainability issues, talent acquisition for the industry and the various research projects being carried out with OPEC Members.*



Professor Lieuwen, tell me about your role at Georgia Tech and SEI.

I have been a professor at Georgia Tech since 1999, primarily focusing on low emissions combustion. Much of my work focuses on the technical challenges associated with low emissions gas turbines used for power generation or aircraft propulsion. Starting last August, I also assumed the role of Executive Director of the Strategic Energy Institute (SEI). The mission of the SEI is to coordinate all of the cutting-edge energy research that is being done in different areas of the university and leverage this expertise to help solve energy challenges. We have more than 100 experts supporting energy-related research and development.

What research are you doing in areas related to the oil and gas industry?

Fuels and value-added chemicals represent a large area of Georgia Tech's energy-related research. This includes the production of new fuels, such as cellulosic ethanol from Georgia soft woods, biodiesel and ethanol from algae, as well as the development of more efficient, cost-effective and environmentally-sound ways of utilizing and recycling current hydrocarbon resources, such as coal, oil, natural gas and shale oil. To help limit and mitigate many of the environmental concerns associated with the use of carbon-based fossil fuels, Georgia Tech researchers are developing technologies for fuel clean-up, exhaust gas clean-up and carbon capture.

Catalysis, which involves converting one chemical to another, is another focus of Georgia Tech energy research. Utilizing catalysts and catalytic processes, Georgia Tech researchers are converting both fossil-based raw materials (coal, natural gas, crude oil) and renewable feedstocks (biomass) into clean chemicals and fuels that can be used in a variety of applications, including combustion to provide heat and power, direct conversion to electricity in fuel cells, and for liquid fuels production for use in aircraft engines and automobiles.

In addition to fuels, Georgia Tech conducts a lot of research on power and energy generation from fuels. This includes combustion, which is my primary area of research, as well as gasification, which is used in many chemical plants and with nuclear power.

Transmission and distribution is another area of Georgia Tech's energy-related research. This area focuses on improving overall network reliability and energy efficiency. There has recently been a lot of discussion on and investment in "smart grid" technologies that will help make power networks more resilient and responsive to changing energy needs.

Energy utilization with energy-efficient building technologies, such as heat pumps, motors, high-efficiency devices for light-emitting diodes (LEDs) and electric cars is also a strong area of Georgia Tech's energy research efforts.

Looking at tight oil specifically, do you think it will have an impact on pricing as much or more than natural gas?

All images in this feature courtesy of Georgia Tech.

Timothy C Lieuwen *(pictured above) is Executive Director of Georgia Tech's Strategic Energy Institute (SEI), which was founded in 2005. Lieuwen has been a Professor in the School of Aerospace Engineering since 1999 and is a leading international expert on clean energy, in particular low-emissions combustion. The US Secretary of the Department of Energy appointed Lieuwen to the National Petroleum Council (NPC) in February this year, where he joined other distinguished energy leaders who are responsible for advising the Secretary on matters related to oil and natural gas. He earned both his Masters and PhD at Georgia Tech, which is consistently ranked among the top engineering universities worldwide.*

In terms of pricing, it's not clear to me that shale oil will necessarily have a big impact on pricing as opposed to natural gas where you can see some fairly massive price differences around the world. The price of oil is so cheap to ship; it is pretty much a globally priced commodity.

A lot of people in the US are starting to talk about oil independence, or substantially reducing the need for imports, but what I don't think they appreciate is that oil, being a globally priced commodity, is not going to shield the country from price shocks, unless it was exclusively producing its own oil and was a totally insular economy.

Oil also has a significant impact on geopolitics and commodity flows. Saudi Arabia has a lot of crude oil and a lot of shale oil, but they are not going to have the singular grip on oil supplies, although certainly the cheapest oil supply by a long margin. It will be particularly interesting to see if the US and China can move forward in the spirit of cooperation in accessing their own resources, rather than competing for limited resources as both countries try to expand their influence in various regions around the world, including the Middle East and Africa.

Is China actively pursuing tight oil?

