REDDIE & GROSE

London | Cambridge | Munich | The Hague

Sustainable Future

Exploring innovations for the Energy Transition and a Circular Economy

ISSUE TWO

SUMMER 2022 EDITION

This issue at a glance

From the Editor

Some months on, countries around the world are processing the global agenda set at COP26. The summit in Glasgow brought into stark focus the challenges faced by the global community in combatting the effects of climate change. And now, Russia's invasion of Ukraine has created more challenges for the global economy, emphasizing Europe's dependence on Russian oil and gas, and bringing energy to the forefront as a matter of national security.

Against this background the need for innovation into green, sustainable technologies, especially in the energy sector, seems clearer than ever. While patents continue to play a significant role in stimulating innovation, what the patent system cannot do by itself is drive innovation in a particular direction or to a specified time scale. To achieve net-zero by 2050 and stand any chance of keeping global temperature increases to less than 1.5 degrees Celsius, we cannot sit back and wait for technology to evolve at its natural pace. Intervention by policy makers – in forms such as regulation, incentivisation and public sector funding – is likely to be a key driver in ensuring that technology can evolve at the right pace and in the right areas over the coming decades.

And we have to ask the question, are patents a good thing? While the patent system works well as a way of stimulating innovation, there are also negative implications that should not be ignored. The exclusivity that brings financial return for investors can lead to high pricing that limits access to new technologies, especially in developing economies. Allowing one player a dominant position in a particular sector can suppress competition which, in turn, can stifle further innovation.

On balance, we would suggest that the good outweighs the bad. The incentives to openly innovate afforded by the patent system drive forward innovation in a way that could not be achieved otherwise, and patents provide clarity over ownership of innovation that, handled correctly, encourages collaboration between companies that might traditionally have regarded one another as competitors.

Perhaps this is where policy has a role to play. In the telecommunications sector we have seen policy step in to set fair and reasonable licence fees for patents to technology that is essential to operation according to industry standards. Might there also be a case for policy to do the same in relation to patents for technology deemed essential to combatting climate change, or to otherwise ensure a more equitable IP system? And surely we should be seeing policy incentives built into the patent system aimed at encouraging green innovation.

In this second edition of Sustainable Future, we take a look at a range of innovative and sustainable technologies, including medium-long term energy storage, heat pumps, carbon capture, geothermal energy, and the practicalities of recycling solar panels. We've also been giving some thought to just how modern some climate change mitigation technologies really are. In this issue we've taken a look at some historical patents to find some early examples.

At Reddie & Grose, we are dedicated to green innovation in all its aspects. Our attorneys are experts in a range of technical disciplines, and are well placed to handle the diverse technologies underpinning the energy transition and the circular economy. We pride ourselves on listening to our clients, and offer expert and pragmatic advice that is tailored their needs. If you have a question about IP, or about any of the issues discussed in this magazine, please do not hesitate to contact us.

Georgina Ainscow • Editor

Meet some of the team…

Georgina Ainscow • Editor, Partner

Georgina is a UK and European Patent Attorney who regularly reports in the media, providing an IP perspective on developments in renewable energy. She specialises in hi-tech electronics, software and AI based inventions and can advise on protecting innovation relating to digitalisation of the energy sector.
Email her at georgina.ainscow@reddie.co.uk, or click here for her full bio.

Dr Alan Bates • Partner

Alan's background is in Metallurgy and Materials Engineering and much of his current work involves aspects of materials science. Much of Alan's current work involves aspects of materials science, and he deals with clients involved in technologies such as metal extraction, medical equipment and implants, and semiconductor devices. Alan also handles work from wider engineering fields such as mechanical devices and radar technology.
Email him at alan.bates@reddie.co.uk, or click here for his full bio.

Andrew Carridge • Partner

Andrew handles patents in areas including fractionating lignocellulosic biomass; production of biogenic activated carbon; producing fuels, electricity and raw materials using algalderived biofuels; and catalytic conversion of alcohols to hydrocarbon blendstock.
Email him at andrew.carridge@reddie.co.uk , or click here for his full bio.

Duncan Nevett • Partner

Duncan has gained extensive experience working across a range of technologies, reflecting his background in physics. Areas of particular expertise include: the energy sector (both conventional oil & gas as well as renewables); medical devices; cooling and general airflow systems; smartphones; consumer products; packaging; high-speed manufacturing machinery; and various IoT and software-related inventions.
Email him at duncan.nevett@reddie.co.uk , or click here for his full bio.

Nick Reeve • Partner

Since studying climate change in his final year MSc Physics project more than 20 years ago, Nick has a huge interest in renewables and sustainability innovation. Nick is a fluent Japanese speaker; he primarily handles patents for electronics, electrical devices and computer implemented inventions.
Email him at nick.reeve@reddie.co.uk , or click here for his full bio.

Gillian Taylor • Partner

Gillian handles patent work in the chemical and mechanical fields, including food technology, manufacturing processes, wind turbines, building materials and packaging.
Email her at gillian.taylor@reddie.co.uk , or click here for her full bio.

Alex Cope • Senior Associate

Alex Cope handles patents within the electrical, electronics & telecoms and software & business methods fields. He has an interest in the renewable energy sector and has experience handling patent applications relating to solar cell power conversion and control units for wind turbines.
Email him at alex.cope@reddie.co.uk, or click here for his full bio.

Dr Dustin Bauer • Associate

Dustin handles patent work in the engineering, materials and consumer products fields. He is a native German speaker who has a PhD in Materials Chemistry, focussed on the hydrothermal synthesis of nanoparticles for use in a range of energy storage devices. Dustin is interested in renewables and automotive engineering, especially solar cells, fuel cells, and electric vehicles.
Email him at dustin.bauer@reddie.co.uk , or click here for his full bio.

Meet some of the team...

Dr Ben Hipwell • Associate

Ben handles patent work in the electrical engineering and software field. His PhD focused on development of new magnetic resonance imaging (MRI) techniques for studying cancer, computational modelling of water diffusion processes in tissue, and applying machine learning algorithms to infer tumour properties from raw MRI data. His areas of expertise include medical devices, biophysical modelling, artificial intelligence and image/ video processing algorithms.
Email him at ben.hipwell@reddie.co.uk, or click here for his full bio.

Lizzie Alexander • Assistant

Lizzie joined Reddie & Grose in 2019 having graduated from the University of Nottingham with a masters in theoretical physics. She works in the fields of electronics, electrical devices and software. During her final year project she developed an equation based on techniques that allow strongly coupled quantum theories to be studied at experimentally unattainable energy scales using known physical laws.
Email her at lizzie.alexander@reddie.co.uk, or click here for her full bio.

Matthew Booth • Assistant

Matthew joined Reddie & Grose in January 2021, he works in the fields of electronics, electrical devices and software. During university Matthew took a particular interest in areas such as medical physics, laser physics, optoelectronics, and condensed matter physics.
Email him at matthew.booth@reddie.co.uk, or click here for his full bio.

Olivia Buckingham • Assistant

Olivia joined Reddie & Grose in January 2021 after graduating. In her final year she completed a research project focused on developing experimental and computational methods for the creation and analysis of Bose-Einstein condensates.
Email her at olivia.buckingham@reddie.co.uk , or click here for her full bio.

Lucy Harvey • Assistant

Lucy handles patent work in the biotechnology & pharmaceuticals sector. Her research masters involved developing in vitro models to study angiogenesis. In particular, her work focussed on developing a VEGF-dependent tubulogenesis assay for studying the pro-angiogenic effects of VEGF, a growth factor which is upregulated in many cancers.
Email her at lucy.harvey@reddie.co.uk, or click here for her full bio.

Dr Dongyoung Kim • Assistant

Dongyoung handles patents in the fields of semiconductors, photonics, electronics, and electrical engineering. For his Master's research, Dongyoung worked on the mechanical and electrical properties of ZnO nanowires, for which he awarded the best MEng project of the year by the department.
Email him at dongyoung.kim@reddie.co.uk, or click here for his full bio.

Daniel Marchant • Assistant

Daniel handles patent work in the engineering, materials and consumer products fields. Daniel completed a summer research placement in computational chemistry at the University of Pittsburgh where he co-authored a paper on 'Branched-Selective Direct α-Alkylation of Cyclic Ketones with Simple Alkenes'.
Email him at daniel.marchant@reddie.co.uk, or click here for his full bio.

Katie Smith • Assistant

Katie has a Master's degree in Chemical Engineering and handles patents in the chemical and mechanical fields. During her placement year, Katie worked as a Process Engineer implementing operational improvements within Industrial Gas facilities.
Email her at katie.smith@reddie.co.uk, or click here for her full bio.

Food Waste

One Man's Household Trash is Another Man's Treasure

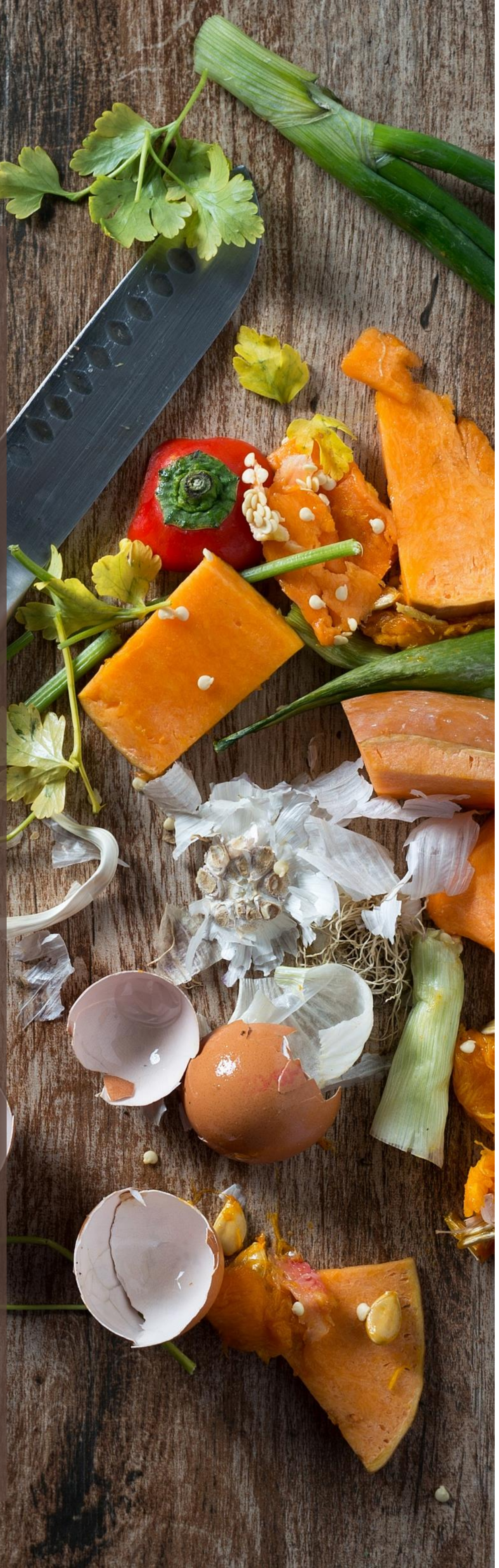
In 2021, the UK Government made separate food waste collection mandatory for households in England by 2023. This legislation, imposed as part of the Environment Act 2021, is designed to accelerate the transition to a circular economy and tackle significant challenges of waste generation.

In England, 50% of local councils are currently collecting food waste separately or as part of their green waste collection. However, some 6.6 million tonnes of household-produced food waste is either disposed of in landfill or incinerated, where it emits carbon dioxide and methane gas as it breaks down. These gases are released uncaptured into the atmosphere, resulting in net carbon release.

