How can Emerging Technologies be deployed to transform sustainability?

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Key:
Green = Positive
Dark Orange = Negative
Gold = Very Important Aspects in Key Points.
Purple = Key Point

Other colours are just used for Aesthetics, including other shades of the same colour.

Batteries

History:

American Scientist, Benjamin Franklin first used the term 'Battery' describing a set of linked capacitors. However, the first scientifically accepted battery was invented by Alessandro Volta, an Italian physicist in 1800. This invention came to be known as the 'Voltaic Pile' and was simply piles of copper and zinc discs piled on top of each other, with a layer of cloth soaked in an electrolyte, which was brine (salty water).

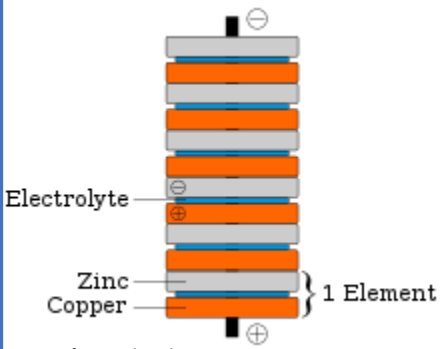


Image from Wikipedia

How do Batteries link with sustainability?

Batteries are essential in modern day life and are what we use to hold charge in every single gadget we use, to store excess produced energy, and are essential to make sure we don't get large scale data wipes during power cuts. They are so widely used to store electricity that their efficiency becomes so important, as less efficient batteries will waste more energy through heat for example, and this effect adds up immensely to energy wastage when we consider things like electric cars also using batteries and how many people around the world use gadgets. Currently, the most efficient batteries with the highest power density we have are Lithium Ion batteries, and these are used in cars and phones, but the mining process for Lithium Ion batteries is immensely damaging to the environment, and often using child labour in places like Bolivia. This means the development of battery technology is vital for sustainability.

New Types of Battery Technology that can Improve sustainability:

The main improvements in battery technology come with efficiency, power delivery and power density. The Proposed lithium sulphur battery has many advantages over the Li-ion batteries.

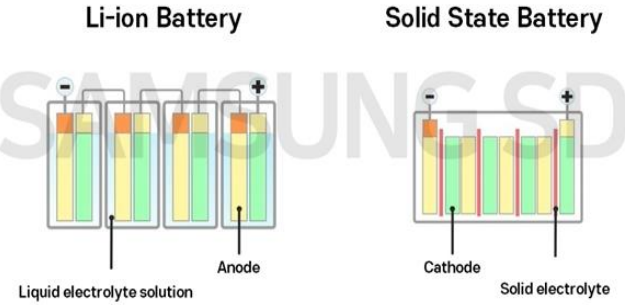
1. **They have Higher Energy Density:**
2. **They are cheaper and use more readily available materials**
3. **They are potentially safer**

All of these factors lead to an improved sustainability:

Firstly, Higher Energy Density means that less volume of a battery can be used to provide the same amount of charge, meaning that less mining has to occur to keep up with current energy usage. With this however it should be noted that higher energy density will mean the same amount or more will most likely be mined as companies can advertise higher battery lives on their devices by using the same space. On the other hand, this does still provide a net gain for sustainability as we can store more electricity in large scales due to the lower volume of battery required, lowering energy wastage.

Secondly, Lithium sulphur batteries use sulphur instead of cobalt, which is a far more expensive material. Sulphur is also a by-product of the oil industry, allowing us to make extra use of waste materials, increasing the sustainability of these batteries, compared to Li-ion batteries where cobalt is specifically mined to be used in theme, heavily damaging the environment, with the chemicals used to extract them. On the other hand sulphur is also mined separately on the sides of volcanoes, where workers are paid very little to perform this incredibly dangerous job that is harmful to their health, so these batteries could also increase the exploitation of labour, especially seeing the decrease in the oil industry, though I still believe that with ethically mined sulphur these batteries can significantly help sustainability as we go into the future

Thirdly, they have incredibly safety potential, as they don't need to host Li-ions in their materials, significantly reduces the risk of disastrous failure in batteries, reducing the likelihood of fires and other such damaging accidents. This is more and more important towards sustainability with every product going electric such as cars. Li-S batteries would have a far smaller risk of setting on fire during a crash and car fires can cause immense damage. With Li-S large battery plants also become a possibility, and with their increased safety, it reduces the chances of large scale ecosystem impacting fires or explosions, which we would have with Li-ion, making them better towards sustainability as such too.