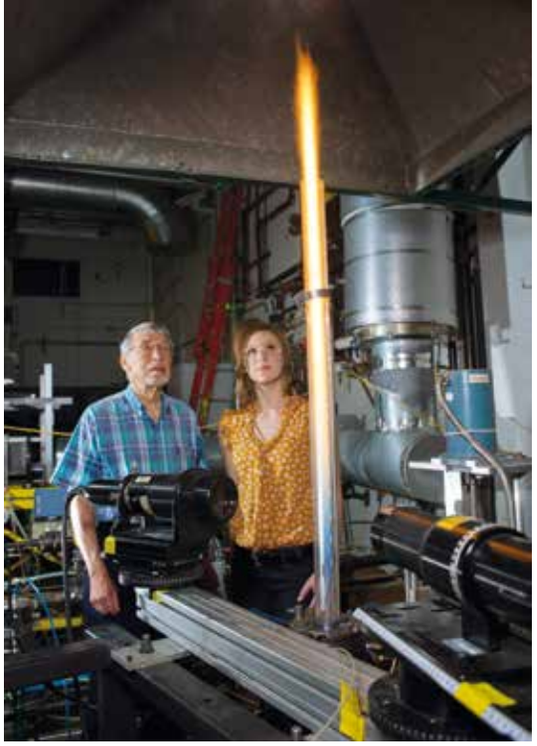
Yes, absolutely. Though the figures are highly uncertain, if you look at some of the numbers on shale gas reserves, China has more shale gas reserves than anybody, including the US, so they are very interested in accessing these resources. The country is really focused on this issue right now. I understand that there is a major shale oil conference in China every week that brings a broad group of stakeholders together to discuss the country's energy strategy as it relates to shale.

In Europe, there is more resistance to shale oil due to environmental concerns. Is there any of this sentiment in the US?

There is — you are hearing about this in New York and California these days, as well as somewhat in Michigan. California is a very environmentally-conscious state in the US. There was a bill proposed there that would restrict fracking, but it was not adopted, and California will probably begin exploiting their own shale resources soon. I think that the economic impacts are so enormous that it is hard to pass up.

How quickly do you think the tight oil and shale gas development will move forward?

It is amazing to see how quickly things are moving already now with regards to shale oil. My research focus at Georgia Tech is combustion and, five to six years ago, we were doing a lot of work to determine the impact of importing LNG on our natural gas-fired power generation because the gas composition is a little different than domestic gas. Now, we're talking about exporting natural gas. So, just to see how quickly this transformation has happened is amazing.



Georgia Tech combustion researchers test the properties and characteristics of fuels using the Jet-A spray auto-ignition facility in the Ben T Zinn Combustion Laboratory.

Is the tight oil production process sustainable? Is it costly? What is the time frame of the process?

In terms of sustainability, there are a few adverse impacts. The first one is seismic activity. When you start pumping liquid under high pressure into the ground, you can induce seismic activity, so there have been some questions on that.

Probably the biggest issue is groundwater. In general, groundwater is not nearly as deep as where the fracking occurs, so people who support the practice would point out this differential to you.

I was recently at the IHS CERA conference and attended a panel on water usage in fracking. What was very clear to me is that the water treatment issue is evolving very rapidly. The big oil service providers, such as Schlumberger, know that groundwater is going to make or break this deal. And so it is very clear that they are putting a lot of time and effort into this issue. It is not entirely clear to me what concerns are still up to date and which ones are not, merely because the amount of water they are using has dropped a lot, and they're recycling a lot of water.

I am not a water guy, but what's clear to me is that the situation is evolving very rapidly as to how they handle groundwater.

In terms of sustainability, there are certainly concerns from environmentally-minded people on what this shale development is going to do to the prospect of renewables. With natural gas being so cheap in the US, it is just taking the wind out of the sails of a lot of renewables and I am sure the same thing is happening elsewhere. The prices of wind and photovoltaic energy have come way down, but it is still hard to compete with the low energy prices that the shale gas boom has enabled. Natural gas is a carbon emitter, though it emits half the carbon of coal, so it does have a net global warming impact.

