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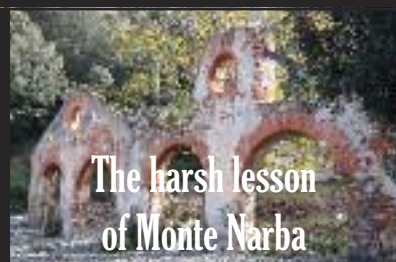
**Climate change: 40 years of lies?**



Ensuring energy security  
in the age of renewables



Microalgae: an alternative  
to conventional CCS?

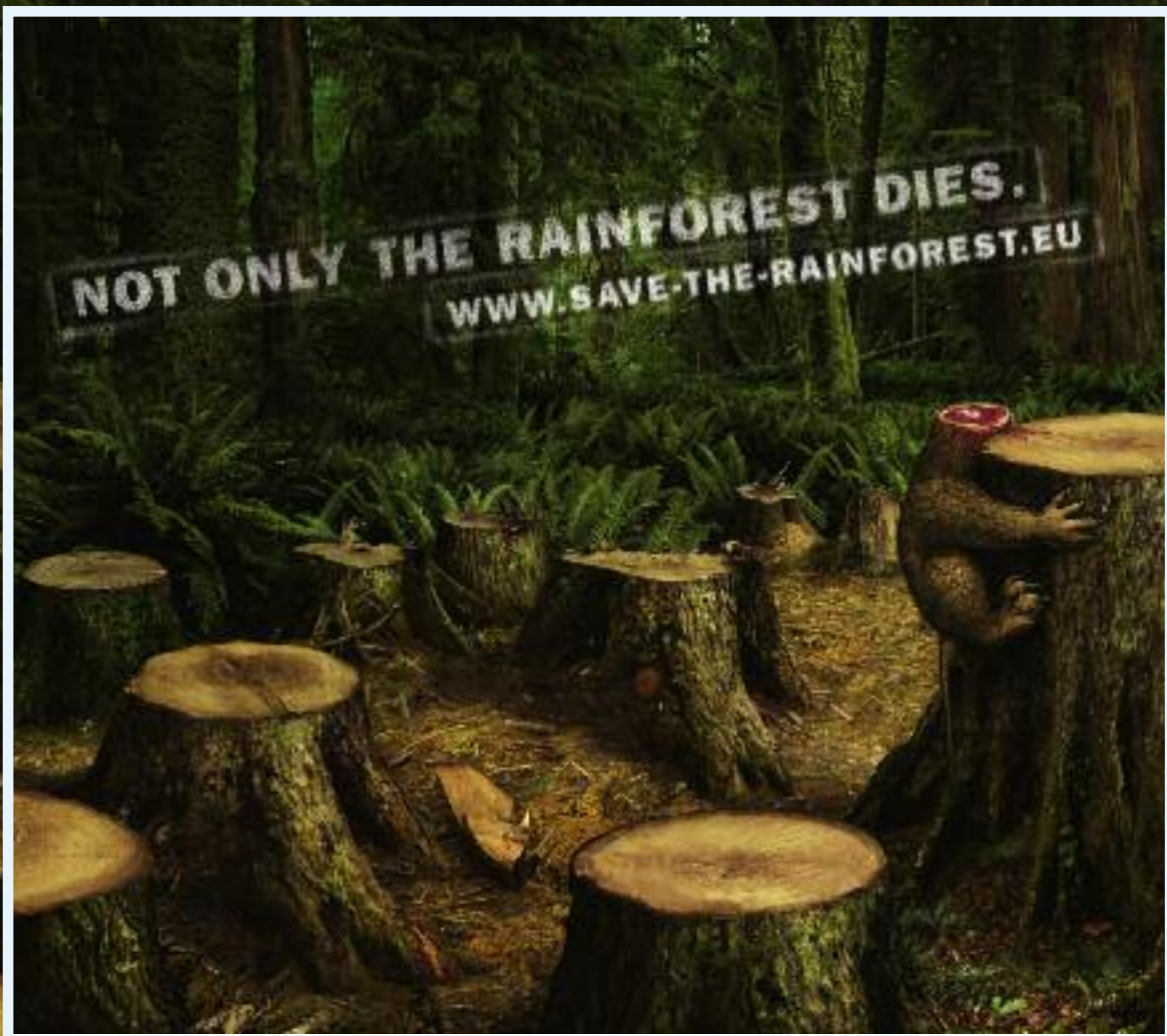


The harsh lesson  
of Monte Narba



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New York Attorney General Eric Schneiderman, who subpoenaed Exxon last November seeking information about the company's research on climate change over several decades.

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**Exxon  
Knew**

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We are here  
for our  
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Photo credit: Maisa NYC

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# True lies?

**The saga started last autumn. The allegations, however, of a huge corporate cover-up on the then emerging science of climate change date back around 40 years.**

By JEZ ABBOTT  
*ONE*

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And now the FBI could become involved. The saga of one of the world's largest oil and gas companies started last autumn. The allegations, however, of a huge corporate cover-up involving lies and then more lies on the then emerging science of climate change date back around 40 years.

ExxonMobil is being investigated to see if it misled the public on the catastrophic impact of climate change. This March the FBI was the latest to be linked to the on-going controversy, following 17 US states' attorney generals joining an initial probe by New York's senior-most lawyer.

Counterparts in those countries will cooperate in the investigation on whether not just ExxonMobil but other fossil fuel companies lied to investors on climate change and the dangers of global warming to maximise their financial gains – in ExxonMobil's case this amounted to \$4.9 billion in first-quarter earnings for 2015.

“We have heard the scientists and we have heard what is happening to the planet,” said New York attorney general Eric Schneiderman in a press briefing. “Every fossil fuel company has a responsibility, to be honest with its investors.”

He was spurred into action following an independent study published last September by Pulitzer-Prize winning website Inside Climate News and the Los Angeles Times. What they found was bad. The reports revealed scientists employed by ExxonMobil warned the company about the link between burning fossil fuels and a warming climate as far back as 1977.

Even worse, the company is said by some to have relentlessly and systematically ignored what it knew to the point of allegedly

misleading the public while it continued to belch carbon into the air without hindrance by its drilling. It is then said to have spent millions of dollars to promote climate denial. Regardless of the climate, it's hotting up for ExxonMobil and maybe more oil giants.

Controversy follows ExxonMobil. The largest, most high-profile descendant of John Rockefeller's Standard Oil Company was ruled an illegal monopoly in 1911 and broken up into various companies including Exxon, Mobil and Chevron. Exxon and Mobil merged in 1999.

Not so high-profile, until recently, was just how much that merger, ExxonMobil, knew about climate change and for how long. Judicial watchdogs will also be wanting to know what the company did or did not do to inform the public or limit the effects of its production methods.

One of Europe's most well-known environmentalists and founder of the climate campaign 350.org Bill McKibben wrote in British newspaper the Guardian: “To understand the treachery – the sheer, profound, and I think unparalleled evil – of Exxon, one must remember the timing.”

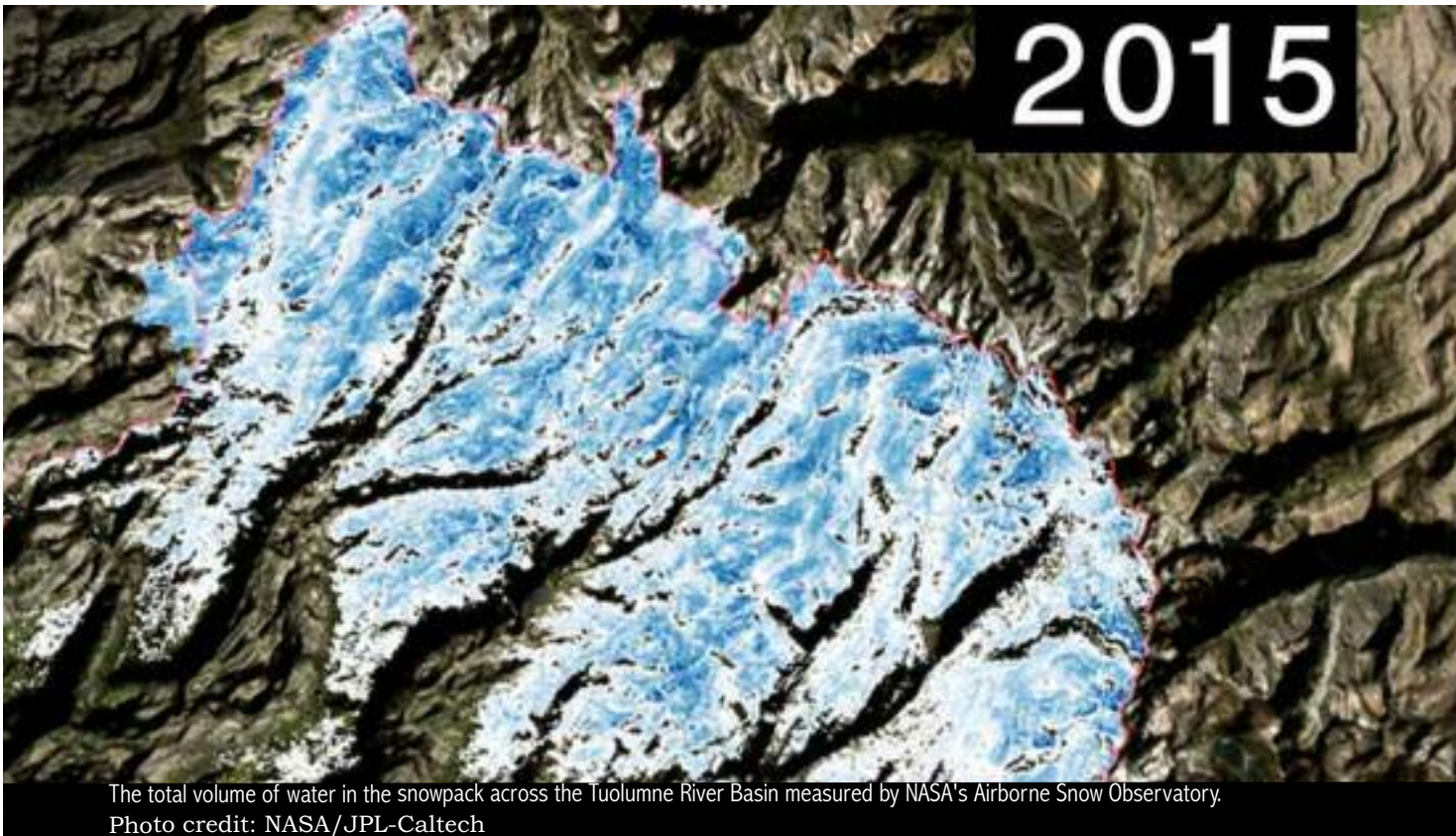
Global warming, he went on, became a public topic in 1988. If the company had admitted its research had suggested scientists were right and that “we are in a dangerous place,” the debate would actually have ended.