According to Kerry Mashford OBE, Energy Strategy Lead for Worcestershire Local Enterprise:

"Waste collection and disposal authorities will need to work fast to devise local solutions across the almost 50% of Local Authorities that do not currently provide separate food waste collection, and potentially modify the rest to comply - all for implementation during 2023/24."

Anaerobic digestion (AD) technology is now increasingly employed across the UK to generate useful products from waste, particularly food waste. In 2021, industrial capacity for food waste recycling using AD was 3.2 million tonnes of input. With the introduction of mandatory separate food waste collections, millions of tonnes of additional food waste will become available for processing. This naturally shines the spotlight on capacity, and whether the country has a sufficiently sized infrastructure to deal with the new



model. Until the industry expands and develops to catch up with supply of refuse, excess waste will have to travel greater distances to sites which might have spare processing resource. This may bring unwelcome offsetting of CO2 emissions and transport costs, meaning that the country could be creating more carbon emissions by transporting waste than it is capturing carbon by processing it.

As Kerry Mashford comments:

"We need to consider how food waste collection will fit in the wider energy system, using this opportunity to advance the energy system transition to a net zero future, by carefully considering the size, distribution and siting of AD plants, including potentially closer coupling of these to local uses of biogas such as in heat networks or commercial vehicles."

All of this highlights the need for innovative means and measures to process food waste effectively.

Biogas

Food waste is a fruitful source of green gas, with much greater methane production potential as other starting materials for AD. As energy prices soar and the world looks towards renewable energy generation and energy independence, capturing the energy from food waste has gained large-scale governmental and industrial attention.

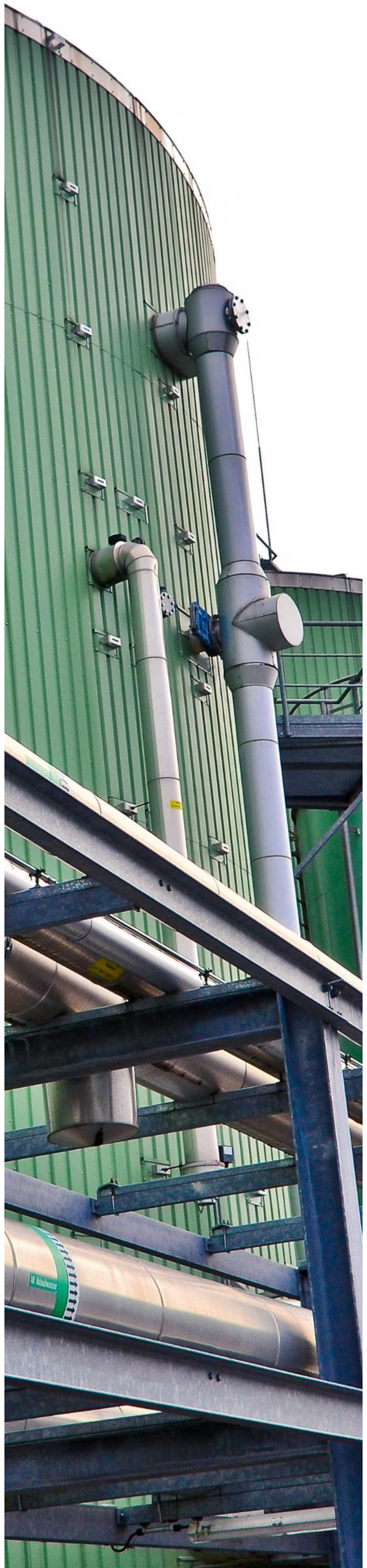
AD is a series of processes in which microorganisms break down organic matter in the absence of oxygen to produce biogas and digestate. Biogas is a mixture of gases, primarily carbon dioxide and methane. The mixture can be used directly to power houses and factories, or fuel vehicles and enter the National Grid if upgraded to biomethane (pure methane produced from biogas). The relative quantities of each gas produced varies depending on the biological agents involved in the reaction and the reaction conditions.

Biomethane is the most useful component of biogas, and so efforts are being made to tilt the balance towards production of methane and away from CO2.

Patent databases indicate that the control and measurement of reaction parameters is the subject of earlier research in the field, whereas more recent advances relate to optimising biogas output through developing novel bioactive compositions. For example, European patent no. 3808850 B1 provides biological cocktails of a consortium of bacteria and enzymes, with an optional host of biostimulants, which enhance methane production. Further innovation in the field focuses on the pre-treatment of food waste before it is processed. Chinese patent application no. 106698879 discloses hydrothermal hydrolysis pre-treatment of food waste to improve AD efficiency and methane production.

Digestate

Another huge focus of food waste recycling is on the production of biofertilisers, such as digestate. Digestate is the material remaining after the digestion process, and contains all of the recycled nutrients that were present in the original organic material but in a form more readily available for plants to absorb. Biofertilisers restore the fertility of the soil after crop production, and enhance water-holding capacity of the soil, which are gradually lost with prolonged use of chemical fertilisers. Again, a lot of innovation is in directing the digestion process towards producing valuable digestate, including enzyme and bacteria additives and reaction parameters.



Challenges facing the food waste collection scheme

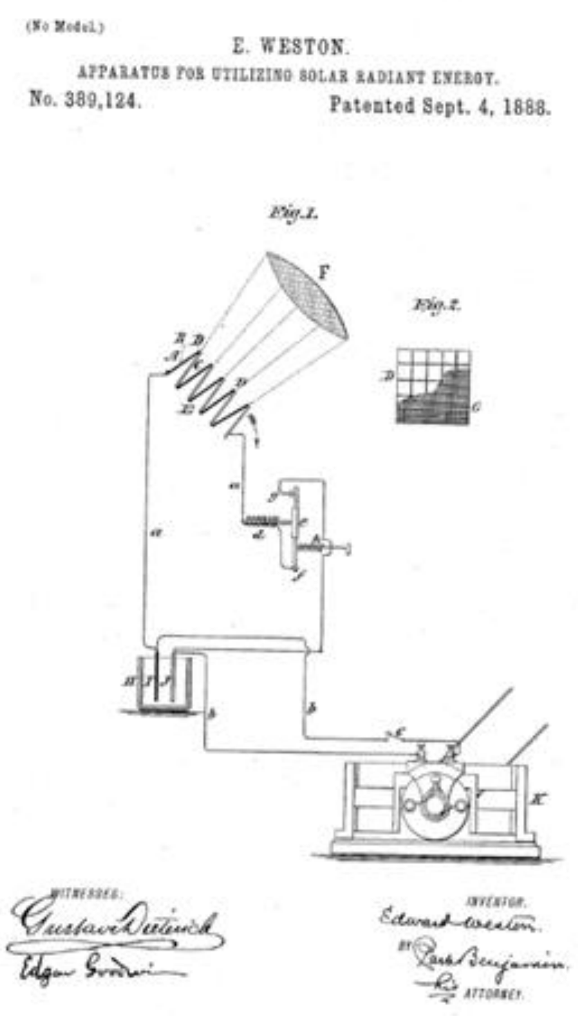
The UK government is currently offering £295m of funding to go towards the collection of food waste (e.g. procuring new vehicles). However, the costs of processing, disposal and building new treatment facilities will need to come from local authorities. Lack of governmental funding is limiting critical developments in infrastructure required to process additional residential food waste.

One potential solution to this financial problem has been developed by Ørsted. Ørsted has created a first-of-a-kind technology called Renescience that is able to greatly increase recycling rates from unsorted refuse, negating the need for refuse sorting. The technology mixes water and enzymes with municipal waste, breaking down all organic material, such as food waste, labels and food that adheres to packaging and cans. The resulting bioliquid is drained and can be sent to an anaerobic digestor to produce biogas and digestate. The technology also simultaneously sorts the remaining refuse according to material composition, such as metal and plastic, for further recycling.

Ørsted's bioenergy facility in Northwich, Cheshire, treats approximately 80,000 tonnes of waste per year, equivalent to waste from around 70,000 homes. Technology like Renescience may lessen the pressure on funding for separate collection of food waste, which can be directed towards further innovation in this area instead. However, unless more funding is provided to the AD sector, incapacity to process an increased supply of food waste will have knock-on effects for the government's 2050 net zero target.

Author: Lucy Harvey

There's nothing new under the sun #1 – Solar voltaic energy

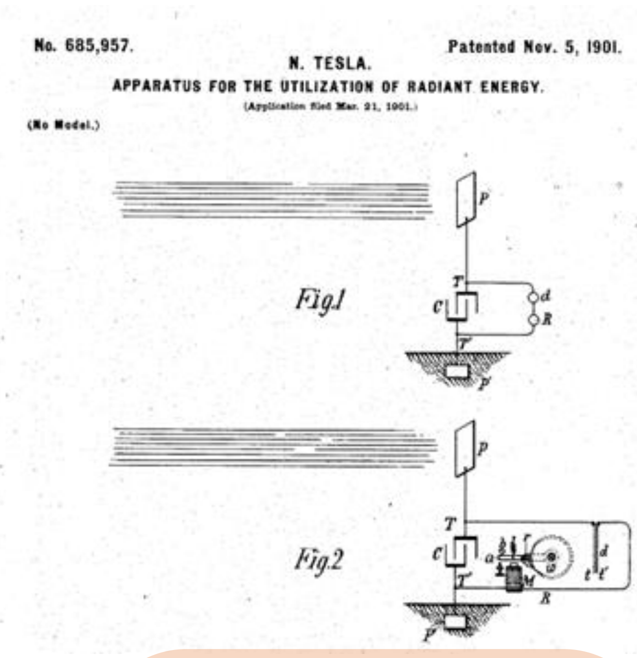


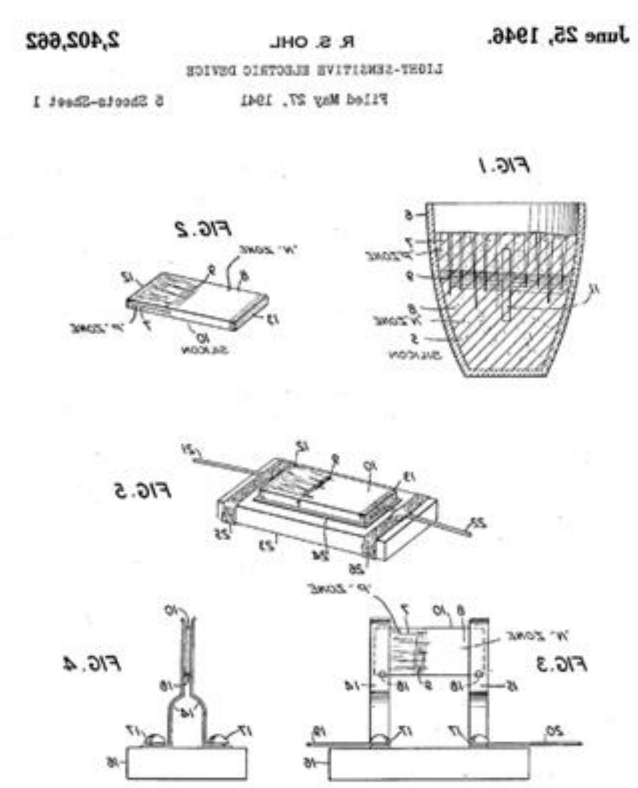
Solar panels are a cornerstone of modern renewable technology. They can be deployed on under-utilised land as solar farms, on individual buildings and vehicles, and can even be small enough to wear. 29,000 patent applications were published in the solar voltaic field in 2021*. But when were the earliest patent filings in this area?