The US Secretary of Energy, Dr Moniz, talks about natural gas as being a "bridge fuel" that over the next 40 to 50 years could transition us to an entirely renewable future where we are emitting vastly less carbon. But certainly, if you burn natural gas, you put carbon into the air. When you put natural gas into the air on its own, it's a much more potent greenhouse gas, warmer than carbon dioxide. So, there is a lot of talk about how much natural gas leakage occurs at these fracking sites. However, one important factor I think people don't necessarily point out is that although natural gas is a much more potent greenhouse gas emitter, it only stays in the atmosphere for 10 to 20 years versus carbon dioxide, which can stay in the air well over 100 years. Therefore, as far as the long-term effects go, it is quite different.

Do you have any idea of the costs and investments involved in doing it right from an environmental perspective?

I don't have any specific numbers, but it is my sense that the large energy companies are spending a lot of money and are being very careful. But the concern is that there are shortcuts being taken by other companies that may not share this concern for the environment that could not only erode public trust and confidence, but have significant consequences for the environment, the industry and the regulatory landscape.

Moving on to the talent acquisition issue, are institutions of higher education such as Georgia Tech adequately serving the needs of the oil and gas industry in terms of providing the talent required by the industry now and in the years to come?

Georgia Tech is the largest educator of engineers in the US. We are educating students across the whole span of upstream, midstream and downstream. More specifically, we have a lot of R&D activities with the oil majors, such as Master agreements with ExxonMobil; we also do lots of work with Phillips, BP, Shell and Chevron, in addition to Saudi Aramco and Total.

Most of the large petrochemical companies are engaged with research at Georgia Tech. When we engage with these companies, certainly R&D is something of interest, but, frankly, another big piece of it is just developing the student pipeline for companies seeking talent. We're seeing a lot of interest across the oil and gas sector in engaging with Georgia Tech, not only for research, but for developing that pipeline.

We also have fairly significant distance learning programmes, as well as international education programmes. Take the Kingdom of Saudi Arabia, for instance; there are a number of different types of educational outreach programmes, professional Master's degrees and other types of initiatives with the King Abdullah University of Science and Technology (KAUST), with the King Fahd University of Petroleum and Minerals (KFUPM) and with companies like Saudi Aramco.

Do you have similar working relationships with other OPEC Member Countries?

Yes, we have partnerships established with Nigeria, Saudi Arabia and the United Arab Emirates. In fact, we recently had the Minister of Science and Technology from Nigeria come to meet with us to discuss future collaboration. So, these are exciting developments. *(Please see side feature 'Partnerships with OPEC Member Countries' on p65)*.

Do you agree that talent acquisition is a major issue for the oil and gas industry?

Yes, absolutely. In working with our industry partners, it is clear that talent acquisition is a big piece of a larger relationship. In fact, we have recently just completely revised our whole Master agreement framework. Negotiating a Master agreement as opposed to a project-specific agreement is common between large companies and universities like Georgia Tech.

Negotiating some of these agreements can take a year or two for companies to see eye-to-eye on all the intellectual property (IP) terms. So, that's why we've just revised the framework for these agreements, in order to expedite how we interact with big energy companies and create much more rapid negotiations on agreements and IP. More details on this can be found at: *www.industry.gatech.edu*.

What percentage of students enrolled at Georgia Tech are studying topics related to the oil and gas industry?

Though I don't have a specific figure, I can tell you that the energy industry as a whole is a big draw for our graduates at Georgia Tech. Whether it is oil and gas, grid, power generation or electronics, a lot of our students are moving into the energy industry after they graduate.

As far as exploration goes, are there ways, technically speaking, that producers can utilize to discover oil and bring it to market more quickly today than in the past?

Yes, at Georgia Tech, we have the largest geotechnics group nationwide in our civil engineering department. They have been actively working on fracking for decades. We also have a very extensive geosignal processing/seismic processing/geoprocessing group. Our computer/electrical engineering group is also the largest in the country.

OPEC's long-term strategy states that technology is one of the key drivers of future energy supply and use. It also states that OPEC supports the development and promotion of technologies that advance the environmental performance of oil and advocates the continuous improvement in standards for exploration and development activities to minimize the industry's environmental footprint. Can you give some examples of where Georgia Tech is working in this area of technology and sustainable development?

The whole area of separations, separating one gas from another and next-generation separation, which I touched on previously, is a major focus. We have the best separations group in the country, which is housed in our chemical engineering department.