“Instead, knowingly, they helped organise the most consequential lie in human history and kept that lie going past the point where we can protect the poles,

prevent acidification of the oceans, or slow sea level rise enough to save the most vulnerable regions and cultures. No

**“Every fossil fuel company has a responsibility, to be honest with its investors.”**

**Eric Schneiderman,** New York attorney general



The total volume of water in the snowpack across the Tuolumne River Basin measured by NASA's Airborne Snow Observatory.  
Photo credit: NASA/JPL-Caltech

corporation has ever done anything this big and this bad.”

ExxonMobil hit back in no-less forthright terms: the climate research stories are “inaccurate and deliberately misleading”. For nearly 40 years it has supported the development of climate science in partnership with governments and academic institutions, and has done so in an “open and transparent” way, said vice president of public and government affairs Ken Cohen. “Activists deliberately cherry-picked statements attributed to various company employees to suggest wrongly definitive conclusions were reached decades ago by company researchers. These activists took those statements out of context and ignored other readily available statements demonstrating our researchers recognised the developing nature of climate science at the time which, in fact, mirrored global understanding.

“Both Inside Climate News and the Los Angeles Times ignored evidence provided by the company of continuous and publicly available climate research that refutes their claims. The facts are that we identified the potential risks of climate change and have taken the issue very seriously.” Cohen added his com-

pany embarked on decades of research with parties including academic institutions such as the Massachusetts Institute of Technology to advance climate science. Meanwhile, ExxonMobil scientists had been selected by the UN's Intergovernmental Panel on Climate Change and had contributed to various National Research Council boards and committees.

“We recognise that our past participation in broad coalitions that opposed ineffective climate policies subjects us to criticism by climate activist groups. But we will continue to advocate for policies that reduce emissions while enabling economic growth.” This has done little to quell momentum for a full-scale legal investigation. According to the New York Times, more than 40 of the nation’s leading environmental and social justice groups demanded a federal probe of Exxon Mobil in late October 2015, accusing the company of deceiving the American public about the risks of climate change to protect its profits.

In the late 1990s, the newspaper reports, Exxon joined with many business groups to try to block American participation in an international climate treaty, the Kyoto Protocol. And for at least a decade it helped finance right-leaning ideological organisations



2014

that fought the treaty and attacked climate science to put doubt in the public mind. In a letter to the attorney general, the groups likened the actions of Exxon Mobil to the fraud of tobacco companies decades ago when they hid the risks of smoking. Even presidential hopefuls Hillary Rodham Clinton and Bernie Sanders are said to have called for a probe. And Joining the chorus is Greenpeace USA executive director Annie Leonard.

“To make matters worse, ExxonMobil's climate denialism isn't just a thing of the past, it's ongoing. While deeply shocking, it's sadly not surprising: Greenpeace has been exposing ExxonMobil's climate denialism for over a decade. “Yes, it's outrageous, but now we need to turn that outrage into action to get governments and citizens to hold ExxonMobil and other fossil fuel companies legally accountable for the damage their activities have caused. “If a fossil fuel company like ExxonMobil continues to fight action on climate change even after years of its hypocrisy being exposed,” asks Leonard, “what will it take to stop it? The answer is legal action: ExxonMobil won't stop unless it's forced to,” she says, urging people to sign a petition calling for an investigation by the Department of

Justice.” Even the Dallas Morning News, right on ExxonMobil's doorstep in Texas, sees a missed opportunity: “Long the focus of controversy over its leading role in global oil production, Exxon had a chance as far back as the 1970s to change the international conversation about fossil fuels and climate change,” a recent editorial summed up. “It chose to go the opposite route.”

The editorial asked the million-dollar questions: What did Exxon executives know about global warming and when did they know it? From a 2015 perspective, it appeared Exxon could have taken a decisive, responsible course to gradually steer the world away from a “reckless dependence” on fossil fuels. Instead, the company spent years publicly denying global climate change.

“Sadly, Exxon had the opportunity to lead the world toward a measured, manageable approach toward a solution. With profits to protect, Exxon provided climate-change doubters with a bully pulpit they didn't deserve and gave lawmakers the political cover to delay global action until long after the environmental damage had reached severe levels. That's the inconvenient truth as we see it.” [UNE](#)

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# Ensuring energy security in the age of renewables

**Policy makers in countries at the forefront of the renewables revolution are now being forced to rethink fundamentally the way in which these markets operate.**

By TOBY LOCKWOOD

*ONE*

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The last ten years have seen a remarkable growth in the use of wind and solar power worldwide as nations have sought to make dramatic reductions in CO<sub>2</sub> emissions from their energy sectors. From a mere 2.6 GW in 2004, global installed capacity of solar photovoltaics is now estimated to approach 250 GW, whilst wind power grew from 48 to 432 GW in the same period and more than any other energy source in 2015.

Primarily driven by attractive subsidies for renewable energy in parts of the US and Europe, countries such as Denmark, Spain, and Germany are now generating significant proportions of their annual electricity from the wind and solar. More recently, China has taken up the baton, rapidly becoming home to the world's largest capacities of both technologies. This growth has been key to driving down production costs, to the point where wind power, in particular, can begin to compete on a level playing field with more established energy sources.

On top of this, both the US and Europe have also started to see closures of coal and gas power plants which are no longer profitable, or not sufficiently profitable to invest in the pollutant removal equipment required by increasingly strict emissions regulations. Whilst environmental groups have lauded these

trends as evidence of an unstoppable march towards an entirely green energy sector, others have complained of rising electricity costs, or warned of impending blackouts and a threat to the reliable power supply on which developed countries have come to depend. In reality, a careful balance needs to be struck between these often conflicting concerns, with a level of precision which seems to be beyond the market mechanisms which currently determine the energy supply of most countries. As a consequence, policy makers in countries at the forefront of the renewables revolution are now being forced to rethink fundamentally the way in which these markets operate.

The intermittent, weather-dependent nature of the wind and solar power presents a new challenge for electricity grids, which need to precisely match electricity supply to demand at any given moment, regardless of whether the sun is shining or the wind is blowing. In most developed countries, this balance is achieved through energy markets, in which power producers compete to offer the lowest priced electricity at a future date, or in real time throughout the day. Investment in renewables has tended to drive down this wholesale price of electricity, due to the increased supply and the fact that wind and solar farms have minimal operating costs and will carry on producing

**The UK and France have recently adopted a more market-based approach, in which prospective generators bid to provide a guaranteed supply at a competitive cost.**



In Germany the wind and solar production can outstrip actual demand, leading to offloading of the cheap electricity to neighbouring countries. Photo: The Krughütte Solar Park



regardless of the price. This has famously led to periods with significant energy surpluses and negative power prices in countries such as Germany, where the wind and solar production can outstrip actual demand, leading to offloading of the cheap electricity to neighbouring countries. On the other hand, in times of high demand and low wind and solar production, conventional power plants are fired up to meet the shortage, and electricity prices increase.

Adapting to this backup role has proved difficult for many fossil fuel power plants, which struggle to recoup their costs under such sporadic operation and can experience greater wear and tear. Due to their higher fuel cost, gas plants have been struck hardest in

Europe, and many have closed while dirtier but cheaper coal plants are left running. With even existing power plants struggling with low power prices, there is little incentive to invest in new plants, and such projects have largely halted in the US and Europe.

