SET MATCH

Dutch Design Week

TILOS
100%
autonomous

Solar Roads

A more sustainable network

Direct Air Capture and CO_2 Utilization

Volume 3
Edition 2
February 2019

TILOS

The first autonomous island in the Mediterranean

Thanasis Vasileiadis – Sakatias

Let's take this from the beginning. Tilos is a small island located in the southeastern part of the Aegean Sea, in Greece. Through the ages, Tilos was conquered by many civilizations. From the Minoans to the Byzantine Empire, the Crusaders and the Ottomans. In recent history, the island was ruled by the Italians until it was reunited with Greece in 1948. As a result of the different cultures that ruled Tilos, the island has a rich history and many landmarks, mainly castles that protected the inhabitants from pirates since the Dark Ages. This rich history justifiably fills each and every one of the 780 Tilians left on the island with pride.

Now they have another reason to feel proud and this is none other than the TILOS (Technology Innovation for the Local Scale) project. It refers to the development and operation of a prototype battery system based on NaNiCl2 batteries coupled with renewable energy generation, wind and solar. More specifically, the project involves the installation of 592 PV panels with a total capacity of 160 kWp, one medium-sized wind turbine of 800 kW and two battery containers each of 1.4 MWh nominal energy capacity.

Although, as mentioned before, the population of the island is small, it quadruples during the summer months, due to tourists arriving both from abroad, as well as from the rest of Greece.

Left: PV modules and Right: wind turbines installed on the island

Thus, the sizing of the system proved to be very important and was a major challenge for the engineers involved. Currently, it can sustain 1.5 days of no energy production during the summer period. In case of overproduction the excess energy is diverted to Cos through the undersea connection of the two neighboring islands.

Regarding its organization, the initiative is a multinational effort comprised of 15 enterprises and institutes from 7 European countries, namely Greece, Germany, France, Italy, Sweden, Spain and the United Kingdom. It is largely funded by the EU, which provided 11 million euros, out of the total 13.7 million-euro costs. This is largely due to the fact that Tilos is envisioned to serve as a blueprint for other small islands inside the European Union that have in common their limited grid connection to the mainland!

More specifically, the aim is the creation of an island platform that would make the transfer of technological experience possible, through the development of smart grid systems of islands such as Pellworm in Germany, La Graciosa in Spain and Corsica in France. Replication of the proposed system will be made possible through the creation of an advanced micro grid tool, called "Extended Microgrid Simulator", while innovative business models will be developed for easier diffusion of the integrated battery solution in the market, also engaging the local public community.