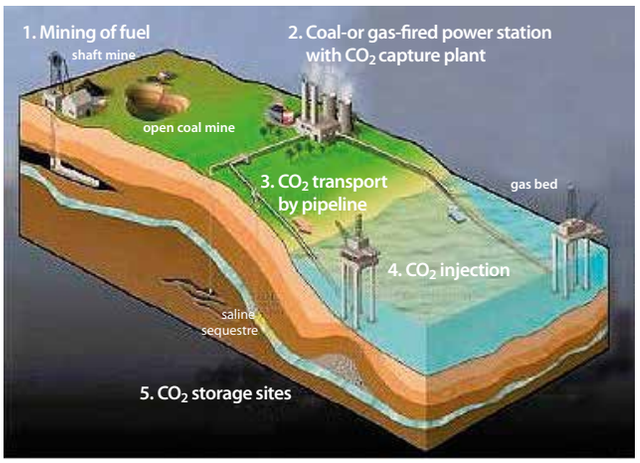
Water usage and sustainability are other areas we focus on through our civil engineering department, as well as at Georgia Tech's Brook Byers Institute for Sustainable Systems, which is an institute here at Tech that focuses on sustainability issues.

Another topic is the utilization of hydrocarbons and low emissions combustion. We have the largest combustion research group at Tech focused on more cleanly burning and utilizing fuels, which include hydrocarbons, fossil fuels and alternative fuels. Chemicals, advanced chemicals, catalysis and upgrading are other areas researched by our catalysis group.

Materials in extreme environments is an additional area of focus for us. This research is conducted in our mechanical engineering group, as well as in our dedicated material sciences department. When you are trying to extract, refine and utilize oil and gas, these processes are done in very high-temperature, high-pressure environments. For example, with the whole BP issue (Deepwater Horizon oil spill), one of the major challenges sitting at the bottom of the ocean was that the pressures were just phenomenal.

We also have the Georgia Tech Research Institute (GTRI), which is our applied research arm that looks at areas such as remote sensing, which would be applied to sensing in extreme environments, such as in the Arctic, or the desert, or for pipelines — basically sensing in areas where it is hard to figure out what is happening.

A unique material for carbon capture and sequestration (CCS)



Georgia Tech School of Chemical and Biomolecular Engineering Professor Christopher Jones and his team have developed a new material called hyperbranched aminosilica (HAS) that captures and stores carbon dioxide emissions directly from the emissions source, such as smokestacks at coal-burning power plants and chemical facilities. The team has also successfully used this technology to remove CO_2 from even very dilute gas streams, such as ambient air.

Aminosilica is formed through covalent bonding (combining two molecules by joining their electrons) that binds nitrogen-based organic compounds called amines with silica (quartz). The result is a powdery substance that looks like white sand. The name hyperbranched comes from the branch-like structures that form within the substance as a result of the bonding. The tips of the branches contain amino sites that capture CO_2.

When HAS is combined with sand, the team found that the resulting compound was capable of trapping CO_2 when flue gasses — emissions found in smokestacks — passed through it.

The HAS compound not only captures CO_2 but hangs onto it. To release the CO_2, the material must be heated, after which the released CO_2 can then be captured and stored (either as a gas or cooled into liquid form). This process not only reduces CO_2 emissions, but also makes it possible to reuse the captured CO_2 to feed biofuel stock.

Hyperbranched aminosilica has several advantages over other methods of carbon sequestration. It is recyclable and can therefore be used over and over again. The material also is not affected by moisture, which is a plus since water vapour is present in flue gases. Unlike traditional energy-intensive methods, HAS requires very little energy input, which comes from the generation of the heat that releases the CO_2.

Partnerships with OPEC Member Countries

Nigeria:

- In August 2013, Georgia Tech hosted a high-level delegation led by the Minister of Science and Technology of Nigeria. A general memorandum of understanding (MOU) between Georgia Tech and the Ministry was signed on this occasion to initiate a partnership involving three universities in Nigeria.