The photovoltaic effect was discovered in 1839 by Edmond Becquerel. Almost 50 years later, in 1883, the first solar cells were invented by Charles Fritt. In 1888, US patent 389,124 was granted to Edward Weston for *"The combination of a thermopile, a means (such as a mirror or lens) arranged to concentrate or converge solar rays thereupon, and a secondary or storage cell in circuit with said thermopile, substantially as described."*

Weston's patent relates to an attempt to concentrate the sun's rays onto a solar panel, which was needed due to the extremely low efficiency of the early solar cells.

Solar technology has historically attracted some great names, including Nikola Tesla. This image is from Tesla's 1901 US patent 685,957, for an apparatus for the utilization of radiant energy.





Efficiency remained a problem that restricted the use of early solar cells, but developments continued in first half of the 20th century. In 1946 Bell Telephone Laboratories were granted US patent 2402662 for a photovoltaic cell formed using columnar silicon crystals. The efficiency of solar panels at this point had improved to about 6%.

With the most efficient solar panels now approaching efficiencies of 50%, we have come a long way. However, there remains room for further work if we are to approach the maximum theoretical efficiencies of over 80%.

*Search performed using the Y02E10/50 patent classification code.

Author: Dr Alan Bates

The Role of Geothermal in the Green Energy Mix:

Geothermal energy has long been used as a direct source of heat and for generating electricity, with a global installed electricity capacity of 15,608MW in 2020. And yet today, geothermal sources still provide only a fraction of the world's energy needs. As the world faces a growing energy crisis, could the time could be right for its wider scale adoption? Many experts see geothermal energy as an essential component in the future energy mix.

Geothermal energy utilises heat generated during the formation of the planet and sustained by radioactive decay. Since it can be used without being depleted it fits the definition of renewable energy. The flow of heat to the Earth's surface is estimated at between 43 and 49TW, which more than doubles humanity's current consumption, but geothermal energy extraction has traditionally been constrained to regions with active volcanoes or where plate boundaries merge.

In these regions, the Earth's internal heat is accessible at or close to the surface. One of the most active geothermal areas is called the Ring of Fire, which encircles the Pacific Ocean and is home to New Zealand, Indonesia, the Philippines, Japan, the west coast of the US and Mexico. All of these regions are represented in Think GeoEnergy's Top 10 Geothermal countries for 2021. A list which also includes Turkey, Italy, Kenya and Iceland, all countries known for their volcanic activity.

However, as evidenced by the Eden Geothermal project in the UK, the geographical reach of geothermal energy utilisation has been broadened by developments in deep-drilling techniques, which allow access to high temperatures in the Earth's mantle two to three miles down. At these sorts of depths, hot water or rock can be accessed across much of the planet, meaning that utilisation of geothermal energy is not so geographically constrained. Indeed, research has shown that when geothermal energy is developed, it will be capable of providing around 20 per cent of the UK's current electricity demand plus a vast amount of heating.

Patent trends in geothermal energy*

Evidence of innovation relating to deep-drilling is supported by patent data, where geothermal energy filings for drilling techniques come second only to heat pumps, with over 8,000 patents in the last 10 years.

There is also substantial patent activity relating to three types of geothermal power station. Each operates in a different way, but implements the same basic design of drawing hot water and steam from the ground to spin turbines and generate electricity. Traditional dry steam geothermal power stations show the most patent activity, with over 5,000 patents filed in the last 10 years, while there are nearly 4,000 filings for more complex (and more common) flash steam power stations. Both rely on high temperatures: 150°C or higher for dry steam and 180°C or higher for flash. By contrast, more recent binary cycle power stations are able to utilise fluid temperatures as low as 57°C. To date, filings in this area are lower, at nearly 2,000. However, lower temperatures bring greater flexibility and this, coupled with advances in deep-drilling, has the potential to see geothermal energy utilisation more widely deployed in the future.

Another key area of development for geothermal energy is remote sensing, where nearly 4,500 patents were filed in the last 10 years. These are sophisticated devices and techniques, many using AI to advance geothermal exploration. Technical advances have the potential to drive down the cost of exploration and reduce risk to investors.

Heat pumps account for over half of patent filings officially tagged as geothermal energy in the last 10 years. While many of these filings relate to ground source heat pumps which utilise solar energy absorbed at the Earth's surface rather than geothermal energy in a strict sense, the high patent activity is an indicator of innovation in an area that has potential to reduce reliance on fossil fuels and drive down emissions.

Geographical distribution of patent activity

Geographical distribution of patent activity gives insight into the location of technology centres with specialisms in different aspects of clean energy innovation. According to an EPO/IEA report, centres in Europe, Japan and the US dominate, accounting for more than three quarters of patent filings since the turn of the century. South Korea and China are some way behind, but show a sustained increase in recent years.

Japanese, US and South Korean companies all appear in the top 10 applicants in the period from 2010-2020 with Toshiba heading the list, followed by Haliburton and GE. However, the top 10 companies account for only 6.5% of total filings, indicating a spread of applicants in this open and emerging field. And if we look at where these applicants are filing patents, China dominates, followed by the US, Japan, South Korea, Australia, Canada and Germany.

Notably, the geographical distribution of patent activity in geothermal energy does not correlate directly with production. While the US and Japan are both listed in the top 10 producers of geothermal electricity, China is not. The use of geothermal resources in China has a long history, but large-scale exploration and development only began more recently.

For decades, low-temperature geothermal resources in China were directly utilised, but geothermal energy generation is still in its infancy, which may explain China's absence from the top 10 geothermal energy producers, despite a high level of R&D.

Indonesia and the Philippines also present interesting anomalies. They occupy the number 2 and 3 spots in the top 10 geothermal energy producers. Indeed, with measures in place to reduce reliance on coal, Indonesia looks set to move to the number 1 spot. However, we see very few patent filings in these countries, suggesting that applicants may be neglecting key territories. The finding reflects a challenging patent environment and barriers to licencing and commercialisation of IP assets in both countries. The US Chamber's International IP Index, which scores countries on the strength of their IP systems, ranks Indonesia 51st out of 55 countries, with a score of 30.42%, and the Philippines 37th, with a score of 41.58%. However, this could change over the 20 year lifetime of a patent and applicants for geothermal energy technologies would do well to give thought to filing patents in countries where geothermal energy plays a key role in the economy.

Patent activity by research organisations

Another interesting statistic to come out of the EPO/IEA report is that

patent filings in the geothermal energy field originating from public research organisations and universities has increased from 2% in the period from 2000-2009, to 11% in the period from 2010-2019. Although this is not high compared to areas such as carbon capture and bioenergy, an increase in interest by research organisations often precedes increased activity on an industrial scale and should be regarded as a positive sign for geothermal energy.

At present, geothermal energy is a small but important player on the global energy stage. In those countries where geothermal resources are easily accessible, geothermal solutions present a clean, reliable and consistent source of heat and electricity. And improvements to geothermal exploration, deep-drilling and utilisation of lower temperatures have the potential to make geothermal energy accessible more widely.

*Patent searches performed using the Y02 patent classification code, which tags technologies for mitigation or adaptation against climate change.

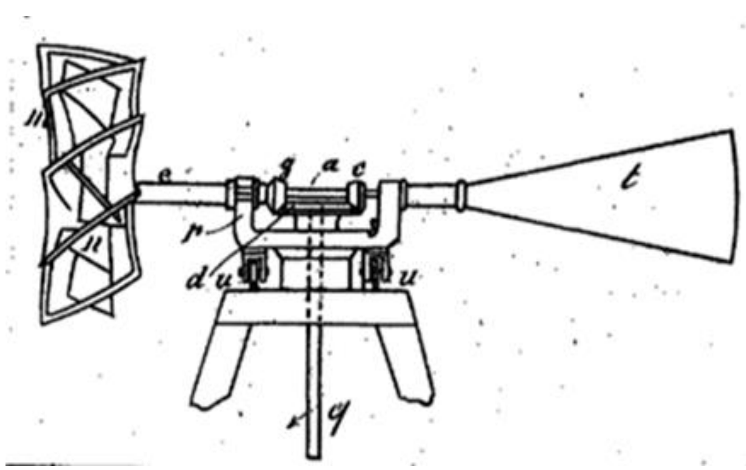
**based on an article recently published in Energy Global Magazine

Author: Georgina Ainscow

There's nothing new under the sun #2 – Wind turbines

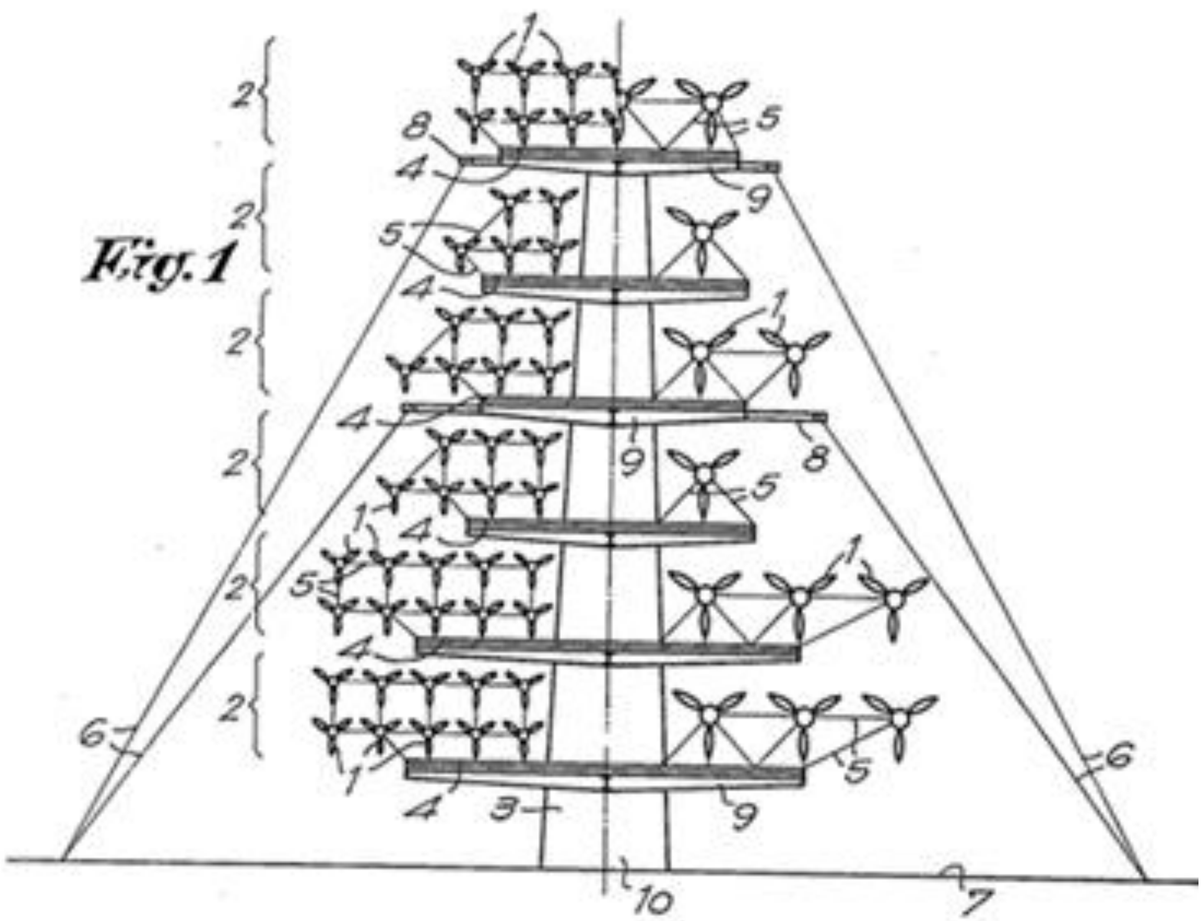
Wind turbines can be utilised on a large scale in offshore wind farms, or on a smaller scale to, for example, power individual street signs. 11,000 patent applications relating to wind energy were published in 2021*. We look at some early patent filings to see where these developments have their roots.