Baby steps towards Modernization

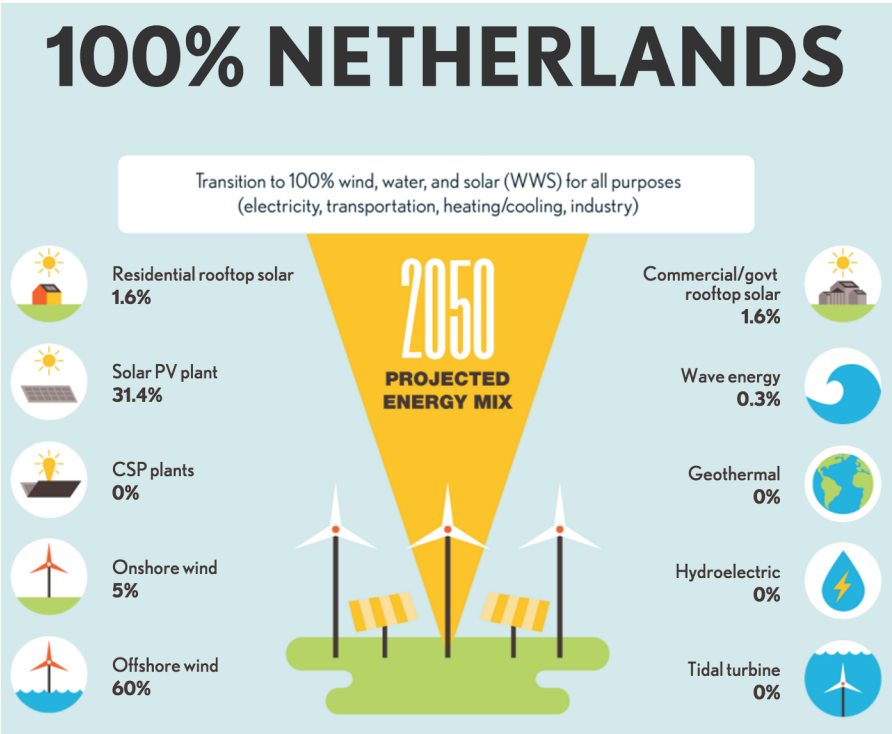
Kritika Karthikeyan

There are more than eight million connections in the Netherlands, with a total current demand of some 118.6 TWh, and an installed capacity of around 31.25 GW. The power mix is dominated by natural gas, followed by hard coal and wind, with a mere 6% coming from renewable energy sources (RES). For a country that focuses so much on technological innovation, it has managed to reduce greenhouse gas output by only 11% since 1990. Given the rising concern for energy transition, Netherlands is poised to make dramatic changes in completely phasing out coal and even natural gas to an extent, thus embarking on a path that may become a trend for the rest of Europe.

It is easy to set high targets and innovate on various renewable energy. However, grid innovation will have to be one step ahead to allow greater integration of large-scale renewable energy systems into the power grids and improve integration of customer- owned power generation systems such as rooftop solar power systems.

"That's one small step for man, one giant leap for mankind".

These now famous words proclaimed by Neil Armstrong certainly hold strong even in the energy sector. One step towards change can make all the difference towards our future.

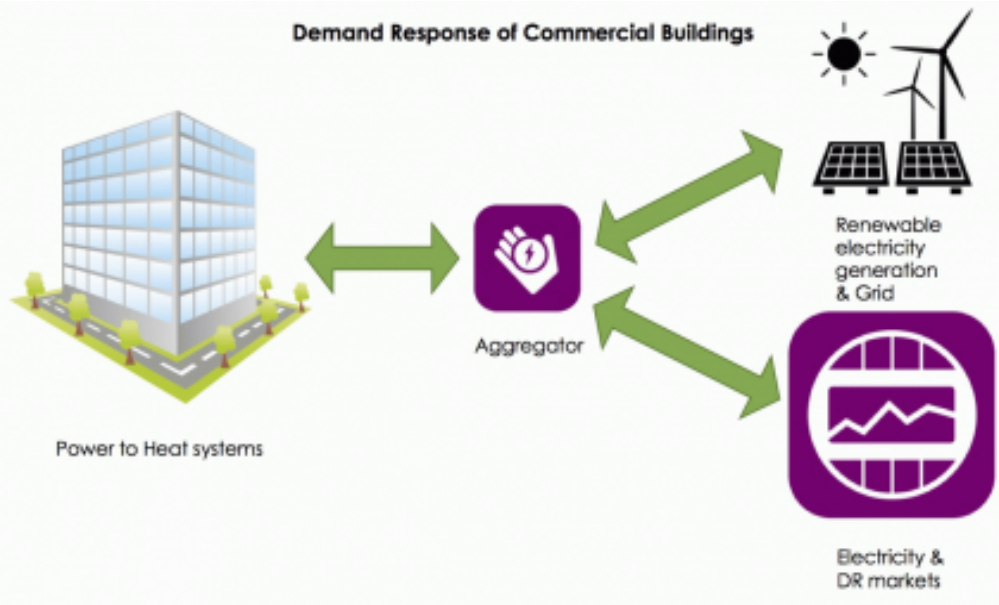


The Dutch economy is heading for a major bump due to acute capacity problems in the country's power infrastructure. The concept of capacity can be seen as a measure of how much reliable electricity generation the grid needs to meet ever- changing peaks and troughs in energy demand. Even if NL wants to move upwards in the list of most sustainable countries in the EU, grid restrictions will make it very difficult in the event of increasing distributed energy resources (DERs). The problem is quite common around Amsterdam, where the expansion of the power network is no longer possible.

A much more efficient, secure and cheaper solution to deal with this would be to tap the flexibility that the decentralized production and consumption will offer. This can be done by making the consumer side active and exploring opportunities that flexibility in consumption can bring about. For example by controlling and switching off the electricity consumption that is not necessarily needed at a particular time, will form a real- time balance. 'Demand- side flexibility' and 'Aggregators', which are very well understood concepts in the US, will become highly relevant in the Dutch energy market sooner than expected.

As an electricity grid participant, the aggregator, for example, tracks the consumer's consumption and transmission system operators' (TSO) requirements in real time. During peak consumption periods, the aggregator "asks" those consumers that are able to do so to shut down some of their machines in order to save kWh. The aggregator then makes the freed-up power available to the TSO, who sells it to customers requiring it. The aggregator provides uninterrupted grid balancing to optimise energy use and pays its customers for making their electricity available.

Now, this is just one definition of an aggregator. As the power grid gets smarter and becomes more dynamic, so will the role and definition of an aggregator.