As subsidies are withdrawn, even investment in renewable energy will become unfavourable in this environment. In countries such as the UK, which requires urgent replacement of ageing coal and nuclear plants, this situation poses a growing problem. Even a power plant which operates for only a few hours a year still forms a crucial part of a country's energy supply, and requires some business case. As a result, many countries are introducing energy market reforms which attempt to make power plants profitable, and ensure a constant supply of electricity at all times of the day and year.

The most popular strategy is known as a capacity mechanism, where power plants are paid a constant revenue to guarantee they can produce a set amount of electricity when called upon. In several European sta-

tes, these already exist in the form of 'strategic reserves' of plants which are kept on standby in case of particularly high demand. However, these normally consist of old plants which would otherwise have been decommissioned, rather than encouraging investment in cleaner, new plants which can guarantee an energy supply for years to come. Instead, countries including the UK and France have recently adopted a more market-based approach, in which prospective generators bid to provide a guaranteed supply at a competitive cost. In the UK, long contracts of up to 15 years could be awarded for new gas power plants, with a view to providing a long-term business case for investors.

**A fundamental problem with energy markets is that consumers are rarely exposed to fluctuations in the wholesale price of electricity, instead paying a fixed rate. There is a growing awareness that future energy markets will need to allow for more interaction between suppliers and consumers, with consumers able to reduce their energy use when prices are high.**

Unfortunately, the UK's inaugural capacity auction did not produce the desired results, with contracts mainly going to existing coal plants and small diesel generators which are cheap to build but detrimental to local air quality. The system is currently being reformed to

encourage gas plants in the next round of bidding, mainly through making more contracts available further in advance, but the UK example highlights how difficult it can be to get markets to produce the desired balance between investment in a secure energy supply and low CO2 emissions.

Other regions have sought to avoid capacity markets, arguing that they distort the electricity market and result in wasteful, excess generating capacity on the grid. This 'energy-only' market approach requires governments to minimise their intervention in existing electricity markets and let backup power plants find sufficient revenue from power sales alone. Currently, at times of high electricity demand and small renewables output, soaring electricity prices are usually capped to a reasonable level by governments to prevent individual suppliers from abusing total power over the

market, and because very high prices are politically unfavourable.

In Australia and Texas, the approach has been to raise this cap to the much higher levels required for plants to make a profit from very low running hours, with further limits in place to prevent the plant from making excessive profits over the year. A standard bearer for the renewables revolution, Germany has recently opted for an energy-only approach in energy market reforms aimed at better dealing with its huge expansion in wind and solar power. Power prices will be uncapped, and harsher penalties will be imposed on energy retailers who don't buy enough to meet consumer demand.

A strategic reserve consisting mostly of old coal plants will still be maintained outside the market for emergency shortages. In contrast to the UK situation, Germany's reforms are not intended to spur investment in new fossil fuel plants, but the country's existing plants are much newer and there is much less concern over future energy shortages.

A fundamental problem with energy markets is that consumers are rarely exposed to these increasingly wild fluctuations in the wholesale price of electricity, instead paying a fixed rate which effectively averages the variation over an extended period. There is a growing awareness that future energy markets will need to allow for more interaction between suppliers and consumers, with consumers able to reduce their energy use when prices are high.

This approach helps prevent moments of severe power shortages and the associated spikes in price, reduces the amount of spare capacity needed, and results in more efficient use of green energy resources. Known as the demand-side response, it is already well established in parts of the USA and Australia, where industry and commercial consumers are paid to give suppliers the option of turning down some of their power hungry processes. Improvements in computing and communication technology could allow this to be extended to residential consumers in the form of


smart metering, and European states are increasingly viewing demand-side measures as an ideal means of reducing the need for a backup power plant.

Developing energy storage technologies and providing more electrical links between countries are other promising approaches for improving the flexibility of electricity grids and reducing the need for backup power plant. Germany and Denmark already benefit greatly from connections to Norwegian hydropower plans, which are able to store excess wind energy for later use.

For island nations such as the UK and Ireland, connections to other grids are currently limited, and could provide a particularly effective means of easing the growing strain on supply. However, if all countries aspire to high levels of wind and solar, times of shortage and surplus are likely to coincide largely, and connections may yield diminishing returns. Whilst significant advances are being made in batteries, longer-term and larger-scale energy storage systems, such as the conversion of electricity to hydrogen gas, will be needed to eliminate a significantly alleviate the need for backup power plants.

Significant changes to energy markets will also be necessary to encourage investment in energy storage, which currently has a limited business case based on payments for providing minor adjustments to the power supply.

In the near term, several countries are faced with an urgent need to come up with an energy policy which can provide a long-term, secure energy supply with minimal cost to the environment and consumers.

Although market-based approaches for both energy and carbon are widely seen as the best solutions, ensuring on-demand electricity is such a political issue that markets can rarely be left to their own devices. With so much uncertainty surrounding the future of the energy landscape, encouraging any kind of large investment requires huge guarantees from governments. In the end, the fear of the blackout is likely to prevail, but it remains to be seen at what cost. . 

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# Microalgae to capture CO<sub>2</sub>: a viable alternative to conventional CCS?

By XING ZHANG

*ONE*

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In April 2013 at the site of the International Building Exhibition Hamburg, a green coloured house captured people's attention. The outer layer of the house was made of algae panels. Flue gas and water were pumped into the panels for algae to grow. Apart from serving the conventional purpose of insulating the building from sound, heat and cold, the algae facades produced heat and biomass to supply the building with energy from renewable sources. In the meantime, it removed CO<sub>2</sub>, NO<sub>x</sub> and SO<sub>x</sub> from the flue gas. This algae house is still a showcase of the concept of biological post-combustion CO<sub>2</sub> capture. Using microalgae to capture CO<sub>2</sub> is a complex process, especially in flue gas environments. There are many factors to consider, such as CO<sub>2</sub> concentration, the presence of pollutants in the flue gas, the initial inoculation density, culture temperature, light, nutrients and pH, as well as hydrodynamic parameters including flow, mixing and mass transfer. The growth of microalgae and its tolerance to the environment depends on all the process factors and how they interact with each other.

## WHICH SPECIES?

The choice of microalgae species is also important as it directly influences the photosynthesis efficiency, and hence, the performance of carbon fixation and biomass production. The desirable microalgae species for capturing CO<sub>2</sub> need to have a fast growth rate, a high rate of photosynthesis, strong tolerance/adaptability to the trace constituents of flue gas, high-temperature tolerance, the possibility to produce high-value products, and be easy to harvest and process. Also, the economics of CO<sub>2</sub> capture can be significantly improved if the algae products can be sold.

## WHERE?

Microalgae cultivation can be carried out in an open pond or closed photobioreactor systems. Open culture systems are usually cheaper to build and operate, more durable and have a large production capacity compared to largely closed reactors. However, they are more susceptible to weather conditions and do not allow the control of the culture medium temperature, water evaporation and light. Potential contamination is also a serious threat to the operational success of outdoor open ponds or raceways. Most importantly, they require an extensive land area and consume large amounts of water. In contrast, closed system photobioreactors have more operational stability and condition control. However, the high capital and operating costs of photobioreactors are the barriers impeding the mass cultivation of microalgae. The key to promoting the use of microalgae to capture CO<sub>2</sub> is to make the photobioreactors cheaper.

## THE LIMITS

Technologies are available to harvest, process and produce valuable products from microalgae. But most of the existing technologies are adapted from those already in use in the food, biopharmaceutical and wastewater treatment sectors and have not been developed specifically for algae production. As a result, they are inefficient and require a significant amount of energy. The economics of carbon fixation by algae could be improved by work in this area.

## CARBON AND CAPTURE UTILISATION

Co-firing dried microalgae with coal to produce electricity is the easiest and most obvious way to utilise microalgae. However, since microalgae contain lipids



Raceway pond used for the cultivation of microalgae. Photo: © JanB46

(7–23%), carbohydrates (5–23%), proteins (6–52%) and some fat, depending on the species, these constituents can be converted into several commercial applications, such as human food, animal feed, cosmetics, medical drugs, fertilisers, bio-molecules for specific applications and biofuel. For the power generation industry, these algae applications are an extra bonus after capturing CO<sub>2</sub> from coal combustion because of the generated revenue.


Therefore, although it has the same drawbacks as conventional carbon capture and storage methods, namely large energy requirement and equipment cost, CO<sub>2</sub> mitigation by microalgae can be classified as carbon capture and utilisation due to the production of value-added biomass. Microalgae capture and convert CO<sub>2</sub> into useful products. Thus, CO<sub>2</sub> becomes a feedstock instead of a waste product.