Windmills capable of grinding grain existed as early as the 9th century. However, the first machine using wind power to generate electricity was built in 1887 by James Blyth, and patent filings were not far behind.

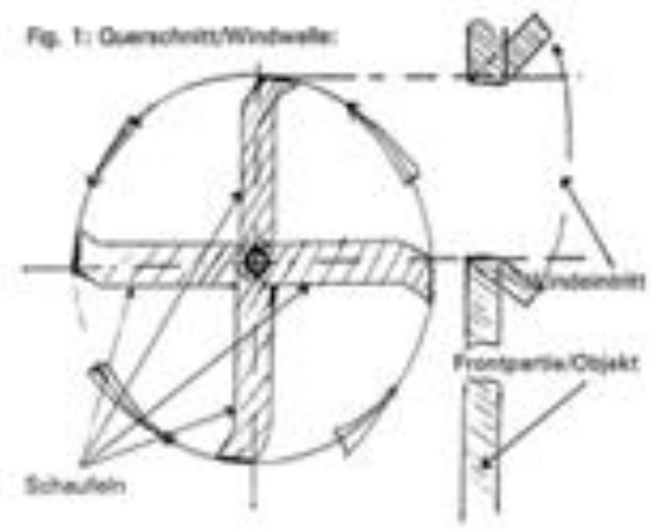


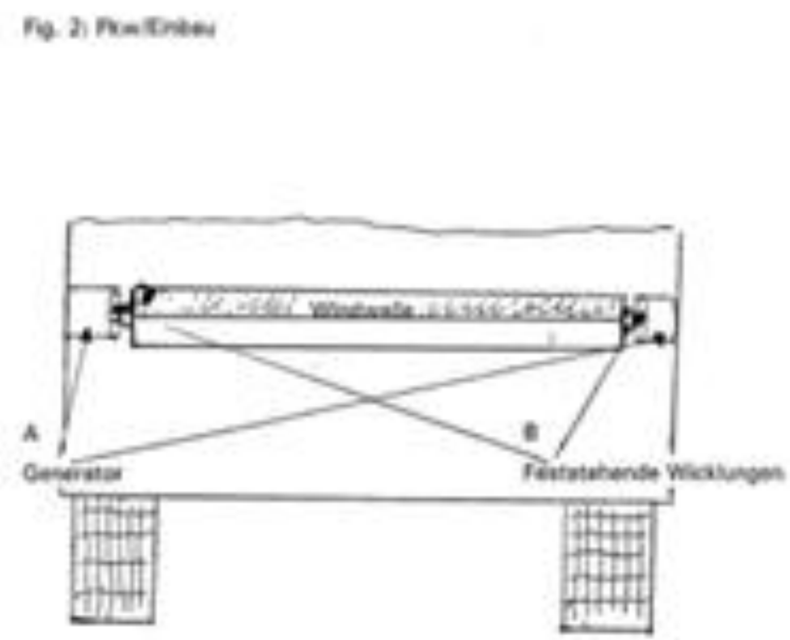
British patent application GB189321510A, filed by Ridley James Urquhart in 1893, discusses a compound propeller as "wheel for wind motors or mills", and was capable of turning to face the direction of the wind.

A problem faced by modern wind turbines is the ability to cope with high winds. Swiss patent application CH241186A, filed by Germaine Van Der Veken in 1989, proposes an arrangement of six turbine branches at different altitudes, all attached to a central stem. Van Der Veken purports that “Wind turbines at different altitudes can be engaged either individually or in stages, so that when high-altitude winds attain dangerous velocities the lower-level turbines may continue in operation.”



German patent application DE19708624A, filed by Harald Lorek in 1997, details a wind turbine that can be attached to a car, train or aircraft. Similar designs attaching wind turbines to vehicles have been the subject of serious research over the years.





The Global Wind Energy Council estimate that wind turbine technology could provide 30% of the world’s electricity by 2050, up from 3% in 2014. It is clear that wind turbine technology will play an increasingly important role in the world economy as governments seek to replace fossil fuels.

*Search performed using the Y02E10/50 patent classification code.

Author: Matthew Booth

RECYCLING SOLAR PANELS – Completing the sustainability cycle of photovoltaic power generation

The solar energy industry has seen an extremely rapid development in the past decade. In 2020 alone, we saw over 127 GW of new photovoltaic (PV) power generation capacity installed, leading to the total global PV power generation capacity of 707.5 GW (702.9 GW on-grid and 4.584 MW of off-grid) at the end of 2020. This means more than one fifth of renewable energy in the world today is generated by PV technology.

Solar boom

This recent "solar boom" has been driven by technical advances in PV technology which have allowed for not only the optimisation in gathering and producing energy, but also a reduction of its associated costs. According to IRENA's recent report, the global weighted-average total installed cost of utility scale solar PV fell from 4 731 USD/kW to 883 USD/kW between 2010 and 2020. Over the same period, the levelised cost of electricity (LCOE) from utility-scale solar PV also fell by 85% between 2010 and 2020, recording 0.057 USD/kWh. This figure is comparable to that of coal-fired power generation (which is the cheapest fossil-fuel competitor) option available in 2020 (0.05 USD/kWh). Given the cost savings over fossil fuels projected in the years to come alongside international efforts to respond to climate change, the rapid growth of global solar PV capacity is expected to continue for the foreseeable future.

"Dying" solar panels

However, whilst this should be welcome news in view of energy transition, the already large and increasing number of solar panel installations inevitably leads to a problem: What happens to solar panels when they reach the end-of-life (EOL)? So far, EOL disposal of solar panels has not caused too much concerns as solar panels only started being widely deployed in the early 2000s and the industry standard lifespan of solar panels is about 25 to 30 years (although many believe that the actual lifespan may be as long as 35 to 40 years). However, given that most of the solar panels in the world were installed in the past decade (2011-2020) we are likely to see a sudden increase in the number of dead solar panels starting from mid-2030s. To give you a rough idea, PV panels installed in the past decade provide 640,225 MW total capacity which is equitant to over 2 billion 300W solar

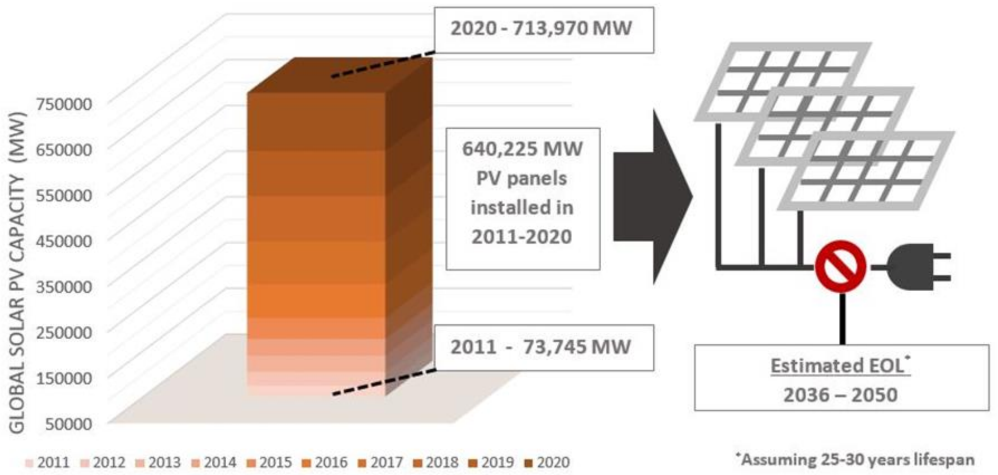


Figure 1 Global solar PV panel installations in 2011-2020 (data from IRENA) and estimated EOL for panels installed in 2011-2020

EOL management of solar panels

The above mentioned mid-2030s timeline may make you think that it's too early to worry about EOL management of solar panels. However, there are many good reasons why we should start taking this issue more seriously now.

The good news is that many governments have already started introducing frameworks for recycling, reusing and, if neither is possible, disposing of dead solar panels. For example, in the UK and many European countries, collection, recycling and recovery targets for all types of electrical goods, such as solar panels, are set according to the Waste Electrical and Electronic Equipment Directive (WEEE Directive). It is questionable, however, whether the capacity of the existing recycling facilities dedicated to electrical and electronic waste would be able to cope with the ever-increasing volume of solar panel waste. Moreover, conventional recycling processes for general electrical and electronic waste may not be able to deliver the best material recovery rate for solar panel waste.

Material recovery

But why do we need to worry about how to reuse and recycle EOL solar panels and their parts? Although the most obvious answer to this question would be to minimise the environmental impact that such large volumes of solar panel waste can have on the planet, this isn't just an environmental issue. Solar panels are made of many components, including PV cells (electricity-producing devices), electrical connections and support frame, all of which contain materials that can be reused or extracted for further use.

Currently, materials from EOL solar panels are typically recovered at general recycling plants (e.g. MRFs) alongside other types of electrical and electronic equipment. These material recovery processes typically involve shredding EOL solar panels into small pieces and mechanically separating major components and materials of the panels. Such processes can already achieve high overall material recovery rates that are in line with the existing regulations, such as EU WEEE Directive. However, processes involving shredding typically accompany loss of high-value materials, such as silver, which are dispersed in form of dusts during shredding. So far, due to the relatively low volume of solar panel waste, such losses have been considered to be negligible. However, without significant improvements of recycling process, the volume of unrecovered high-value materials would only increase along with the growing volume of solar panel waste.

Environmental impact

In view of the environmental impact, finding better ways to reuse and recycle EOL solar panels is an essential step of completing the sustainability cycle of solar PV power generation. Unlike the environmental impacts of manufacturing, installing, and maintaining solar panels and plants, the environmental impacts of dead solar panels have largely been neglected to date. However, according to a study, recycling 1,000 kg of silicon PV waste produces greenhouse gas emissions of 4.46×102 kg CO_2eq, most of which comes from transporting solar panels waste to recycling facilities and incinerating plastic materials from the panels, and further treatment for metal recovery from the bottom ash. Given that burning 1 litre of petrol produces ~2.3 kg of CO_2, this is equivalent to burning ~193 litres of petrol. Such EOL phase emission is not often taken into account when assessing the environmental impact of solar power generation. However, as the volume of solar panel waste grows, the impact of such emission would reach a significant level in coming years.

Future technologies

Thanks to the advances made in solar energy sector in the past two decades, the cost per kilowatt-hour of solar power generation is now comparable to the cheapest available fossil fuel-based power generation. The increased profitability of solar power means that government subsidy is no longer a requirement for large-scale solar projects and will also open up more opportunities for subsidy-free solar projects. This, in turn, will lead to further cost reductions through economies of scale.

However, although solar energy has come a long way, more work is still needed to make solar power generation more sustainable both socio-economically and environmentally. In particular, as discussed above, much work is need in relation to the EOL phase of solar panels to complete the sustainability cycle of PV power generation.

The problems relating to the EOL phase of solar panels, like other challenges the solar energy industry faced in the past, could be overcome by innovations.