It may seem that aggregators are just a redundant addition to the electricity market hierarchy, especially when the aggregation can be done by distribution system operators (DSOs), Local flexibility markets (LFM) or utility companies. But issues like DSO's inability to appear biased, LFM's lack of capacity/leverage to participate in wholesale markets or the utility company's ability to obtain sufficient data to make a strong enough business case, makes the role of an aggregator significant.

It is essential that such innovation is encouraged if electricity usage is to be made more efficient, and if the switch to renewable energy sources is to gather pace.

Solar roads

The potential of a more sustainable road network

Carlotta Ferri

It would be repetitive to explain why we need to find new ways of generating power, and it would be similarly redundant to talk about the promising photovoltaic conversion technology. One question with a less obvious answer, however, is: Why do we need urban integrated photovoltaics? And also: Why on roads?

In the last decade, infrastructure integrated PV (IIPV) technology has gained more interest from the side of both industry and research, as it is a promising technology for the realization of sustainable urban energy supply. It would support the increased power demand in the urban environment, due to cities getting more densely populated and energy more demanding, and on roads, due to the increasing advent of electric vehicles (EVs) and the electrification of the public system. Additionally, decentralized power conversion through IIPV shows a potential economic benefit from a minimization of grid dependence and transmission losses of urban infrastructures like buildings, street lighting, etc, not to mention the reduced requirements of copper for cables.

What IIPV technology offers in addition to conventional photovoltaic systems is the resolution of the land constraint issue. In fact, providing power with a reasonable energy density from photovoltaic technology requires a great amount of land. This land competes with housing, transportation and especially with agriculture. In fact, optimal sites for photovoltaic systems installation are found to correspond with cultivated land since both the two sectors need an area that is potentially well-insolated, flat, horizon-free, has road adjacency to facilitate transportation and maintenance and has acreage. Hence, a scaling up of photovoltaic power conversion could give rise to a conflict between the agriculture and sustainable energy sector.

Among all the urban infrastructures, roads present a great irradiation potential, absorbing up to 40 MJ/m^2 daily. Harvesting energy from solar roads would, therefore, allow us to maximize the utilization of land dedicated to transportation. Roads are additionally a source of heat in the urban areas, contributing to the well-known effect of the urban heat island. It has been revealed that photovoltaic roads could reduce the urban surface temperature in comparison with conventional pavements.

TNO claims that the Dutch road network, accounting for over 130.000 km, can harvest enough electricity to power all the cars in the country with clean energy. In fact, electric vehicles cannot be considered a revolution towards sustainability unless they are powered with electricity generated from renewable sources. Solar roads would provide clean power where it is needed. Additionally, this could become a great opportunity to revolutionize the transportation sector, including new smart functions in the road itself, such as sensors to collect traffic and temperature data, generation of variable road marking, integrated LED lights, wireless energy transfer to vehicles (inductive charging) and even automatic vehicle guidance.

The first issue that solar roads face is the necessity for innovative design since they need to meet requirements for both pavement structures and photovoltaic modules. Roads surfaces need to support traffic load, rutting, fatigue cracking, rainwater drainage flow, skid forces. On the other hand, photovoltaic modules require minimization of the solar cells shading, strong cells interconnection, a weatherproof structure, and diodes to avoid reverse current. Additionally, solar roads need to be designed to withstand snow accumulation and removal, salt-based winter road maintenance and freezing in cold regions, while overheating should be considered in the hotter climates. At the same time, they need to be modular and easy to maintain, have a low weight to facilitate testing and installation and require readily available components and materials to sink the costs.

It is clear that researchers, both in the private and public sector, need to work on a new and revolutionary design of PV modules for solar roads application.

Actual projects that saw the realization of solar roads only considered c- Si wafers, which is currently the most dominant technology.

In 2006 a U.S. start-up called Solar Roadways started developing modular solar roads with integrated PV cells and LED sources. The solar road can convert power and emit light in form of road signage and street lines. It also incorporates a heating system in the surface layer that can adjust the road temperature and react immediately in case of snow or deposition or ice formation on the asphalt.

A different concept has been launched by TNO in 2011. It is the first solar road pilot project in the Netherlands, called SolaRoad, and consists of a 70 m cycle path in Krommenie, North Holland, built with precast concrete block, upon which a poly-crystalline silicon module is installed. On the top, an anti-skid layer recreates the rough surface of asphalt. The pilot project harvested a cumulative annual energy yield of around 78 kWh/m^2.