## POTENTIAL

It is clear that using microalgae to capture of CO<sub>2</sub> is technically feasible and has economic potential. Selecting efficient energy harvesting and processing methods and high-value strains to produce commercially sound applications is key to promoting capture of CO<sub>2</sub> by microalgae. Flue gas transport is another issue. Keeping algae cultivation systems close to the CO<sub>2</sub> source is one solution to avoid the cost of build-

ing long pipelines. But, microalgae cultivation requires a large land area. For new power plants to use microalgae bio-fixation as a CCS approach, a site with land available for large-scale cultivation would be needed. This requirement could be a problem for existing power plants.

At the moment, the CO<sub>2</sub> fixation rate of microalgae tends to be too low to compete with conventional CCS methods. Using flue gas to culture algae is more applicable to the production of high-value products than the CO<sub>2</sub> fixation. Power companies will only be willing to invest significant amounts of capital, land and water if the microalgae products can be sold at a good price. Algae companies are almost ready to bring their bio-carbon capture and utilisation efforts to the marketplace as a viable alternative to conventional CCS.

However, those strains, which can thrive under flue gas conditions, do not often have a high commercial value. If algae companies have to pay the power companies to reuse the flue gas, they may not have the motivation to produce low-value algae biomass just for the purpose of endorsing CCS. Therefore, it is paramount for algae companies and power companies to form a win-win partnership to share the costs and profits. 

# MICROALGAE: THE PROJECTS AROUND THE WORLD

Power plants around the world have been working on commercialising microalgae capture CO<sub>2</sub>. Of these, the Israeli Seambiotic have been very successful. Founded in 2003, Seambiotic was the first company in the world to utilise flue gas from coal-fired power plants for algae cultivation. Seambiotic's pilot facility for the cultivation of marine microalgae was established in 2006 and is located at the Israel Electric Corporation's Rutenberg coal-fired power station, close to the city of Ashkelon. The algae are cultivated in open ponds using flue gas and cooling seawater condenser effluents piped directly from the power plant.

Following the pilot success, Seambiotic formed a joint venture, Hairong Biology Technology Co., with the Chinese companies Yantai Hairong Electricity Technology Ltd. and Penglai Weiyuan Science & Trading Ltd., both associated with China Guodian Corporation. The project is to build a plant for the commercial cultivation of microalgae using the flue gas from the Penglai coal-fired power plant. The Institute of Environmental Technology and Energy at the Technical University Hamburg and E.ON Hanse AG are working together on the 1.5 million euros project HABITAT (Hanseatic Biophotoreaktoren test center for algae cultivation and technologies). E.ON Hanse AG is supporting the project through the provision of infrastructure, consumables and technical assistance at its Hamburg-Reitbrook power station. In the integrated pilot plant, microalgae were grown in outdoor systems using CO<sub>2</sub> from conventional power plants. The Agency for Renewable Resources is funding the project. Furthermore, E.ON Hanse is supporting two independent research projects: TERM (Technology for Exploitation of the Ressource Mikroalgae) and SUBITEC to develop microalgae cultivation systems. One of the outcomes from the TERM project is the Algae House in Hamburg.

Half funded by the State of Brandenburg and the European Union and the rest by Vattenfall, the Green MISSION (Microalgae Supported CO<sub>2</sub> Sequestration in Organic Chemicals and New Energy) project tested a commercial algae breeding facility at Vattenfall's Senftenberg power station from October 2011. The facility, built by the Austrian company Ecoduna, used CO<sub>2</sub> from the brown coal-fired power plant.

The project was completed in 2012.

A new project 'green VISION' was launched in 2013 with the aim to identify carbon capture and storage strategies using microalgae and to investigate the feasibility of using CO<sub>2</sub> to produce new biomass from microalgae. The 'Hanging Gardens' algae growing system at Senftenberg power station has a photoactive volume of 50,000 litres and is the second largest closed algae breeding system worldwide.

In South Africa, the Nelson Mandela Metropolitan University has developed a technology which mixes coal dust and algae biomass, the algae adsorbs onto the surface of the coal and binds the dust together. The result is a coal-algae composite (briquette or pellet), for which they have coined the name Coal-gae™.

It can be used as a substitute for coal. After demonstrating the cultivation of microalgae in a 20 m<sup>3</sup> closed photobioreactor developed by them, the university is planning a 1-hectare technical demonstration facility in one of South Africa's largest coal mining areas (Witbank) and close to Dube coal-fired power station. The facility will cultivate microalgae in a closed photobioreactor system using CO<sub>2</sub> and NO<sub>x</sub> from the power plant flue gas and a mixture of treated acid mine water and borehole water. It will capture around 400 – 500 tonnes of CO<sub>2</sub> per annum.

The Center for Applied Energy Research (CAER) at the University of Kentucky has the biggest demonstration site on algae capture CO<sub>2</sub> in the USA. Since 2008, CAER has been working on demonstrating an algae-based system that could recycle the carbon dioxide in the coal combustion flue gas. CAER received \$1.8 million funding from the Kentucky Energy and Environment Cabinet in 2013 and set up a partnership with Duke Energy to test a pilot-scale system at the East Bend Station near Rabbit Hash in Northern Kentucky. While the mitigation of CO<sub>2</sub> emissions from coal-fired power plants is the main focus of the project, the production of bio-fuels and other bio-products will also be examined to study the economic feasibility of using algae to capture CO<sub>2</sub>. Duke Power's 650 MW East Bend Station is a single-unit plant that burns high sulphur coal and has a wet limestone scrubber for SO<sub>x</sub> control and selective catalytic reduction with ammonia injection for NO<sub>x</sub> control. **ONE**



**MICROALGAE'S VIRTUES**

The ability of microalgae to photosynthesise and grow rapidly has resulted in the possibility of using them for CO<sub>2</sub> capture. Microalgae have some other advantages that make them suitable for capturing CO<sub>2</sub> from coal combustion flue gas:

- They do not need high purity CO<sub>2</sub> gas so there is less requirement to separate CO<sub>2</sub> from flue gas.
- Some combustion products, such as NO<sub>x</sub> or SO<sub>x</sub>, can be used as nutrients for microalgae, which reduces the need for flue gas scrubbing systems.
- Microalgae could yield high-value commercial products.
- The process is perceived as a renewable cycle with minimal adverse impacts on the environment.

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# Five Takeaways from National Renewable Energy Policy Forum 2016

By GIL JENKINS  
Environmental Leader

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“Policy still matters” was the theme of this year National Renewable Energy Policy Forum. An event, held in Washington last March, which served to remind everyone that while 2015 was a transformational year in terms of policy wins (i.e., COP 21 agreement, Clean Power Plan, ITC/PTC extensions) much more work is needed strengthen the conditions for clean energy’s long-term future.

Here are my top five takeaways from the forum:

### **1) For clean energy, the good times are rolling**

This was no coal industry confab – attendees and speakers portrayed an air of positivity not typically seen for an industry that has seen its fair share of setbacks and detractors over the years. The positive vibe was perhaps best expressed by Janet McCabe, EPA Acting Assistant Administrator – Office of Air and Radiation, who deftly paraphrased the old Irish blessing (wind was at our back, sun was shining warm) on St. Patrick’s Day to describe the ebullient mood of the industry.

And despite some relatively minor shortcomings and potential roadblocks that would be discussed throughout the day around 2015’s major policy wins, the Clean Power Plan, Paris agreement and Investment Tax Credit/Production Tax Credit (ITC/PTC) tax extensions were all hailed as transformational moments that would propel the industry’s continued growth.

### **2) Corporate renewables purchasing is becoming the operational mainstream**

Panelists from Google and Amazon in the “Hot Topics in Changing Electricity Marketplace” session highlighted tremendous growth in corporate demand for renewables, which was also a theme of the ACORE pre-conference workshop.

Speakers noted that corporate renewable purchasing grew 60 percent in 2015 for a total of 3.44 gigawatts purchased, which is incredible considering 2012 cor-

porate renewable purchasing was around 100 megawatts. And it’s not just the numbers that show the trend is going mainstream; it’s the new players who are joining in. According to BRC, nearly two-thirds of the total energy purchased last year was from companies new to utility-scale renewable energy. Google, Amazon and tech companies are still the vanguard but increasingly it’s companies like Dow Corning, Procter & Gamble Co. (P&G) and other non-tech companies that are making major investments in renewables. It’s also going beyond B2B bragging rights; P&G’s new Tide PurClean liquid detergent to be released in May will remind consumers on the label that it is produced with “100 percent renewable wind-power energy.”

### **3) Renewables going from “appetizer to entrée” presents challenges & opportunities**

While wind and solar only account 5.1 percent of total large-scale electricity generation in the U.S. (up from 1.4 percent in 2008), the explosive pace of growth continues to change conversation among energy leaders. Speaking on panel on the changing electricity marketplace, Jonathan Weisgall of Berkshire Hathaway Energy best encapsulated the major shift happening in electricity markets when he remarked that renewables are going from “appetizer to entrée.”