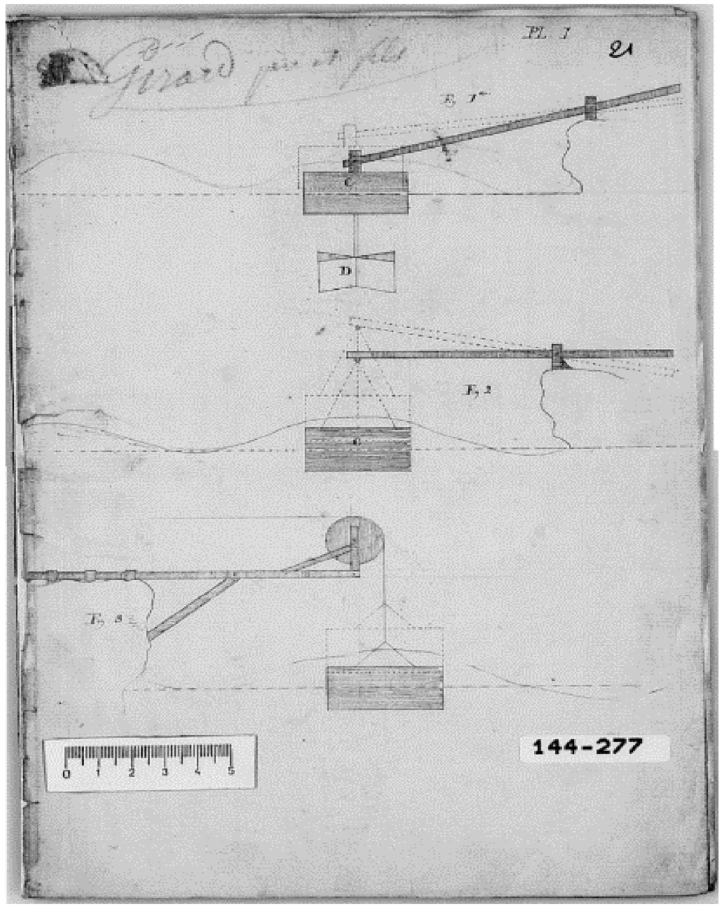
For example, developing recycling processes dedicated to PV panels could increase treatment capacities, improve the quality of extracted materials, and increase material recovery rate. More work can also be done to design solar panels to enable easy separation of panels parts or materials without having to use a shredder or thermal treatment. PV cell material research, which currently mainly focuses on improving cell efficiency, may also need to focus on making cell materials more easily reusable or recyclable. Moreover, improved monitoring methods for analysing “gate-to-gate” impact of EOL solar panels, considering all impacts from transporting solar panel waste to recycling plants up to sorting of the different recyclable materials and disposal of residues, may help us identify which aspects of the EOL phase needs more urgent improvement.

The increasing needs for innovations in the non-cell parts of PV systems will be good news for new businesses that wish to step into solar power industry. Perhaps the rapid increase in the number PV-related patent filings in recent years is not only a reflection of technological advances of PV cells, but also a sign of a wider range of innovations to come.

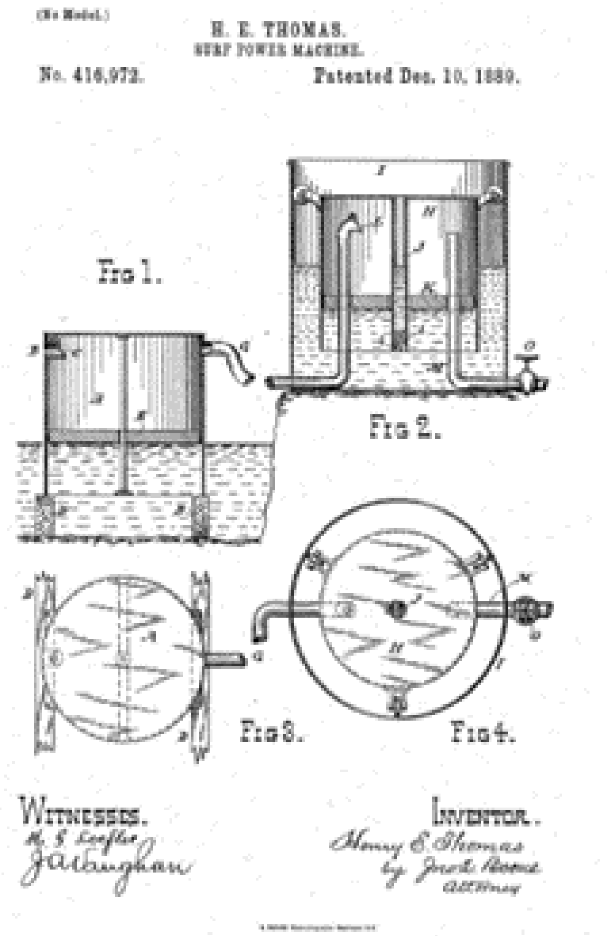
Author: Dr Dongyoung Kim

There’s nothing new under the sun #3 – Ocean Energy

The ocean is a vast reservoir of energy, with sources including surface wave, tidal current, tidal range, deep ocean currents, ocean thermal gradients and salinity gradients.
Estimates predict that ocean energy technologies could generate between 20,000 and 80,000 TWh of electrical energy, which is up to four times current global demand. Despite this, inventive activity in the field is low, with only 1300 patent applications published in 2021*. We look at some early patents.



French Patent No. 1BA110 was granted in 1799 to Pierre-Henri-Joseph and Philippe-Henry De Girard for “Various ways of using the waves of the sea as engines”, i.e. a surface wave converter. The patent discloses a float attached to a lever, the float extending into the ocean and being lifted up by surface waves.



US416,972, filed in 1899, relates to the use of surface wave energy to compress air. This apparatus was more complex than De Girard's contraption, but still lacked the efficiency to be widely commercialised.

In 1933, Parsons was granted US patent 1,930,958 in for a wave motor which aimed to "improve the efficiency of this type of apparatus",

and used the energy of surface waves to store accumulated water under pressure, which was used to generate electricity. This type of wave motor was subsequently commercialised by the Parsons Ocean Power Company.

Nowadays, several promising principles are used for wave energy conversion, including oscillating water columns (waves create air pressurisation which drives a rotor), overtopping devices (a reservoir creates a water elevation difference to drive hydro turbines), and wave absorbing devices (movement of floats drive hydraulic systems). The efficiencies being achieved by these devices suggests a promising role for ocean energy in meeting global energy demand.

*Search performed using the Y02E10/30 patent classification code.

Author: Dr Dustin Bauer

Renewable Energy Oversupply and Storage

In the British Energy Security Strategy (BESS), published in April 2022, the UK Government announced its energy ambitions, stating that by 2030 95% of British electricity could be low carbon, and that by 2030 over half of the UK's renewable generation capacity will be wind.

Wind power has the potential to generate huge amounts of the UK's electricity. However, it is variable by nature leading to significant swings in power output. The UK's ambitions to reduce fossil fuel reliance and to increase renewable electricity generation through wind energy will therefore present significant new challenges when it comes to balancing the grid.

It is not just lack of power during periods of low wind that energy generators need to worry about. Analysis by LCP indicates that by 2030 there will be an oversupply of power for 53% of the hours in the year, compared to the expected 6% for 2022. Unless effectively managed and mitigated, oversupply will put a huge strain on the grid and lead to energy wastage. While there are already many mechanisms in place to balance the grid and smooth the electricity supply, it is clear that the increasing reliance on renewables will require a new approach to system flexibility.

It is predicted that over 50 GW of new demand-side flexibility from energy storage, electrolysers and interconnectors will be needed to support the drive for more renewable energy.

Tracking patent filing trends is a useful way of understanding technological development. As shown in Figure 1, there was a steady increase in the number of European patent filings for “energy storage”, published between 2010 and 2020. However, the number of published patent applications is yet to show the exponential growth that may be required to support increases in renewable energy generation.

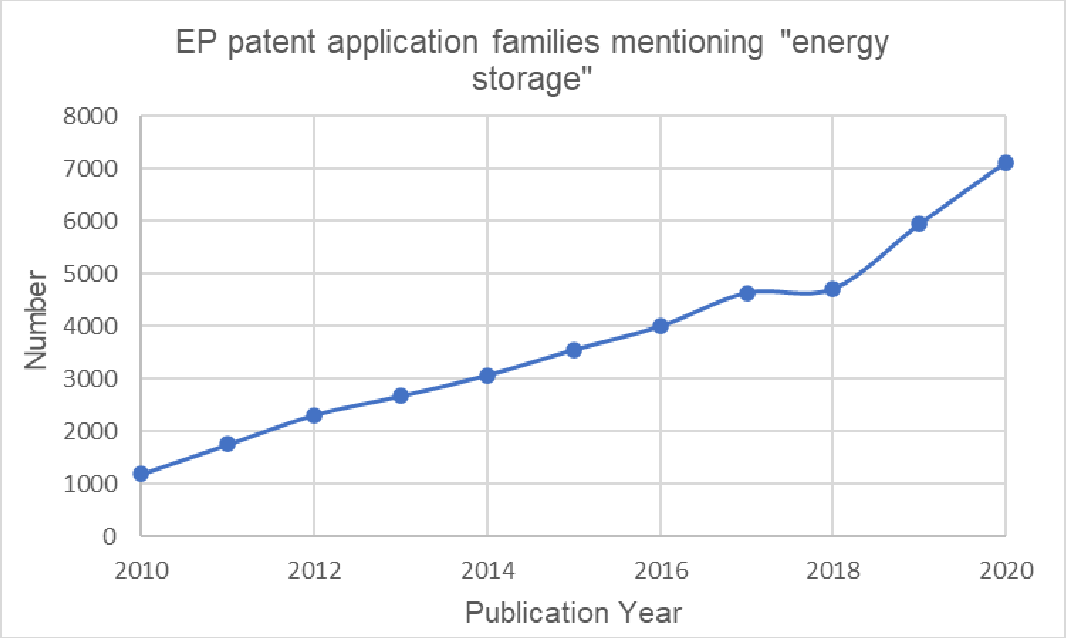


Figure 1

The BESS highlights the need for flexibility with sufficient large-scale, long-duration electricity storage to balance the overall energy system. Long duration energy storage (LDES) is particularly suited to handling renewable over/under supply because it allows energy to be stored for a period of several hours or more.

By 2040, LDES will need to have scaled up to around 400 times present levels and it is estimated that 10% of all electricity generated would be stored in LDES at some point.

The four key areas of LDES are: mechanical; thermal; chemical; and electrochemical.

Innovative areas of mechanical LDES are developing, such as compressed air energy storage (CAES); gravity based energy storage systems, which stores energy by lifting mass that is released when energy is needed; and liquid air energy storage (LAES).

Other examples of LDES are molten salts coupled with concentrated solar power (CSP) plants; power-to-hydrogen-to-power; and batteries such as aqueous flow batteries and metal anode batteries.

Selecting just one of these promising LDES technologies, Figure 2 shows that the number published European patent applications mentioning “compressed air energy storage” has grown by over 400% between 2010 and 2020.