This value is smaller than the electricity yield obtained by other infrastructure integrated PV (IIPV) systems but it is appealing due to the usage of the area with PV potential otherwise left unused. Further ideas of implementing flexible PV modules are gaining ground because of their low costs and material requirement, and their potential versatility in the application design.

Netherlands klimaatakkord

Under scrutiny for absence of carbon tax on industry

Andrew Keys

Dutch industry is responsible for 25% of today's carbon emissions and hence has been a focal point of the recently published Climate Agreement (klimaatakkord) to meet the Paris Agreement goals. On 21 January, Jesse Klaver, the leader of left-wing party GroenLinks (GL), announced that they would not be supporting the klimaatakkord unless a carbon tax on heavy industry is introduced.

The party is bidding for support of their legislative proposal in exchange for support to the coalition government who are set to lose their majority in the upcoming Provincial States elections in March. The legislative proposal would oblige heavy industrial companies to pay a tax per tonne of CO_2 emitted starting from 2020 onwards. An initial cost of €25/tonne CO_2 would be charged in 2020, with an annual increase to €100/tonne CO_2 in 2030 and €200/tonne CO_2 in 2050. GL claim that this will raise over €2 billion in 2021 which can be used to reduce customers energy bills as well as help large industries transition to low- carbon technologies.

Tata Steel IJmuiden would be the largest Dutch company to be impacted by the introduction of a carbon tax.

The coalition is currently split over the idea of a carbon tax, with D66 and ChristenUnie supporting the idea but VDD opposed to it. Prime Minister Mark Rutte (VDD) said that a carbon tax was deliberately not introduced for industry in the klimaatakkord due to the concern of losing their competitiveness within European and global markets. Another opposer of Klaver's proposal is Hans de Boer, leader of the VNO-NCW employers federation, who claims that Klaver is trying to create a false image of industry. Boer states that the klimaatakkord already puts industry responsible for reducing total emissions by one-third whilst only receiving one-sixth of the government subsidies.

Tata Steel IJmuiden is the largest carbon emitting industrial company in the Netherlands, directly and indirectly emitting approximately 12 million tonnes of CO_2 annually. With the assumption that they cannot achieve drastic emission cuts by 2020, this means they would be taxed €300 million in that year alone. If they must continue selling their product at the same price, how can they remain in operation, never mind make investments? This could put the employment of 9,000 Tata Steel employees at risk with the very realistic possibility of industries relocating out of the Netherlands. Given that climate change is a global issue, the consequence of such a tax must be very carefully considered on all fronts. Is there a better solution to avoid carbon leakage but still keep pressure on industry to decarbonise as quickly as possible?

Jesse Klaver, Leader of GroenLinks, announcing a carbon tax proposal.

Dutch Design Week

Leo Franco

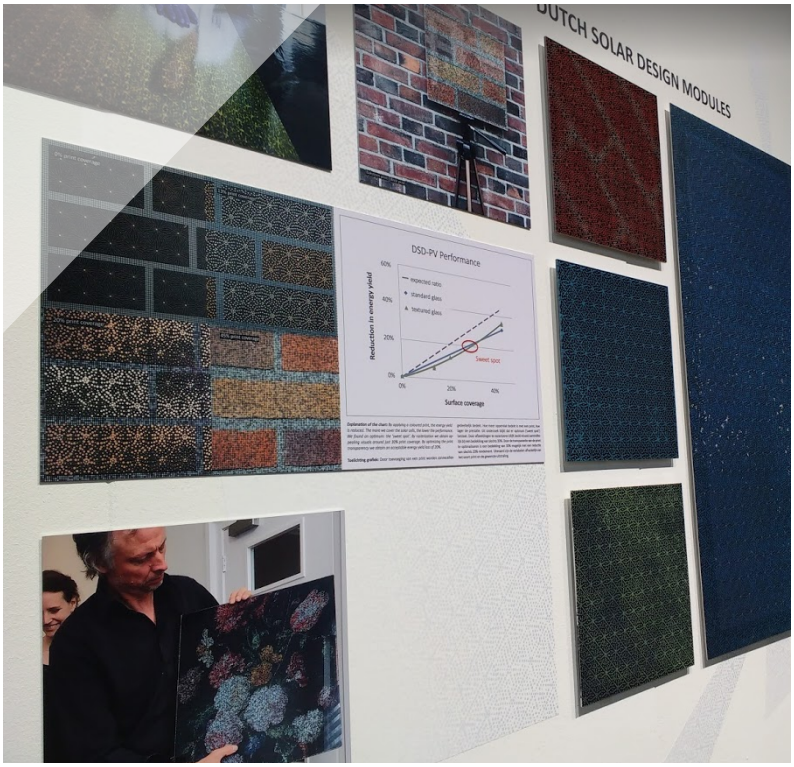
Running from the penultimate Saturday to the last Sunday every October, Dutch Design Week turns an otherwise unspectacular Eindhoven into a hub of intellectual and visual creativity. Typically attracting around 80,000 visitors and seen as a major event in a designer's calendar, this is certainly not one to be missed. What's more, your ticket at a paltry 11 euros is valid for the whole week! This year, the event spanning the entirety of the city featured technical innovations from the TU Eindhoven and other companies, artistic visualisations from the Eindhoven design academy and a rather enticing exhibition titled Robot Love.