Attendees talked about how these “entrées” will get even larger if the trend around aggressive statewide renewable portfolio standards continues. Oregon’s recently passed law calling for a 50% renewable portfolio standard (RPS) for the state power mix by 2040; California’s for 50% RPS by 2030; and Hawaii’s for 100% RPS by 2045 were all cited as transformational examples. While this shift presents great opportunities for the renewables, it also underscores a need for stronger governance that will enable better interconnection between regional power grids. Going into the forum I expected grid energy storage to be a hotter topic, but a lot more time was spent discussing how a more efficient dispatch of renewables

# International Sulcis CCS Summer School <sub>2</sub>

Centro Ricerche Sotacarbo Grande Miniera di Serbariu  
Carbonia, Italy

4<sup>th</sup> edition

The interest in the Sulcis CCS Summer School can easily be explained by the growing attention worldwide for the technologies of separation and containment of carbon dioxide (so called CCS – “Carbon Capture and Storage”). The lectures programme will cover the range of techniques developed for the capture, transport and geological storage of CO<sub>2</sub>, for which the Sulcis basin is the ideal laboratory for experiments.

**Tuesday, June 28<sup>th</sup>, 2016**  
Introduction

**Wednesday, June 29<sup>th</sup>, 2016**  
CO<sub>2</sub> capture approaches and technologies

**Thursday, June 30<sup>th</sup>, 2016**  
CO<sub>2</sub> utilization technologies

**Friday, July 1<sup>st</sup>, 2016**  
CO<sub>2</sub> storage

June 28<sup>th</sup>  
July 1<sup>st</sup> 2016



IN COLLABORATION WITH



could prove more consequential – a point made recently in a study from Nature Climate Change which found that better interconnection would enable wind and solar power to provide 80 percent of US electricity without price increases or the need for electricity storage.

#### **4) EPA's Clean Power Plan will probably endure legal challenges**

Despite the recent decision by the U.S. Supreme Court to issue a stay of the U.S. Environmental Protection Agency's (EPA) Clean Power Plan (which calls for reductions in carbon emissions from the electricity sector by 32 percent over 2005 levels in the next 15 years) most speakers seemed cautiously optimistic the rule would survive legal tests and implementation would not be materially impacted as the case against EPA heads toward a likely hearing in the Supreme Court in Spring 2017. To the point on implementation, panelist in the session entitled "Prospects for the Clean Power Plan" noted that while EPA cannot impose any Clean Power Plan requirements on states during the stay, nothing is withholding them from continuing to develop guidance on emissions trading. When it comes to the makeup of the Supreme Court and how that might impact Clean Power Plan's fate, most speakers seemed to agree that Justice Kennedy the would be favorable to EPA's arguments, thereby downplaying the significance of how Scalia's eventual replacement might shift the balance on this particular issue

#### **5) New laws (or at least new interpretations) may be needed meet Paris commitments by 2025**

The U.S. commitment to cut greenhouse gas emissions 26 to 28 percent by 2025 (compared to 2005 levels) in the Paris Agreement last December was lauded by many speakers for its potential to embolden clean energy investment in the U.S. and abroad, but attendees ultimately seemed split on whether new U.S. laws would be needed to meet our specific Paris GHG reduction commitments.

On one side, a few speakers indicated they didn't think the variety of existing policies led by EPA's Clean Power Plan, tax incentives for renewable energy and national fuel economy standards would be enough to meet Paris commitments. Instead, their view was that new regulation in the likely form of a cap-and-trade system would ultimately be needed. On the other hand, speakers like Robert Sussman of Sussman & Associates talked at length about the possibility to meet or exceed our Paris commitments under existing law. Specifically, Sussman pointed to an existing provision under the Clean Air Act called Section 115 that would give a future administration the solid basis for action on climate change across many sectors of the economy, not just the power sector.

There's a lot more to read about the prerequisites for action under Section 115 here, but essentially the provision says that EPA must determine that emissions of "any air pollutant" in the U.S. "may reasonably be anticipated to endanger public health or welfare in a foreign country" while also finding that the foreign country or countries have provided "reciprocity" to the U.S. by giving "the United States essentially the same rights with respect to the prevention or control of air pollution occurring in that country as is given that country by this section."

In summary, the reason there is a strong legal case to be made is because we already classify greenhouse gas emissions as a pollutant and the U.S. is given "reciprocity" via the United Nations Framework Convention on Climate Change (UNFCCC). At the end of the day, everyone seems focused on defending the Clean Power Plan and improving tax incentives for more forms of renewable energy to meet climate goals, but I would not be surprised if Section 115 continues to be brought up as a potential solution for meeting Paris commitments, regardless of the outcome of the Clean Power Plan in the courts.

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by Environmental Leader  
March 31, 2016*

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# Clean energy from human urine

By ALICE MASILI  
*ONE*

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It used to be good only for water closets. Not true anymore. From human urine now we can extract potable water and energy too.

Energy self-sufficiency can be reached even using waste products as human urine. All we need to do is just walking - to circulate the fluid that feeds voracious bacteria: thus, it gets clean energy in emergencies.

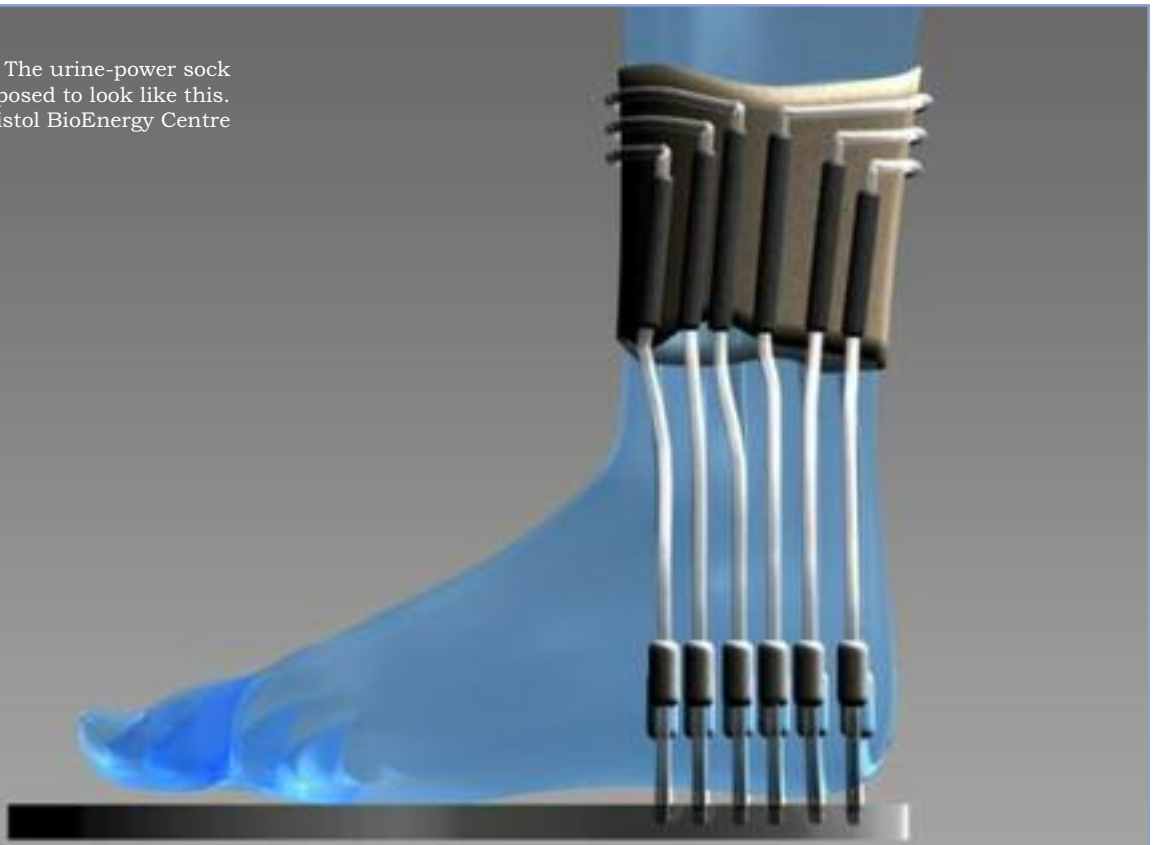
An earlier English study confirmed this. The Bristol BioEnergy Centre, the Centre of Micro-BioRobotics and the Centre for Research in Biosciences have developed a portable and wearable device to transform human urine into clean energy.

The research team exploited the technology of microbial fuel cells (MFC), a bio-electrochemical system that drives a current by using bacteria and mimicking bacterial interactions found in nature.

These cells contain microorganisms similar to those found in wastewater treatment plants. When bacteria come into contact with liquid urine, they trigger a chemical reaction capable of generating a potential difference and, therefore, electric power.

The device is essentially a pair of highly technological socks inside which, through a network of small flexible silicone tubes and check valves connected to microbiological fuel cells (MFC), urine flows. The

The urine-power sock  
is supposed to look like this.  
Photo: © Bristol BioEnergy Centre



operation of the system is simple and based on the user's walking. Tubes filled with urine pass under the heels, so that walking activates a pump that puts into circulation the urine already present in the device - about 648 ml of fluid, the maximum a bladder can hold.