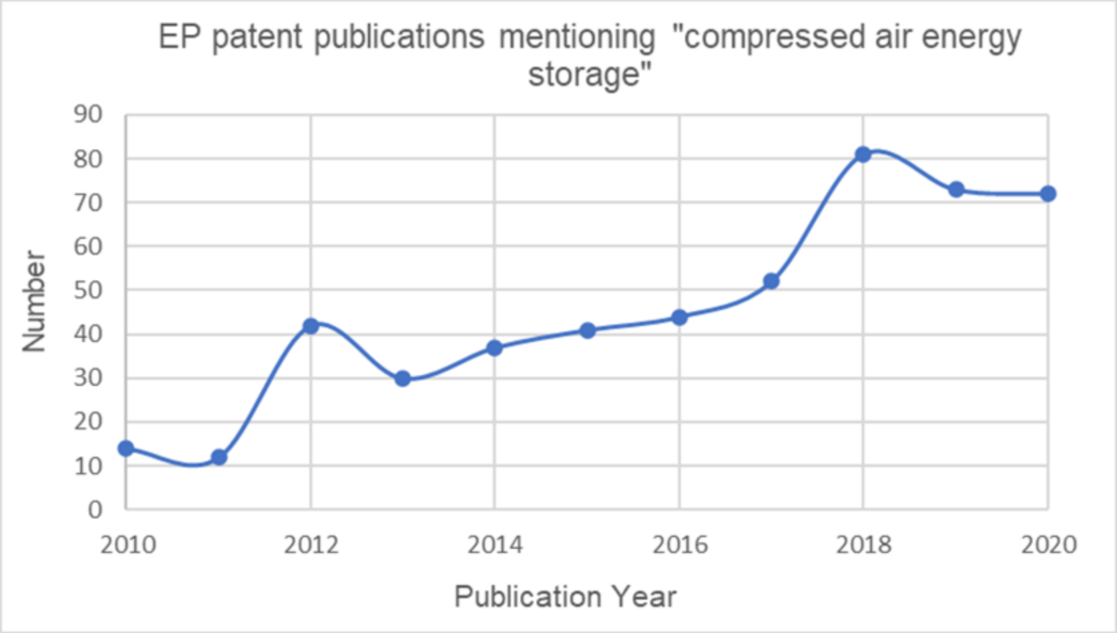


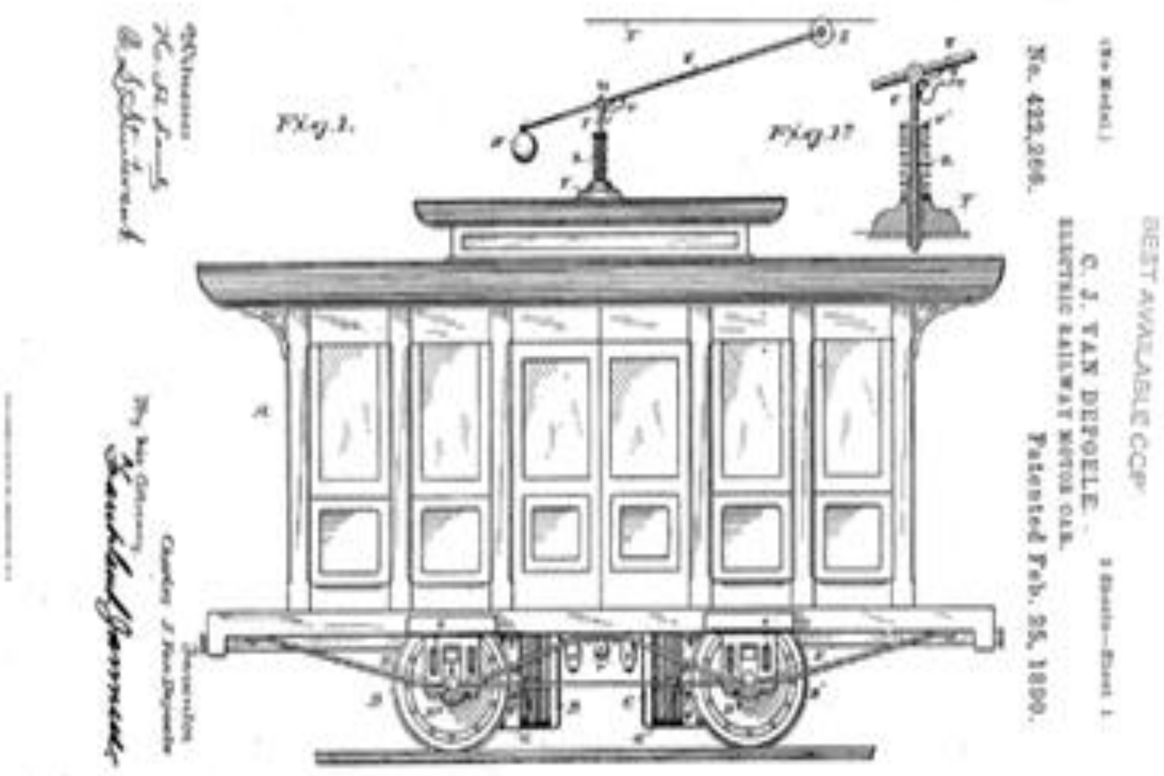
Figure 2

While the total number of publications is relatively low in comparison to energy storage as a whole, the data show a clear increase in interest around CAES. This growing interest in CAES may or may not be indicative of the growth in research and investment in LDES as whole, but it certainly shows that energy storage systems are being developed to support the increasing de-carbonisation of our electricity supply.

Author: Katie Smith

There's nothing new under the sun #4 – Electric Vehicles

Electric cars are the headline act in climate change technology. Glamourous rock stars like Tesla are pushing the boundaries of innovation to drive out the internal combustion engine. 28,000 patent applications were published in 2021*, but the original concept is much older.

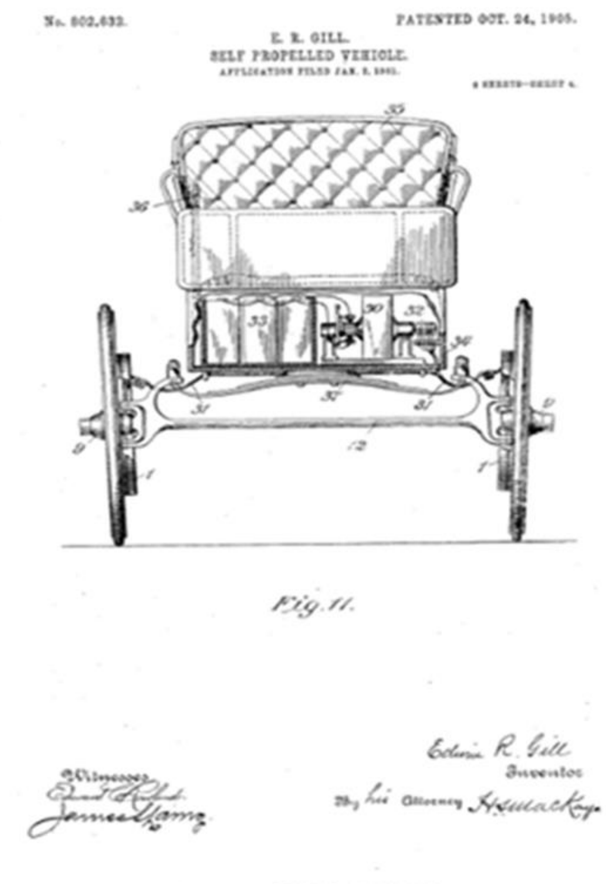


Early EVs can be traced back to breakthroughs in electric motors in the early 1900s, with patents dated as early as 1890. US patent 422,266 for an 'electric railway motor car' was granted to C. J. Van.

Depoele, the inventor of the trolley pole. The patent describes a car propelled by two electric motors, designed to act as a locomotive.

Electric cars enjoyed widespread success for a brief period in the early 1900s. In 1905, US patent 802,632 was granted to Edwin R. Gill for a 'self-propelled vehicle'. The patent describes an electric motor and wheel which aims to eliminate the need for gearing.

Interest in electric cars declined during the 20th century, because they were unable to offer the range necessary to keep up with improved road infrastructure.



However, they were still useful in certain applications. US patent 2,571,180, granted to Joy Manufacturing Company in 1951, discloses a 'steering operated control mechanism for electric motor drives of vehicles'. The vehicles are for transportation through mine passageways, and the rear wheels each have their own driving motor for navigating sharp turns, a feature we are likely to see more of in the future.

Today's electric cars boast ranges of several hundred miles, and we can expect to see ranges further increase with improvements in batteries. Electric cars are undoubtedly the transport of tomorrow, but it should be remembered that the original concept is as old as the motor vehicle itself.

*Search performed using the Y02T10/60 patent classification code.

Author: Olivia Buckingham

IS NOW THE TIME TO CAPTURE CARBON?

In November 2020, the UK Government published their Ten Point Plan for a Green Industrial Revolution. Point 8 of the plan focuses on investing in carbon capture, usage and storage (CCUS). The Government has set out their target to capture and store 10 $MtCO_2$ annually by 2030, which is equivalent to four million cars worth of emissions. In the plan, the UK Government has committed to investing up to £1 billion to support the establishment of CCUS across four industrial clusters.

In the past, support for carbon capture has been criticised for encouraging carbon emitters and prolonging our reliance on fossil fuels, rather than tackling the problem at source and preventing the production of CO2 altogether.

While no CO2 emissions may be the ultimate goal, it is clear that we must do everything we can to drastically reduce our global emissions if we are to limit the global temperature increase to less than 1.5 degrees Celsius. So perhaps we should embrace every opportunity available to us to reduce the amount of CO2 in the atmosphere. Whether that be by displacing fossil fuels with cleaner alternatives, by capturing CO2 from industrial processes before it is emitted, or even more ambitiously capturing carbon dioxide directly from the air in the atmosphere.

Carbon Capture Technology

There are several types of carbon capture technology that may be utilised as we strive to reach net-zero. Carbon dioxide emitted from traditional power generation and industrial processes can be captured and prevented from entering the atmosphere at source. For example, capturing the CO2 flue gas from traditional steam-methane reforming to produce "blue" hydrogen could help us to transition to cleaner fuels.

There are three main carbon capture techniques used to remove CO2 from the emissions created by burning fossil fuels. They are:

- Post-combustion capture
- Pre-combustion capture
- Oxy-fuel combustion

Each method has its own benefits and no single solution will be the answer. For example, post-combustion capture can be retrofitted to existing plants, whereas pre-combustion capture is cheaper, but cannot be applied to older plants.

Carbon capture can also be used to "suck" in CO2 from the open atmosphere in a process known as Direct Air Capture (DAC). The estimated energy needed for DAC is higher than for conventional carbon capture units used for emissions at source. The cost of implementing DAC is also likely to be higher, but it is a good option for tackling the emissions from many diffuse emission sources.

After the CO2 is captured, instead of it being emitted back into the atmosphere, there is potential to use and commercialise the captured carbon, or it can be stored underground.

Carbon Capture Innovation

The European Patent Office "Y02" classifications scheme classifies patent applications that relate to climate change mitigation technologies. The graph in Figure 1 below shows the published patent application families over the last 10 years related to carbon capture technology, using the "Y02C20/40" CPC class for capture, storage, sequestration or disposal of CO2.

In general, the number of patent applications related to carbon capture technology has been steadily increasing over the last 10 years. There were nearly three times as many published applications in 2020 compared to 2010, reflecting the growing interest in this field and the increased urgency to achieve net-zero.

CPC class Y02C20/40 also shows which applicants are filing these patent applications. The top ten filers over the last 10 years are shown in Figure on page 30.