I first went to visit Strijp S, a former Phillips industrial park, to see the more technical aspects of the event. There was a bounty of sustainable building materials on showcase as well as many for the fashion industry. One of the showcases that really piqued my interest was an alleged new form of underwater breathing apparatus (shown on the right). The complete outfit came with layers up to and covering the mouth of the wearer. The rigid material was intended to split water into oxygen across its surface whilst removing the respired carbon dioxide. It must be said that this technology is still under construction so don't hold your breath (pardon the pun) but was certainly a fascinating display in any case.

For more information check out

http://www.junkamei.com/amphibio/ .

Another design that caught my eye was the coloured metal wrap- through cells exhibited by Vision Solar. For those who don't know, metal wrap-through solar cells were a new concept presented by ECN in 2003 which allowed much freedom for top metal grid design. Here this concept was used to create elaborate patterns for facades on buildings. Using this technique, bespoke designs could be created based on customer requests. The finger patterns were then painted again as per request. The paint is applied as dots on top of the metal grid such that the loss of photoactive area is minimised. The end result was a kind of pop-art or mosaic effect that was quite attractive. They also claimed only a 10% reduction in module performance and a cost price similar to a typical glass façade.



The third exhibit that really stood out for me was a bioplastic presented by Dutch designers Maartje Dors and Eric Klarenbleek. These two have developed a technique to process algae into a usable material for 3D printing. This algae polymer can then be used to create a myriad of plastic products in a clean and renewable way. At the Dutch Design Week they were showcasing some bowls and cups made from this process, and I have to say, not only were they renewable but also very stylish – a valuable added bonus.

Thanks to Renault, I was also able to visit my next stop for free using their donated electric taxis service. I travelled easily to the design academy, where graduation projects were showcased.

Here the designs were more geared towards artistic representations – a good change of pace from the other site. There were some really fantastic exhibits making this a real highlight for me (and any art lover). The Robot Love exhibition was also found on this site. This explored our growing relationship with artificial intelligence, showcasing both the horror and the allure of these machines. Another fascinating pit-stop.

As an avid traveller of the Netherlands I would say Dutch Design Week is a real must see. It is great value for money and provides inspiration in both art and engineering. It shows us what is possible technically, but also aesthetically, an important balance for any design. Perhaps most importantly though, is that it gives you an excuse to visit Eindhoven. Which on any other occasion probably does not have that much to offer.

Photo credit: https://www.dezeen.com/2017/12/04/dutch-designers-eric-klarenbeek-maartje-dros-convert-algae-biopoly mer-3d-printing-good-design-bad-world/

Fracking

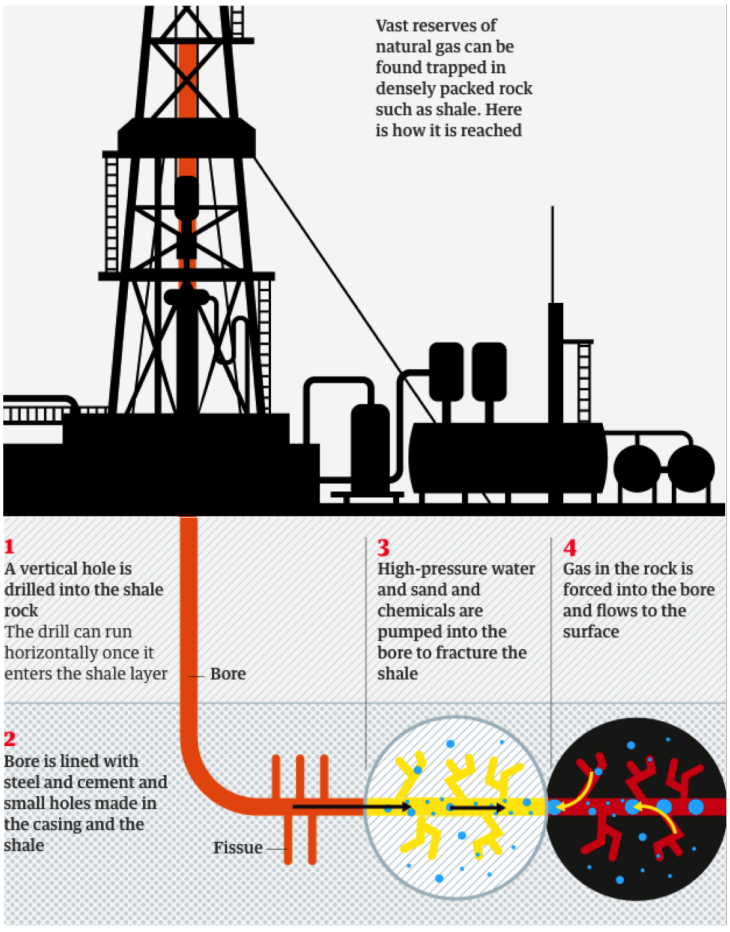
The energy miracle of the US is coming across the Atlantic