The device is linked to a programmable transmitter that records how much energy has been produced. The system has been checked for an extended period to test its performance and, during several experiments in the laboratory, it generated enough power to feed, via wireless and every two minutes, an emergency broadcast system.

You can imagine its possible use in highly critical situations: for example, it could be exploited by

the army or by astronauts, but also to transmit the coordinates after a plane crash. It should be noted that the device can be activated by walking, which means that you have survived.

So far the only problem is the urine collection. Scientists do not know yet how to integrate the old urine with fresh liquid. Ioannis Ieropoulos, Associate Professor at the Bristol Robotics Laboratory, and his col-

leagues already imagined it equipped with a built-in fluid system, to get around the passage of the urine collection.

It is not the first time that the bladder scrap has been used to produce energy: with the same system, the

British team had already activated a phone and a 3D printed robotic heart.

Recently they have created a toilet prototype capable of generating electricity from urine. The Pee Power, that unusual toilet name, was designed to solve the problem of the lack of energy in the refugee camps.

Thanks to urine, a free source always available, you can power small devices and provide light to refugees in tent cities without access to the electri-



The current urine-power socks.  
Photo: © Bristol BioEnergy Centre

city grid.

This technology is very attractive and straightforward, and can be used for different things. It can also be applied to sewage treatment plants, not only to purify water but also to produce useful electricity, exploiting everything that pollutes (any waste), to create something totally non-polluting. Too many options to let them cancelled in a flush. [www.ownaturalenergy.com](http://www.ownaturalenergy.com)



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# 5 Years After Fukushima, Nuclear prospects dim

By LEONARD HYMAN and WILLIAM TILLES  
Oilprice.com

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Five years after a devastating earthquake, tsunami and nuclear accident at Fukushima that killed thousands and displaced many more, the Japanese are still cleaning up, people still cannot return to their homes and, possibly the least important statistic, Tokyo Electric Power's shares sell at one quarter of the pre-accident price.

Roughly five years ago, the British government and French utility EDF began a process to build another

nuclear power plant at Hinkley Point, an investment still awaiting the approval of EDF's board. As odd as it seems, the tragic disaster and botched business deal have a common thread (other than the fact that EDF shares sell at one-third of their 2011 price): the role of government in nuclear power.

Let's start with Fukushima. According to a report in the Financial Times, the Fukushima nuclear disaster has cost Japan \$118 billion to date and Tokyo Electric



Photo: Darlington Nuclear Generating Station

Power's shareholders have picked up only 20% of the tab. The government and consumers paid the rest. But Tokyo Electric shares had a market value at time of accident of only one quarter of the expenditures to date.

Bankrupting the company wouldn't have raised the cash needed (assuming that anyone knew the cost

then) and the government couldn't have walked away from the problem. Nuclear operators are not required to have the capital to cover the costs of a giant disaster and they do not have the insurance coverage either. That means that the government, taxpayers and specific utility customers have to pay. Next to Hinkley Point. EDF's CFO just quit, reportedly because he opposed the firm's involvement in







goes up.

In the same way, government can deny the costs of acting as an insurer of last resort because no line item appears in the budget to cover the costs until an accident happens (that's the way a Congressional staffer explained it once at a meeting on the future of nuclear power).

Does Hinkley Point, needing so much government aid to get off the ground, stand at the end of the

Government can deny the costs of acting as an insurer of last resort because no line item appears in the budget to cover the costs until an accident happens

road for big nuclear reactors? Maybe, but as American philosopher, Yogi Berra, said, "When you reach the fork in the road, take it."

Hinkley Point, we believe, is at that fork. One path leads to more strained efforts to make a gigantic public works project – with hidden and unknown costs and unspecified and dubious public benefits –

look like a commercial business. (Maybe energy prices skyrocket and that private owner of the power



PHOTO: Anti-nuclear-protests in Cologne, Germany

plants keeps the benefits and the consumers and taxpayers still pay the fixed costs.)

But the strain seems hardly worth the effort, since other means exist to produce low carbon, secure power at similar or lower costs. And, as Donald Trump has asserted so often, politicians don't know how to make deals.

The other path leads to nuclear power as a quasi-government project, requiring at least the same public scrutiny as a decision to build a new airport runway or bus station. If the project gets approval, government and consumers will pay a lot and take substantial risks they can't avoid.

They deserve a proportional share of the benefits and

profits. If the answer is "No More Nukes," once all the information is out, move on to some other solution, until reaching the next fork in the road.

Let's face it: The only reason nuclear is in play right now is because of its low carbon footprint and valid concerns about global warming.

Nuclear is a solution but we doubt if it's the solution. The next promising fork may lead to small, modular nuclear units that even normal companies can afford to build.

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March 15, 2016*



An aerial photograph of the Great Barrier Reef, showing a vast expanse of coral reefs. The water is a deep blue, and the coral reefs are visible as lighter, textured areas. Some areas appear bleached, showing a pale, whiteish color. The reef stretches across the horizon, with some smaller islands visible in the distance.

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# The unprecedented coral bleaching disaster at the Great Barrier Reef, explained

By BRAD PLUMER  
*Vox.com*

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The scientists who study the Great Barrier Reef are shocked and horrified by what they're seeing right now.

Record hot temperatures in the Pacific Ocean — driven by global warming and a powerful El Niño — have fueled the worst coral bleaching event ever seen along the northern third of Australia's famed reef. Researchers who have recently ventured into this region say the once-vibrant ecosystem is now a ghastly tableau, filled with pale-white corals that are at risk of dying off.

Coral reefs are often thought of as the rain forests of the ocean — they cover just 0.1 percent of the world's sea floor, but they're home to 25 percent of marine fish species. They're popular spots for divers and tourists, but they also sustain food for half a billion people and protect shorelines from storms. And they're just plain lovely.

But coral reefs are also extremely vulnerable to sea-

ring temperatures. In normal times, the living coral form a symbiotic relationship with zooxanthellae, a colorful type of algae that provides the reef with oxygen and nutrients. But this symbiosis only thrives within a fairly narrow temperature range. If the water in the reef gets too warm (or too polluted), the coral will expel the algae from their tissue, leaving the coral with a ghastly "bleached" appearance. At that point, the coral lose a key source of food and become more susceptible to deadly diseases. Often many coral will then die off, which in turn can adversely affect the fish that rely on the reefs.

And right now, scientists say, Australia is suffering one of the worst mass bleaching events in recorded history.

## How bleaching got so bad in the northern Great Barrier Reef

The Great Barrier Reef stretches for 1,000 miles along

**'I WITNESSED A SIGHT UNDERWATER  
THAT NO MARINE BIOLOGIST WANTS TO SEE'**



Australia's northeastern coast, one of the world's great natural wonders. It consists of 3,000 individual reefs and is home to 1,500 species of fish.

The southern part has long sustained heavy damage from tourism, pollution, and invasive species. But the northern third has always been more pristine, located far from (most) human activity. It's usually a bright feeding ground for dugongs, sea turtles, and other marine life. But ever since December 2015, as the Australian summer got underway, ocean temperatures around the reef have surged to record highs, aided by global warming and a powerful El Niño currently raging in the Pacific.

That's helped trigger severe coral bleaching in the northern third of the Great Barrier Reef — an area that had also been hit by several cyclones as well as a series of unusually hot days during low tide.

The damage has been horrifying. This week, Terry Hughes, head of the Australian Research Council Centre of Excellence for Coral Reef Studies, returned from an aerial survey of the reef's northern section

and announced that the bleaching was unlike anything he'd seen before.

Of 520 reefs surveyed north of Cairns, a staggering 95 percent were "severely" bleached. Only four of the 520 were healthy. "This will change the Great Barrier Reef forever," Hughes told Australia's ABC.

Jodie Rummer, another scientist at the ARC Centre, said the view was equally grim from underwater, as the hot water had ravaged corals, anemones, and even giant clams. While the local fish populations were still abundant for now, she worried that the loss of coral and rising temperatures could soon take a toll there, too.

Rummer's statement was dire: "I witnessed a sight underwater that no marine biologist, and no person with a love and appreciation for the natural world for that matter, wants to see."

The Great Barrier Reef Marine Park Authority has raised its bleaching warning to the highest alert and will begin to put in place limits on water pollution — to



The current pace of global warming may not give these damaged reefs sufficient time to bounce back fully. Before the 1980s, mass bleaching events were virtually unheard of.



avoid further weakening the reefs — while monitoring the corals closely going forward. Simply put, it's a disaster.

## **Bleached coral reefs can recover — but only if they're given a chance**

In theory, coral reefs can recover from a severe bleaching event, says Mark Eakin, who runs NOAA's Coral Reef Watch program. But the big question is whether these reefs actually will get a chance to heal.

After a bleaching event occurs, a certain fraction of coral are likely to die off from disease. (It's still unknown how many of the northern Great Barrier Reef's coral will perish, although an early survey off Cape York found 50 percent mortality.) Eventually, howe-

ver, when temperatures return to normal, the coral start growing back.

The hitch is that recovery takes time. Lots of time. In places like the Seychelles — where reefs are mostly sheltered from pollution, tourism, and heavy fishing — it has taken at least 15 years for damaged reefs to come back. In areas stressed by human activity, the process can take much longer.