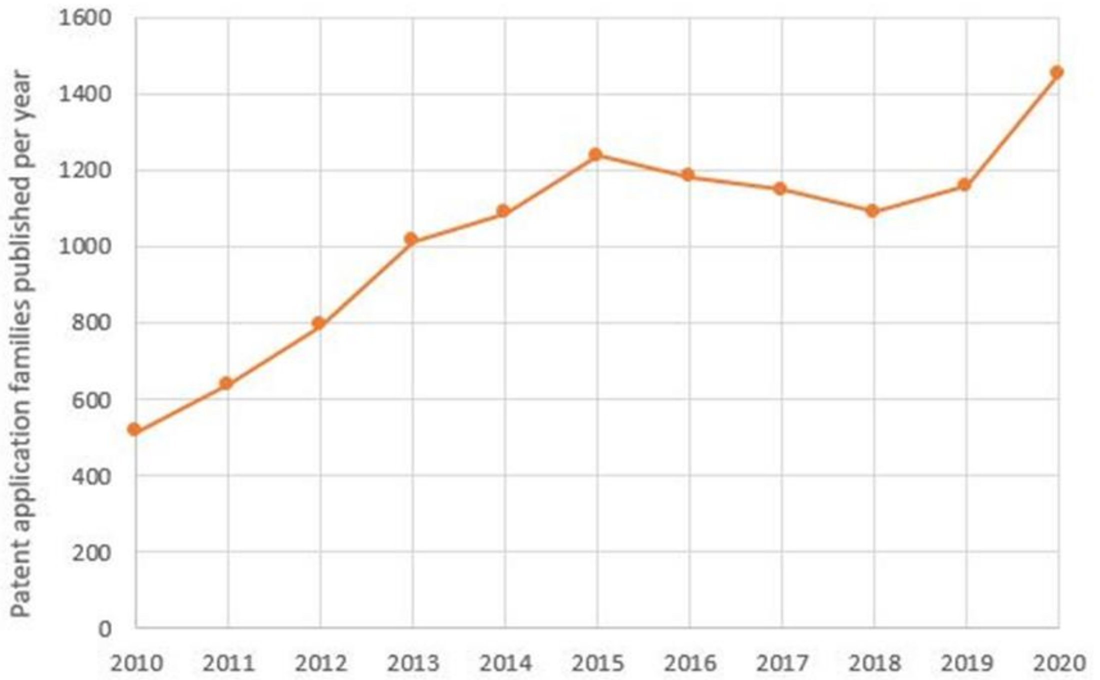


Figure 1: Patent application families published per year in CPC class Y02C20/40

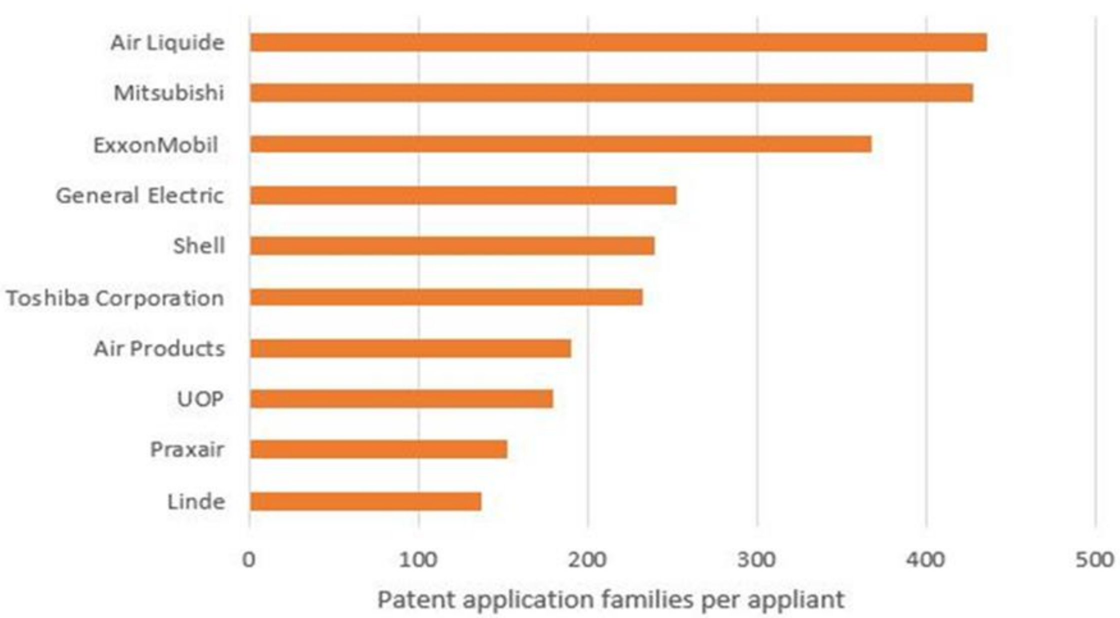


Figure 2: Patent application families per applicant published between 2010 and 2020 in CPC class Y02C20/40

The top filers are large oil and gas players and industrial gases companies, who are adapting their business models and seeking to adopt less polluting alternatives to reduce their emissions from their heavily emitting industries.

However, there are plenty of new innovators in this sector who are developing new carbon capture solutions and protecting their inventions with patents.

For example, Carbon Clean have developed a modular system and proprietary solvent to capture CO_2 from flue gas. The modular system can be easily tailored to the size of the emitting plant, and therefore reduce the costs of implementing carbon capture technology by up to 50%.

Carbon Engineering are a direct air capture focused company and have 10 pending patent and application families. Their DAC pilot plant, was designed and built as a proof of concept and testing facility. When operating, the pilot plant captures one ton of CO2 per day. Last month, they announced that engineering and design has begun on a large-scale commercial facility.

Another carbon capture company is Climeworks. From a search of the European patent database, Climeworks AG has 22 patent families with titles such as “Materials for the Direct Capture of Carbon Dioxide from Atmospheric Air”.

To help fund their projects they have a subscription service where you can sign up to order CO2 removal from the air, or send it to someone as a gift!

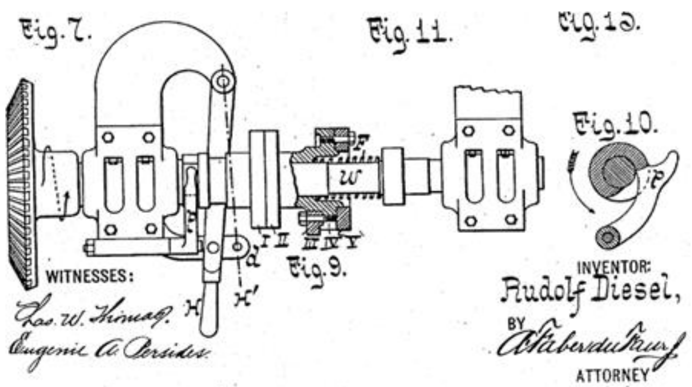
Like many new technologies, the cost of capturing CO2 has been prohibitive for large-scale commercialisation. But with government commitments, private sector innovation and a global focus on tackling climate change, the COP26 summit could serve to accelerate the implementation of carbon capture technology.

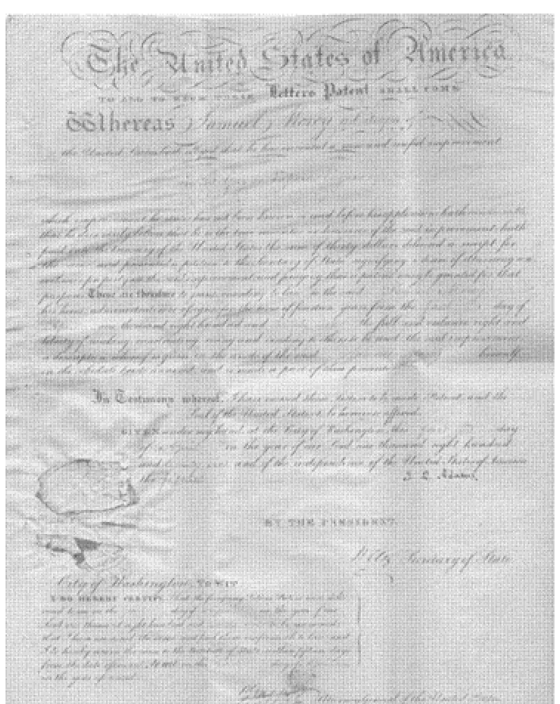
Author: Katie Smith

There's nothing new under the sun #5 – Biofuels

Biofuels represent sustainable alternatives to fossil fuels, with superior environmental performance. 3,500 patent applications for biofuels were published in 2021*, but the technology has much earlier origins.

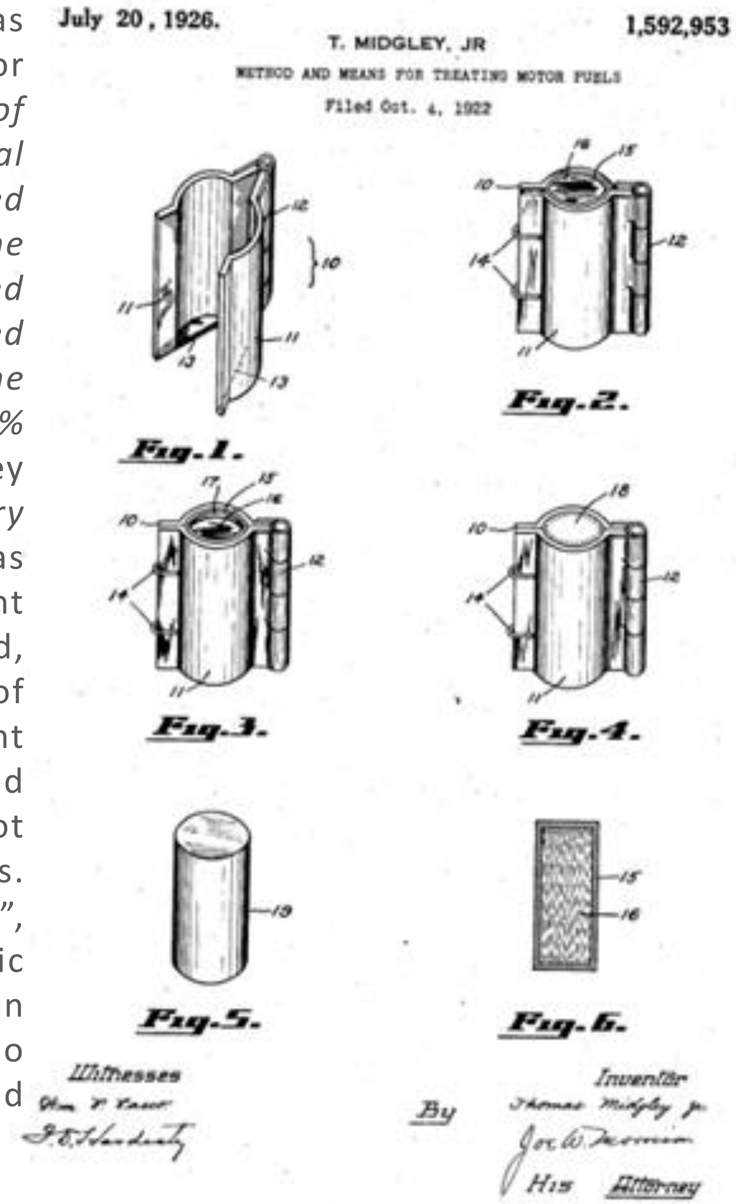
The use of renewable oils for fuel is not new. In 1898, Rudolf Diesel was granted US patent 608,845 for the "internal combustion engine" which originally ran on peanut oil. Diesel himself foresaw a future where vegetable oils would rival fossil fuels. In 1937, Georges Chavanne filed Belgium patent 422,877 for a "process for the transformation of vegetable oils with a view to their use as fuels". The patent concerned treating vegetable oils with low molecular weight alcohols in the presence of a strong acid in a process known as trans-esterification.





In 1826, Samuel Morey was granted US patent 4,378X for a gas or vapour engine. The Morey engine functioned by forming an explosive mixture of air and ethanol mixed with turpentine. Some decades later, Nicolaus Otto used ethanol in his own ground-breaking internal combustion engine.

In 1926, Thomas Midgley was granted US patent 1,578,201 for "*fuel comprising an admixture of substantially 50% commercial ethanol, and 50% of a cracked gasoline, said cracked gasoline consisting of saturated hydrocarbons and unsaturated hydrocarbons, or olefines in the proportions of substantially 84% and 16% respectively*." Midgley identified that this "*satisfactory and practicable fuel*" was required to supplement hydrocarbon fuels. In the end, however, Midgley's discovery of anti-knocking agent tetraethyllead (TEL) eclipsed ethanol as a fuel additive – not in functionality but in profits. TEL was branded "*Ethyl*", avoiding mention of its toxic lead component. It was only in 2021 that there were finally no more countries using leaded petrol to power vehicles.