Megan Atkins

You can read the words again and again and still you can't quite believe that this is really happening. In the US of all places. Yet, California has just written itself into history as the frontrunner to a carbon-free future. For decades, fracking has been polarising people across the world. In the US, it has boomed to become one of the most lucrative and attractive methods of extracting oil. Today it accounts for more than half of US crude oil. But across the Atlantic, it's a different story. Almost all European countries tossed fracking to the side some time ago. France, Germany and even the Netherlands, all have moratoriums against the process. Even the promising prospects of Poland and Romania proved too good to be true.

So why then, has there been such an uproar about fracking in one, lonely European island?

England (unsurprisingly) is currently the only country in Europe that allows fracking. Seven years since all the sites were shut down, after seven years continuously blocking and redrafting of legislation, a new fracking well was opened in October 2018. The gas is flowing and for the well's owner, Cuadrilla, the money is already rolling in.



Yet, so are the complaints. Even before the drilling started, local residents and councillors were tirelessly working against the government to stop the reopening of this site. Protests have been all but constant since the 2011 moratorium was threatened to be lifted. On the opening day, activists and protestors attempted to blockade the fracking site in order to postpone the opening. Several protestors were even arrested (and later released) for this act. Local councils in the area have also been fighting against the issue. So what is all the fuss about? Why has fracking become such a controversial issue on the UK agenda?

What is fracking?

Fracking is short for hydraulic fracturing. Since the 1970s, it has been used to extract gas or other fossil fuels trapped underground in shale or other rocks. It involves pumping a mixture of water, chemicals and sand down a well at extremely high pressures. This mixture is forced into fissures within the rock to create fractures and release the gas or oil trapped inside. This will then flow to the surface to be collected.

The sand inside this "stimulation fluid" is used to keep the fractures open and the chemicals are used for purposes such as lubrication and keeping out bacteria.

Why is it controversial?

Despite the UK government repeatedly saying that fracking is safe for both human health and the environment when properly regulated, many reports have been published disputing these claims. Fracking has been linked to an increase in seismic activity, water contamination and air pollution.

Fracking related earthquakes were the original reason why the UK moratorium was imposed in 2011. And inevitably, the first 10 days of the Cuadrilla site's opening saw 11 cases of seismic activity recorded, two of which were strong enough to shut down drilling operations according to new regulations. Yet, the company continues to drill. And the US sees a similar story. The state of Oklahoma putting fracking down as the sole cause of a millennium's worth of earthquakes seen there.

Water contamination is also a huge environmental risk. In the US it has made some water supplies undrinkable, usually caused by wrongly disposing of waste. Luckily, the UK government has put strict regulatory restrictions on the chemicals used in fracking processes. Leaks from fracking in the UK will be far less risky than those in the US.

In addition to increased water pollution, fracking also contaminates the air. A recent report states that the levels of air pollutants such as nitrogen dioxides and volatile organic compounds were substantially higher in local areas that surrounded fracking sites. There have been many studies linking high levels of air pollution to increased risk of respiratory and other, life threatening illnesses as well as lower development in babies and young children.

None of this, of course, begins to even touch on the biggest problem with fracking. Pro-fracking arguments detail how gas is much cleaner than other fossil fuels like coal. It is a bridge between these dirtier fuels and the clean, renewable technologies we are aiming towards.

However, the product extracted at the end of the process is still a fossil fuel and when it is burned, it still contributes to climate change.

We only have limited amount of fossil fuel we can extract and burn before we are guaranteed to exceed the 2C warming level set by the Paris Climate agreement. Large scale fracking in the UK will guarantee we zoom past the legally binding targets that were set. We should be investing in renewable technologies now, not searching and opening new sites for more fossil fuel extraction.