What's more, recovery is often uneven. The fast-growing "branching" corals bounce back first. But there are also older, massive corals that are centuries old and provide valuable shelter for bigger fish. When those die off, they don't return overnight.

The first step is admitting we have a problem. And here's the catch: the current pace of global war-



*PHOTO. Swanbank Power Station (Queensland, Australia)*



ming may not give these damaged reefs sufficient time to bounce back fully. Before the 1980s, mass bleaching events were virtually unheard of. Now they're becoming more and more frequent, particularly every time there's an El Niño, as ocean temperatures spike.

Another complication: as we pump more carbon dioxide into the atmosphere, the oceans are becoming more acidic. In some cases, acidification can make corals more sensitive to bleaching at lower temperatures. It can also make it harder for the corals to build their protective skeletons and recover from events like this.

Now, there are some things that Australia (and other countries) can do to help make reefs more resilient to bleaching. Humans can limit fertilizer and sewage runoff that further damage the coral. We can avoid overfishing key herbivores like the rabbitfish that nurture the reefs by clearing away excessive algae. We can also avoid wreaking havoc on reefs with boats and construction. (Australia is on the wrong track here: in 2015, the government approved plans to expand coal exports via ship in the southern part of the Great Barrier Reef.)

But ultimately, Eakin points out, reducing our CO<sub>2</sub> emissions is the crucial step. He argues that we'd likely need to keep total global warming to below 1.5 degrees Celsius for coral reefs to continue thriving. Right now, we're on course to blow past 2 degrees Celsius, which could doom recovery efforts.

"At 2°C," Eakin says bluntly, "we are likely to lose numerous species of coral and well over half of the world's coral reefs."

## **It's not just Australia: Bleaching is threatening corals worldwide**

The Great Barrier Reef is getting all the attention right now because it's big and famous and hugely important. But large swaths of the Pacific have been experiencing severe coral bleaching ever since El Niño began kinda-sorta poking its head up in June 2014.

Different spots get hit as summer descends on different parts of the globe.

"We've seen bleaching as far west as Tanzania, and as far east as French Polynesia," says Eakin. "There's severe bleaching in Fiji and New Caledonia and the northern third of the Great Barrier Reef. Severe bleaching in the island of Reunion. Bleaching in Seychelles. We might be about to see more bleaching in Galapagos and the Pacific side of Panama, though we're not sure about that just yet."

The last time we saw such widespread bleaching was during the record-setting El Niño of 1997 to '98, when the world functionally lost 15 to 20 percent of its coral reefs. Eakin points out that this current event is still ongoing, so it's difficult to say what the precise damage will be. There are nuances and quirks with every El Niño. But this one is also occurring in the context of warmer ocean temperatures overall, due to climate change.

"Hawaii, for instance, does not normally have El Niño bleaching," Eakin notes. But last year, a huge coral colony in the Olowalu reef in Maui was hit. "This is only the third time they've had bleaching — the other two were 2014 and 1996. So we're seeing where the signal of climate change is very strong in this global event."

And further shocks may still be in store, he adds. "We may next see bleaching in the Indian Ocean, in the coral triangle [in the Western Pacific Ocean]. It may spread into Southeast Asia. And then come this summer or fall, we may see further bleaching in the Caribbean" — a place where coral cover has declined by nearly half since the 1970s, mainly due to invasive pathogens, overfishing, coastal pollution, and tourism.

"So keep your eyes open," Eakin says. "This current story is nowhere near over."

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# The harsh lesson of Monte Narba

**A silver mine, hibernated for decades in its splendid isolation, is now a symbol of the wealth of industrial and architectural heritage inherited from mining golden era. But Monte Narba is equally emblematic of the inability to enhance or, at least, to protect historic valuable sites.**



Photo copyright: ONE

The Monte Narba silver and lead mine, located in the Municipality of San Vito (Sardinia, Italy), is a symbol of the wealth of industrial and architectural heritage inherited from mining golden era. But it is equally emblematic of the inability to enhance or, at least, to protect historic valuable sites.

This situation is quite common for most of the buildings that form the Geopark of Sardinia. An institution only too often unable to protect its assets, due to a mixture of constant political and legal wrangling. Not even the Unesco recognition has stimulated visions and projects able to ensure a present and a future to such glorious chapter of Sardinia's past.

The first mining concession in Monte Narba was given in 1822. But it was only in 1874 when it was granted to the Anonymous Society of Lanusei Mines, that Monte Narba silver and lead mine began operating at full speed. Coming in a few years to remove nearly 1,500 tonnes of minerals, and to employ more than 900 people, operating up to 500 metres deep in an area 18 kilometres long.

The end of the 19th century signalled the start of Monte Narba downward spiral, induced by the opening of new mines in South America and the general lowering of the silver value in the world market. The first decades of the 20th century were marked by several changes of ownership and promises of revival. The reality was a progressive reduction of activities until 1935 when the Montevecchio company finally gave up its concession.

Today visitors find an abandoned village, derelict but still capable of offer-

ring beautiful views and some glimpse of lost wealth. A jewel, hibernated for decades in its splendid isolation surrounded by the Sarrabus mountains, sentenced to death in 1935 by the mining halt and buried, almost entirely, by landslides caused by the floods of 1993 and 1999.

The village consisted of a hospital, housing for officers, employees, carpentry and smithery. Recent landslides have hidden a lot, but something can still be seen. Just like the Villa Madama's amazing paintings. The residence of the director was decorated by an Austrian soldier detained in the mine during World War I, as remembered in the book *"The silver mine of Monte Narba History and memories"* ("La miniera d'argento di Monte Narba - Storia e ricordi", 1999) written by Sergio Mezzolani and Andrea Simoncini.

While walking among the ruins, you stare at the buildings in awe. But also in disbelief for an inheritance so poorly guarded. An ancient beauty weakened by time, scarred by neglect and shortsightedness.

The love for the mine, however, remains. And it is tangible in the words and old pictures shared with the occasional visitor by the competent employees of San Vito's Municipal Museum ("Museo della Via dell'Argento").

Pride and romanticism counterbalanced by the discouragement of the town hall technical office officers, who explained with the lack of agreement with the current owners the inability to design any project of recovery or rejuvenation. Immobilism that ensures the progressive decay of a piece of history that deserved a very different fate. **ONE**





Photo copyright: ONE

An aerial photograph of a lush, forested hillside. The trees are dense and dark green. At the bottom of the frame, a small village with several white buildings and dark roofs is visible. The text is overlaid on the image.

**Tuviois**  
**Serr'e S'Illixi**  
**Nicola Secci**  
**Tacconis**  
**S'Arcilloni**  
**Masaloni**  
**Giovanni Bonu**  
**Monte Narba**  
**Baccu Arrodas**

**The Silver Route**

PHOTO COURTESY: Museo della Via dell'Argento - San Vito



**Museo della Via dell'Argento "Monte Narba"**

San Vito (Sardinia, Italy)

Address: Via Galilei

Telephone: +39 070 9927067

Email: [museosanvito@ifras-spa.it](mailto:museosanvito@ifras-spa.it)

Website: [www.comune.sanvito.ca.it](http://www.comune.sanvito.ca.it)

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**Now**



# Then

PHOTO COURTESY: Museo della Via dell'Argento - San Vito

# Alarmists won't like it, but fossil fuel supply is abundant

By The Oklahoman Editorial Board

*The Oklahoman*

It seems what's good news for most of humanity is bad news for global warming alarmists.

In a recent article in the *Journal of Economic Perspective*, researchers Thomas Covert, Michael Greenstone and Christopher R. Knittel ask, "Will We Ever Stop Using Fossil Fuels?" They conclude: No. This disturbs them, since the three are adherents of extreme global warming theory. Yet their findings should be welcomed by anyone happy that human existence is no longer quite so "solitary, poor, nasty, brutish and short" as Thomas Hobbes described it.

"Peak oil" theory has been around for decades; innovation continues to postpone its occurrence. Covert, Greenstone and Knittel note that "for both oil and natural gas at any point in the last 30 years, the world has 50 years of reserves in the ground."

This is because innovation continues to identify and extract new resources even as consumption increases. From 2005 to 2014, global consumption of oil rose 7.5 percent, while natural gas use increased 20 percent. Yet the world has more proven reserves of oil and gas today than in 1980. In the United States alone, oil and gas reserves "expanded 59 and 94 percent, respectively, between 2000 and 2014."

The researchers note oil from tar sands and oil and gas from shale deposits wasn't even categorized as "reserves" until relatively recently, and that if technological advances continue, "there is a nearly limitless amount of fossil fuel deposits" that may become economical to extract in the future.

Hydroelectric, solar, wind and nuclear are often touted as alternative energy sources that could displace oil and gas, but Covert, Greenstone and Knittel declare this "implausible." For economic and political reasons, nuclear is out of favor. The price of solar energy has plummeted since 2009, but its average price remains twice that of natural gas.