Saudi Arabia:

- Georgia Tech and King Fahd University of Petroleum and Minerals (KFUPM) started a strategic partnership in 2010. Since then, a study abroad programme and a joint research centre have been established. For the last three years, 10 to 15 KFUPM junior/senior students have been spending autumn on the Georgia Tech campus taking engineering and math courses. These students also engage in the American college life experience. They have become ambassadors of Georgia Tech at KFUPM and in Saudi Arabia. In 2012, the Center for Energy and Geo Processing (CeGP) was established where faculty from both universities collaborate on research projects focused on seismic signal processing and other energy information processing. CeGP also funds joint projects on education. In 2012, Georgia Tech President, G P Peterson, joined the International Advisory Board of KFUPM.
- In 2013, Georgia Tech and Saudi Aramco signed a contract to establish a Master's degree programme in the area of sustainable electrical systems.
- The Center for Enhancement of Teaching and Learning (CETL) at Georgia Tech hosted more than 30 faculty members from Saudi Arabia's King Saud University (KSU) for two consecutive summers. The KSU faculty spent two to three weeks taking courses and training in developing skills for a 21st century education and learning experience.
- Professor Bill Koros (Chemical and Biomolecular Engineering) is in the sixth year of a project with King Abdullah University of Science and Technology (KAUST), focused on improved membranes and sorbents for large-scale energy and environmentally efficient purification processes. The project will continue into a seventh year beginning in July 2014. Also, Professor Jean-Luc Bredas (Chemistry) is Co-Principal Investigator (PI) for the Center for Advanced Molecular Photovoltaics funded by KAUST from 2008–14. This has led to collaborative work with researchers at Stanford, the University of Southern California and KAUST. He is also Co-PI for a faculty-initiated collaboration funded by KAUST to work with Professor Aram Amassian (KAUST) and Professor John Anthony (University of Kentucky) on novel molecules for organic solar cell applications.
- Professor Jean-Luc Bredas (Chemistry) is Adjunct Professor at King Abdulaziz University (KAU, Jeddah) in the Department of Chemistry since 2011 and serves as a member of the International Advisory Board for the KAU Center of Excellence for Advanced Materials Research. This has led to strong collaboration between his research group at Georgia Tech and the Computational Chemistry group at KAU funded through a KAU International Cooperation grant.

United Arab Emirates:

- For four years ending in spring 2013, the Language Institute at Georgia Tech was the hub for all US scholars from the Emirates Nuclear Energy Corporation (ENEC). These students spent between three to nine months on the Georgia Tech campus learning English, taking SAT and TOEFL exams, and receiving cultural training that helps them transition into American college life.
- Georgia Tech and Khalifa University of Science, Technology and Research (KUSTAR) in Abu Dhabi signed a MOU for cooperation in education and research. Georgia Tech Professor, Steve DeWeerth, has been involved in helping KUSTAR establish a new Department of Biomedical Engineering and a Medical School.

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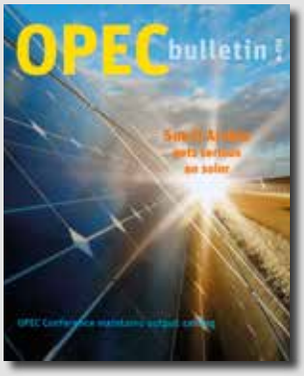

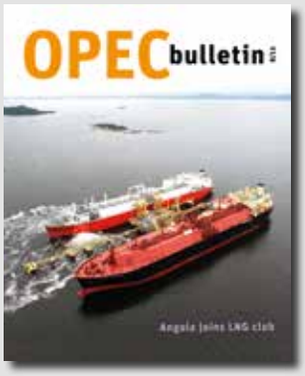

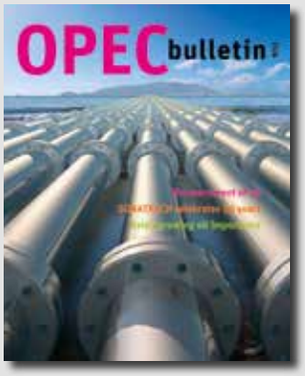

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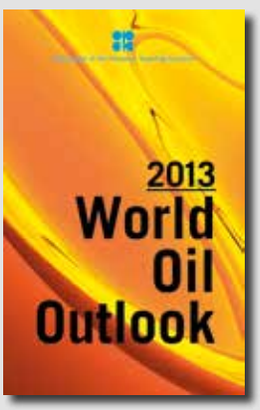

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