Future?

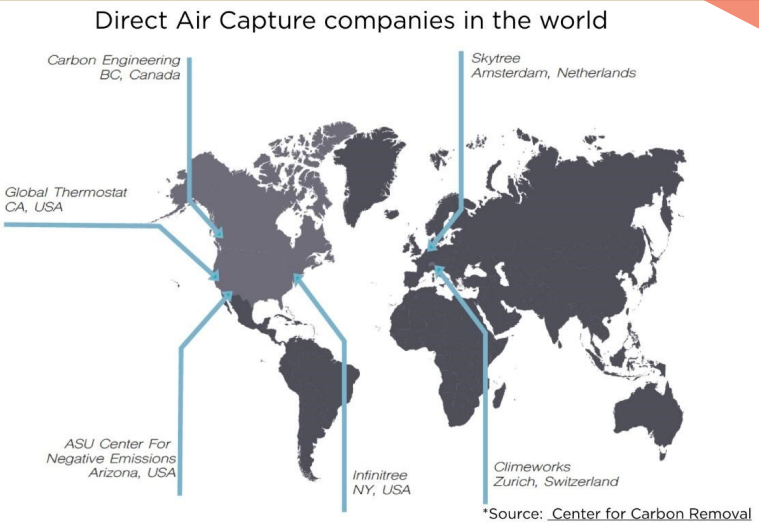
The future of fracking in the UK does not look promising. Although there are other fracking sites hoping to reopen, continuous local protest and activism have delayed this indefinitely until certainty can be guaranteed. As of January, the Greater Manchester council plan to put in measures to stop companies from fracking. And with Brexit currently on the forefront of every UK Member of Parliament, it is unlikely to be brought back into the limelight anytime soon.

The fracking revolution looks to stay on American soil, for now. Markets are increasing in China but companies there are unlikely to be looking to expand into EU. Time will only tell how much this recent boom will affect the balance of oil super powers around the world and whether or not it can overpower the people's voice in UK.

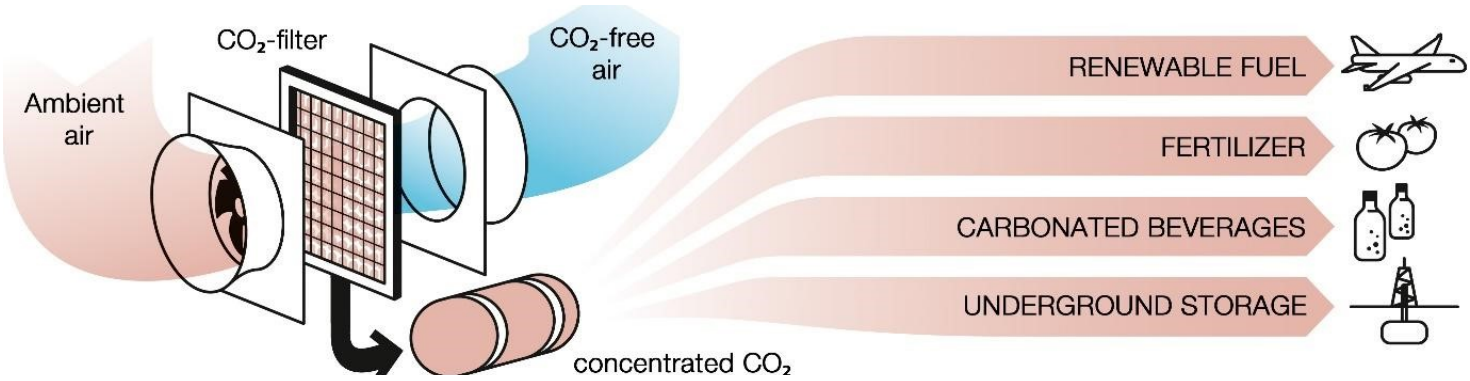
Direct Air Capture & CO_2 Utilization

Stella Chatzisakoula

During the last decades and with the insight of 2020, or better of 2050, the increase of CO_2 emissions is alarming and more and more technologies have been introduced to prevent this increase. These techniques either include the use of renewable energy technologies, which would lead to the overall reduction of CO_2 emissions, or on the other hand technologies that could capture the emitted CO_2 and utilize it further for the production of valuable products, fuels and chemicals.