The authors note most "examples of highly competitive prices for solar energy are from specific locations that are exceptionally well-suited for generating solar energy." Furthermore, "the intensity of sunlight and the speed of the wind vary tremendously across space," and both are "intermittent" sources of energy. Those are major logistical challenges.

The three men say electric cars could displace gasoline-fueled vehicles, but only if "several technology breakthroughs" occur. And even then the impact on greenhouse gas emissions would be minimal unless associated electricity generation is also from a "green" source.

"Otherwise, we could transition from oil-based transportation with moderately high carbon emissions to coal-fired-electricity-based transportation with even higher carbon emissions," they write.

Also, due to various logistical issues, the authors calculate oil prices "would need to exceed \$350 per barrel before the electric vehicle was cheaper to operate . . .".

Future innovation will undoubtedly improve electric cars' efficiency and affordability, but the authors note the same holds true for the internal combustion engine.

Therefore, Covert, Greenstone and Knittel favor government policies that basically discourage use of oil and gas, regardless of economic and societal consequences. Yet innovation that makes oil and gas energy affordable and practical will surely find ways to mitigate any negative consequences of its use.

Covert, Greenstone and Knittel may view with horror their conclusion that "the world is likely to be awash in fossil fuels for decades and perhaps even centuries to come." But that finding should be welcomed by those who understand that the comfort, efficiency and unmatched productivity of modern life are built upon a foundation of fossil fuels.

**POLES**

# End massive subsidies to fossil fuel industry

By Lenore Hitchler

*Citizens' Climate Lobby and 350.org*

Climate change is destructive to the environment and must be dealt with promptly. We should start by immediately halting the vast amount of fossil fuel subsidies given by the federal government to the fossil fuel industry. It is difficult to determine the exact amount of the subsidies. However, Oil Change International reports that the fossil fuel industry receives \$37.5 billion per year in direct subsidies. These contribute to increased emissions of carbon dioxide. CO<sub>2</sub> is the largest component of greenhouse gases and thus contributes greatly to climate change.

Several leading financial institutions, including the International Monetary Fund, have made it clear that subsidies encourage excessive energy consumption. The president of the World Bank stated: "Fossil fuel subsidies send out a terrible signal: Burn more carbon." Exactly how much could fossil fuel usage be lowered if subsidies were eliminated? The International Monetary Fund projects that global CO<sub>2</sub> emissions could be reduced by 20 percent if they were ended. Since they profess to believe in the free market, the fossil fuel industry should not be given government handouts. More importantly, these corporations do not need financial help. Exxon's profits in 2011 were \$41.1 billion. Between 2010-2012, Exxon paid a federal tax rate of 15 percent, resulting in a tax subsidy of \$6.2 billion. Since fossil fuel companies are not paying their fair share of taxes, this tax reduction is an indirect subsidy.

The Koch brothers, advocates of free market capitalism, would like to dismantle the Environmental Protection Agency, Social Security and Medicare, and are opposed to government programs that aid the poor. Ironically, they receive subsidies themselves. This is especially disturbing since the Koch brothers have an extremely poor record when it comes to the environment. The EPA fined Koch Industries \$30 million for its role in 300 oil spills, which resulted in more than 3 million gallons of crude oil leaking into surface water and poisoning our water. Besides various subsidies, the fossil fuel industry receives other financial benefits from the government.

The Department of the Interior regulates fossil fuel extraction on Native American tribal land, and the tribes do not receive a fair price for these resources. Another offensive subsidy occurs when the federal government gives polluting corporations lea-

ses for public lands and coastal waters without fair recompense. The government does not collect adequate compensation for the disasters that occur because of negligence, and this cost is absorbed by the tax-paying public.

To make a bad situation worse, oil companies claim costs associated with cleaning up after an oil spill as a standard business expense. Thus, they pay less in taxes and therefore make higher profits. Further support of oil companies occurs when the government permits pipelines on private property. One estimate is that 3 million gallons of oil are spilled annually from pipelines.

The government also allows extremely toxic petroleum products to be haphazardly transported on railroads. The Department of Transportation predicts 10 oil train derailments annually. Last but not least, the amount of money that the Pentagon spends to obtain and defend overseas oil interests is another form of government subsidy. One low estimate is that the United States spends \$10 billion annually doing this. The war in Iraq was ultimately a war for oil. General John Abizaid, former head of the Central Command and Military Operations in Iraq, stated: "Of course it's about oil; we can't really deny that." Sen. Chuck Hagel said in 2007: "People say we're not fighting for oil. Of course we are."

Halliburton was one of the companies that wanted to build a pipeline through Afghanistan, and Vice President Dick Cheney was the former head of Halliburton. According to Robert F. Kennedy, Jr., the U.S. is entangled in Syria because Bashar al-Assad rejected a proposed oil pipeline through the country. Libya has a large amount of oil, and the government was involved in the overthrow of the Gaddafi regime. The amount of money that the government spent on these wars, an indirect subsidy to the oil industry, is in the trillions. Government policy protecting access to oil has led to thousands of Americans dying or being injured.

Given the plethora of negative consequences, I feel strongly that government aid in any form for the fossil fuel industry is a financial burden that Americans should not have to shoulder. It is time to eliminate subsidies from this industry that causes severe damage to us and our planet.

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# Another Reason To Act Now On Climate Change: Snakes

By CHRISTIE WILCOX

*Discover Magazine Blogs - SCIENCE SUSHI*

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Though scientists have been warning about the disastrous impacts that climate change will have on our planet for decades, we are now starting to feel those predictions manifest. As Eric Holthaus pointed out, the “worst nightmare” scenarios are already happening. Droughts, storms, fires, you name it—the world as we knew it is under siege. Heck, we just had the most abnormally hot month on record; February 2016 was 1.35 degrees Celsius warmer than the average, making it two-tenths of a degree more unusually warm than the previous record month: January 2016.

And as water supplies dwindle, rainforests burn, and corals bleach, we may have yet another thing to worry about: frickin’ snakes.

Some parts of the world know all too well the danger posed by venomous snakes. Scientists estimate that anywhere between 421,000 and over 1.8 million envenomations from snakes occur every year, with as many 94,000 deaths.

Here in the United States, we’re fairly lucky: we have less than ten deaths per year. Meanwhile, our neighbors to the south are plagued by serpentine foes which cause a few thousand deaths annually.

But as our climate changes, so, too, will the habitats that these snakes call home. And with those changes comes the potential for species to expand their ranges and come in contact with people they never would have before.

To determine what might happen to American snakes under different climate change scenarios, scientists from the Universidad Nacional Autónoma de México’s Laboratorio de Biología de la Conservación and the University of Kansas Biodiversity Institute used climate and habitat (niche) models to predict how the distributions of 90 species of snakes—about half the total number of venomous species in all of North and South America—will react to changes in climate. They then used current occurrence and bite data to estimate how snakebite risk will change as the snakes move around.

The results, published this year in the journal *Climatic Change*, were unnerving: the team predicts that

**The Universidad Nacional Autónoma de México’s Laboratorio de Biología de la Conservación and the University of Kansas Biodiversity Institute predicted an overall increase in snakebite risk in a few decades. And this is just considering venomous snakes in a part of the world where these animals are relatively benign. Interesting to see if the trend holds true in Africa and Asia.**

snakebite risk may rise with temperatures, especially in remote, rural areas.

Almost all of the North American snakes were predicted to expand in range. Some of the worst-case-scenario projections have spe-

cies like timber or western rattlesnakes (*Crotalus horridus* and *C. oreganus*) reaching up into Canada. South American snakes were more split, with about half of them reducing their ranges rather than expanding them in most of the climate change scenarios.

Species-specific effects aside, the team predicted an overall increase in snakebite risk could occur as little as a few decades. And this is just considering venomous snakes in a part of the world where these animals are relatively benign—it will be interesting to see if the trend holds true in Africa and Asia, where even a small percentage increase in snakebites could lead to hundreds of thousands of deaths.

However, it's important to note that these results contrast a previous study which found that rattlesnakes may be nearly wiped out due to rapidly changing temperatures. While this team used more variables to pre-

dict habitat, it's possible that the numbers are still an overestimate for some species.

Either way, there's little doubt that the carbon dioxide and other greenhouse gasses we have emitted will have lasting impacts on life on this planet. Climate change isn't just about weather patterns or global temperatures—all species are affected by our actions, including those that can do us grave harm.

But while these results are a little scary, they're also not set in stone: rather than worrying about snakes, we should do our best to reduce our climactic impacts now while we still can.

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# LAST STAND

Photo: Rebecca Stanek



Ka Lae (Hawaiian: the point) is known for being the southernmost point in the United States. It is famous also because here the Kamaoa Wind Farm began operation in 1987. Not exactly a role model: by 2006 its turbines were falling into disrepair, big white remainders of a monumental failure. At the end of August 2006, a new set of wind turbines were placed 2.4 km from the old Kamaoa wind farm to start the Pakini Nui project. Completed in April 2007, the Pakini Nui wind park supplies up to 20.5 MW of power to the island electricity grid. The turbines of the old wind farm have been dismantled. **ONE**



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