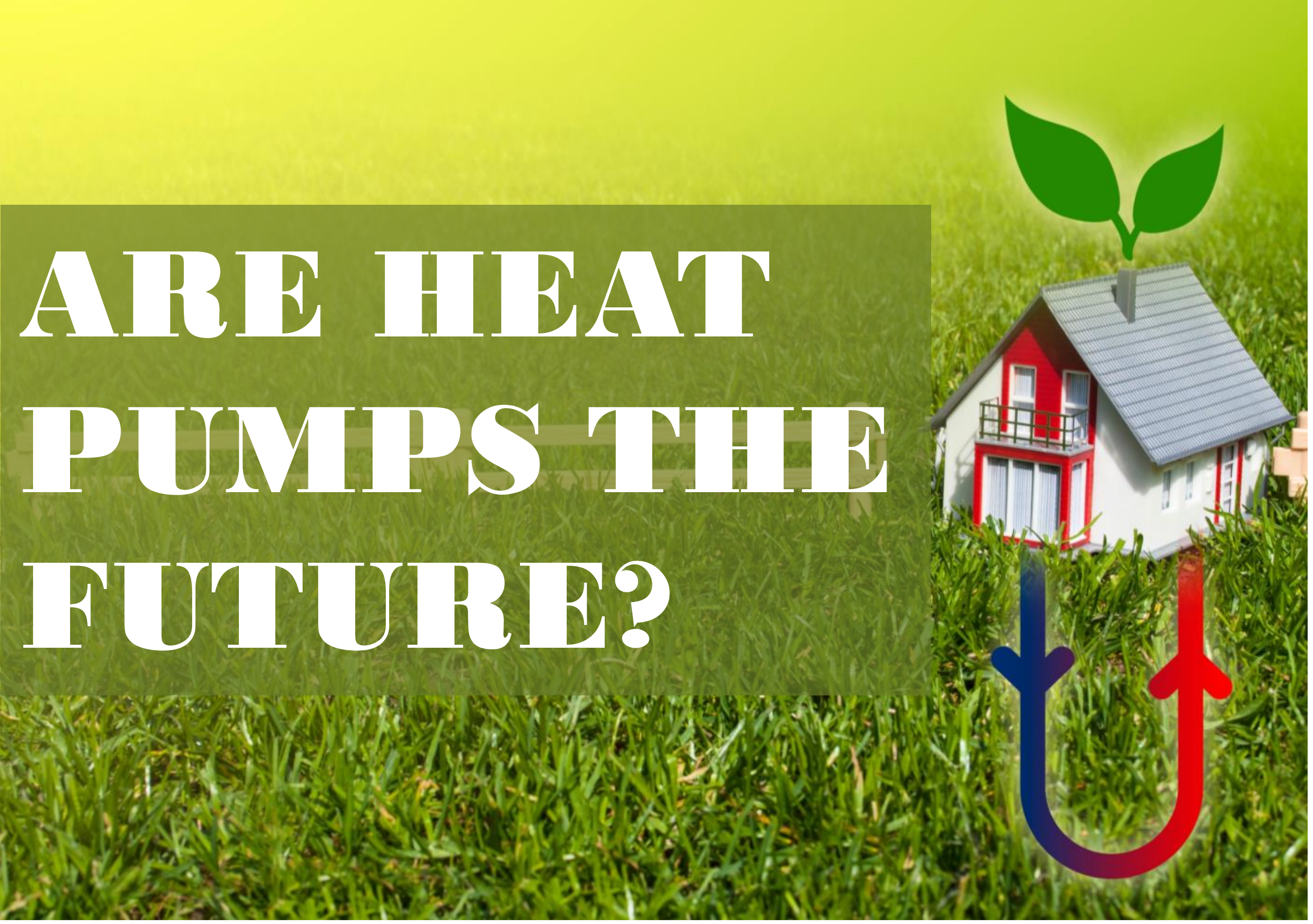


It is remarkable to consider that biofuels were originally considered the default fuel source for engines, and notable how long biofuels were known without widespread uptake.

*Search performed using the Y02E50/00 patent classification code

Author: Daniel Marchant

ARE HEAT PUMPS THE FUTURE?



Heat pumps provide an alternative way to heat our homes and businesses without burning fossil fuels. Implemented in combination with renewable electricity supply, heat pump technology provides a low, or even zero carbon heating solution, and plays a prominent role in most projected net-zero scenarios.

Patent filing statistics are a useful lens through which to view technological development. In the case of heat pumps, patent statistics depict a steady increase in inventive activity between 2010 and 2020, with a growth rate of 190% over this ten year period. This compares with growth of 113% over the same period for climate change mitigation technologies as a whole.

With a diverse range of new technologies competing for an established place in our clean energy future, this statistic is an encouraging sign for heat pump technology.

In recent years, patent filings relating to control of heat pump operation dominate. For example, controlling the flow of refrigerant, or operation of the compressor in response to detected conditions. This reflects the general trend of innovators seeking to optimise heat pump energy performance. More generally, we see an increase in innovation integrating heat pumps into whole-building energy systems serving to optimise energy efficiency of the building as a whole.

According to a report by the International Energy Agency (IEA), heat pump technology could easily satisfy more than 90% of global heating needs. However, as of 2020, heat pumps accounted for no more than 7%. If heat pump technology is to play its projected role in our green energy future, global uptake needs to increase. Policy measures have a key role to play here, by incentivising commitment to the technology and offsetting upfront purchase and installation costs. Innovation also has a key role to play in making the technology attractive to consumers by improving energy performance, and making them cheaper and more practical to install.

There are different types of heat pump: air source, ground source and water source, all of which have grown in popularity in recent years.

Ground and water source heat pumps are naturally the most efficient, because ground and water temperatures are higher and less variable than air. However, the practical implications of laying heat exchange pipes in the ground or in a body of water make air source heat pumps a more practical solution in many cases.

In response, innovators have focussed on improving the energy performance of air source heat pumps, which can be fitted to the side of most buildings, with the result that their energy performance has improved dramatically in recent years.

Recent innovations also focus on compactness, improving the visual appearance of heat pumps on the side of buildings.

Another technological trend over recent years is a move towards inverter-driven variable speed compressors. Conventionally, heat pumps operate at 100% output until they achieve a desired temperature, at which point they cycle between a 100% on state and a 0% off state to maintain that temperature.

Inverter driven heat pumps, however, use a variable speed compressor to adjust their output between 0 and 100% in response to internal and external temperatures and other conditions, in order to maximise efficiency and provide a workable solution in colder conditions.

We also see innovation aimed at reducing the global warming potential of refrigerants, which are highly potent greenhouse gasses. In principle, the refrigerant should be fully contained within the heat pump for the lifetime of the product, and can be extracted for reuse at the end of this lifetime. However, with large scale deployment of heat pumps, the issue of leakage and ineffective disposal adds up to a big problem for climate change.

Author: Georgina Ainscow

The Unified Patent Court and Unitary Patents are coming – What does this mean for you?

The Unitary Patent and Unified Patent Court represent a new patent right and a new legal system that will soon be entering into force. Both have the potential for significant advantages, but there are also uncertainties and risks, which patent owners will need to weigh up when deciding whether to make use of these new provisions. Here we give a brief overview of how these will work and what they mean for you.

Unitary Patent

A Unitary Patent is a European patent granted by the European Patent Office that will initially cover 17 EU states. Unlike the existing system in Europe, where nationally validated European patents are a bundle of national rights requiring separate enforcement, the Unitary Patent is a single.

A Unitary Patent can be enforced across the EU states that it covers in a single action before the Unified Patent Court (UPC). This means that a Unitary Patent that survives a central revocation action will be a valuable right covering much of Europe. On the other hand, a Unitary Patent is susceptible to central revocation from a single action, and an unsuccessful infringement action will also apply across all participating states.

Whether or not applicants will want to use Unitary Patent protection will be influenced by many factors specific to their circumstances and business goals – such as enforcement, licensing and revocation opportunities. However, it is likely that in many cases the decision will ultimately hinge on cost. The unitary patent has the potential to provide excellent value compared to validating nationally when comparing renewal fees and validation costs, but perhaps only for companies seeking wide. coverage across Europe.

Unified Patent Court

The UPC is a new court that will have jurisdiction over both Unitary Patents and European patents that are validated in participating member states. This means that national validations of a European patent will be under the jurisdiction of the UPC unless the patent is "opted out". The UPC will hold infringement and validity proceedings, and any decision made on a Unitary Patent, or national validation that has not been opted out, will take effect in every UPC member state.

Although the UPC hasn't come into effect yet, expectations are that this will happen at the end of 2022, or early 2023. There will be a 3 month sunrise period preceding the start of the UPC that allows rights to be opted out early. This sunrise period will allow proprietors to opt-out their existing rights before the UPC comes into force, mitigating the risk of a revocation action being filed on the first day of the UPC, which would prevent the patent from being opted out.

What should I be considering?

If you currently have pending European patent applications it is worth considering whether you wish to make to make use of Unitary Patent protection. If so, you may want to consider taking steps to delay grant of their application until the UPC comes into force.

On the other hand, if you do not want the validity of your European patent rights to be subject to single action in a new and untested court system, with uncertainty around how judges will decide on matters of infringement and validity, you should consider taking steps to opt your existing rights out of the UPC system once this becomes available.

Our attorneys at Reddie & Grose are ready to discuss these and other questions with you, so please feel free to get in touch.

Author: Dr Ben Hipwell and Lizzie Alexander

HERE TO HELP

At Reddie & Grose, our Energy & Natural Resources and Sustainability teams are dedicated to green innovation in all of its aspects. Our patent and design attorneys have extensive experience of advising research and development departments and a deep understanding of the key issues in an often complex legal and business environment. We help businesses in their due diligence and analysis of whether they are free to launch their products. We protect their innovations by preparing and prosecuting patent applications – building portfolios of rights to protect their commercial interests. We are also skilled in assisting clients to enforce their patents and designs, filing oppositions and cancellation/ revocation proceedings against third party rights, helping to defend our clients' position in infringement proceedings and defending clients' rights in oppositions and cancellation proceedings brought by third parties.

Our support of multinational clients is more than just managing their global patent portfolio and defending crown jewel IP rights. We understand that every stage of a product's development offers a unique challenge and our experience of working in established and emerging markets enables us to think beyond the law and devise patent strategies tailored to the commercial objectives of our clients.

In our support of start-ups and SMEs we have the commercial expertise to protect their innovation, ensure that their businesses are attractive to investors, ready for an IPO or perfectly placed to bring the next blockbuster to market. We pride ourselves on listening to our clients and offering expert and pragmatic advice that is tailored to our clients' needs. Avoiding a 'one size fits all' approach has allowed us to build up many valued long-lasting client relationships. We would be delighted to provide you with further information about our services and to organise a free initial consultation.

The contact details for the Energy team leads are as follows:

Georgina Ainscow
georgina.ainscow@reddie.co.uk

Duncan Nevett
duncan.nevett@reddie.co.uk

Andrew Carridge
andrew.carridge@reddie.co.uk

Gillian Taylor
gillian.taylor@reddie.co.uk

At the start, it can be difficult to decide whose expertise is most appropriate for a project. Please start with the person you think is most appropriate. Our team leads can then build a team tailored for your project.

London
The White Chapel Building
10 Whitechapel High Street
London E1 8QS
T + 44 (0)20 7242 0901

Cambridge
Clarendon House
Clarendon Road
Cambridge CB2 8FH
T + 44 (0)1223 360 350

Munich
Hopfenstrasse 8
80335 München
Germany
T + 49 (0)89 206054 267

The Hague
Schenkkade 50
The Hague
Netherlands
2595 AR
T +(00)31 70 800 2162

General enquiries:
enquiries@reddie.co.uk

Reddie & Grose LLP
www.reddie.co.uk