Capture of CO_2 appears to have great potential in the energy sector and it can be considered to be a mature technology, since its efficiency has been improved overwhelmingly over the years. However, it should be noted that capture of CO_2 refers to pointed sources, meaning flue gases from industrial processes, where the quantities of CO_2 emissions are large and way more concentrated. The concentration of CO_2 in the atmosphere has been measured in the beginning of this year to be around 410 ppm (0.04%), while a common flue gas from an energy intensive process may reach concentration of 12%.



The concentration of CO_2 in the atmosphere has significantly increased during the years, which makes the necessity for strict measurements imperative. Direct Air Capture (DAC) is a novel technology that is used to capture the air and filter the CO_2. Then use the concentrated CO_2 into various applications, including the production of renewable fuels like methane and methanol, the production of fertilizers, carbonated beverages, or even use this captured CO_2 for storing underground. All the aforementioned applications could revolutionize the world's transport industry, as well as the chemical industry. Direct Air Capture is a process that is used by various companies throughout the world, making it more and more attractive to implement.

So, Air2Fuel technology is a potentially game-changing technology, which if successfully scaled up will allow to harness cheap, intermittent renewable electricity to drive the synthesis of liquid fuels that are compatible with modern infrastructure and car engines. So, it could be an effective replacement of fossil fuels and a complement to electric vehicles.

To avoid runaway climate change, emissions must become "net negative", which literally means more carbon being removed than emitted. These negative emissions technologies are unavoidable and vital to be implemented. However, this shift cannot be done fast enough and this transition cannot happen overnight. This is the only large-scale solution and needs to be done no matter what.

What is the Delft S.E.A.?

Yitzi Snow

If you are a part of SET, you have probably had some experience with the Delft Sustainable Energy Association (S.E.A). Perhaps you've eaten a free sandwich at one of our lunch lectures. Maybe you've had a drink with us at a pubcrawl. You definitely know about our magazine; you're reading it right now! But what is the Delft S.E.A? Why do we exist? And how can you get involved?

The Past:

The Delft Sustainable Energy Association is the official study association of the Sustainable Energy Technology (SET) program at TU Delft. Study associations are common at TU Delft, existing for many faculties and studies, and they are often critical in helping students have the best possible experience at the university. The goal of these associations is to help students academically, socially, and professionally. That's why, in 2016, five SET students decided to create a study association of their own: Delft S.E.A was born.

The first board of the Delft S.E.A. - left to right: Ali Chamseddine, Hemant Sharma, Ibrahim Diab, Frank Vollering, Carlos Maquiera

The first board began its term in September 2016. Every six months, half of the board was replaced, with each member serving a one year term. Two and a half years later, the association is still going, stronger than ever.

The Present:

Every year, the SET program grows and changes, and Delft S.E.A is growing and changing with it. We remain committed to supporting SET students, both before and after graduation. With these goals in mind, we maintain a LinkedIn page for students and alumni to remain connected. If you have issues with a course or exam, reach out to us so we can help.

If you are looking for a job or internship, check out the vacancies we post on our website and Facebook page. We are constantly hosting events such as lunch lectures, city tours, excursions, pubcrawls, alumni events, and our annual study tour. And of course, there is SET Match, the magazine for all things related to sustainability and SET!

The current board - left to right: Asvin Sajeev Kumar, Yitzi Snow, Senja Boom, Josu Etxebarria and Peter Blom

(Photo: Stella Chatzisakoula)

The Future:

Are you excited about Delft S.E.A? Here's how you can get involved:

Join a committee or the board! The magazine committee is currently seeking new writers, and the City Tour and Study Tour committees will both start looking for new members in the fall. If you want to join the board, we are looking for a new President, Secretary, and Commissioner of Events to begin in April! Information about interest drinks will be released soon.

Even if you aren't on the board or committees, you can still become a member!

Register with the ETV, at their desk on the ground floor of EEMCS. There is a one-time entrance fee of ten euros, and you get discounts and priority at all kinds of S.E.A events. As an added bonus, you get discounts on textbooks and free coffee!

Finally, if you enjoy the events that we host, be sure to keep an eye on our website or Facebook page! We are proud of everything that we do for the SET community at TU Delft, and we hope to continue that work for years to come.

Magazine Committee

The Magazine Committee is responsible for writing, editing and publising the SET Match magazine of Delft S.E.A. The magazine is published every quarter and contains articles, interviews and columns about sustainable energy, culture and academics. In addition, companies with interesting projects or vacancies in the SET sector are covered.

Members:

Yitzi Snow (chair)
Megan Atkins
Stella Chatzisakoula
Casper Eijkens
Carlotta Ferri
Leo Franco
Kritika Karthikeyan
Andrew Keys
Bertram Peterson
Thomas Spruit
Thanasis Vasileiadis-Sakatias