Solid State Potential: As the name suggests, a solid state battery is one that uses solids instead of the liquid electrolytes currently used in batteries. This would mean the use of a solid ceramic material. Solid State has immense potential to make batteries, lighter, safer, faster, to charge and one of the most important things for sustainability, they will last longer. While Li-ion batteries to tend to last for a few years at most, these would be able to last up to 10 years, reducing the chemical waste made by batteries, one of the biggest factors impacting their sustainability. This is because they are more stable than liquid electrolyte based batteries, meaning they can withstand more charging cycles. As they can hold more energy, they are great for EVs as it will give them a larger range, which is good for efficiency, and though may be marginal can provide an increase in the sustainability of the vehicles through their energy use. This technology is still being worked on, as currently the solid electrolytes are prone to cracking, but the Technology could be immensely useful for sustainability, in our modern society, where we use electricity for everything.

Fusion

How it Works:

Fusion works simply through fusing two lighter nuclei into one larger nucleus. This process causes mass to be converted into energy, and even a small amount of mass is converted into massive amounts of energy. To fuse nuclei, for example two hydrogen nuclei is extremely difficult, due to them having the same charge and repelling each other. This makes fusion only possible when each nucleus is travelling at speeds fast enough to ignore the coulomb barrier, the barrier of electrostatic repulsion preventing the two nuclei from colliding, leading to the collision. The temperatures required to achieve these kinds of speeds are around 10 times hotter than the sun at around 100 million degrees Celsius. These insane temperatures make the energy requirement for fusion massive, but it has the potential to produce larger amounts of energy.

Impact of Fusion Energy on Sustainability (Positive and Negatives):

1. One of the main advantages of fusion energy is that it is clean and renewable. Unlike fossil fuels, which generate greenhouse gas emissions and contribute to climate change, fusion produces no emissions or pollutants. This means that fusion could provide a sustainable and environmentally-friendly alternative to fossil fuels.

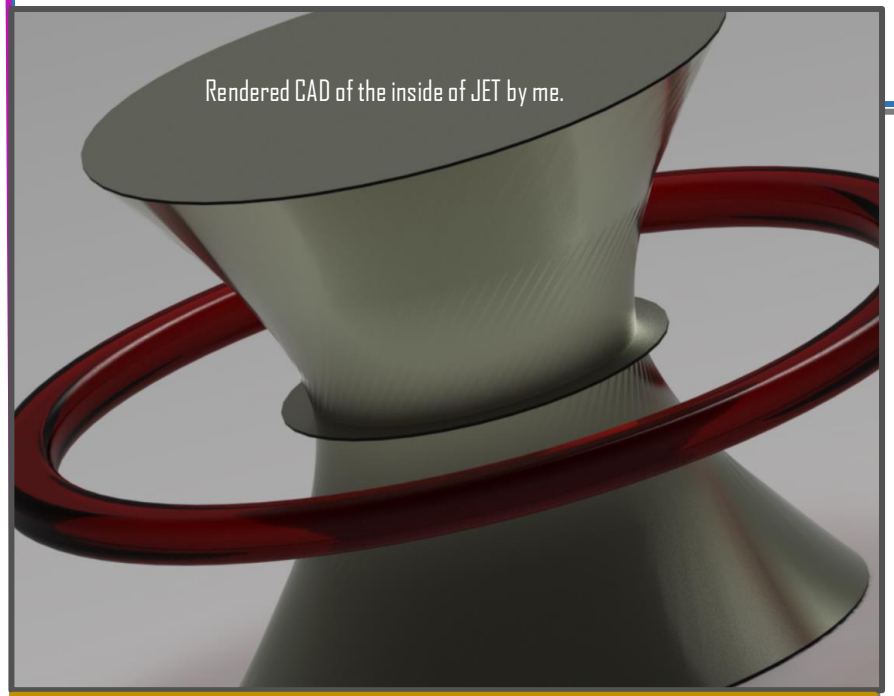
2. Another advantage of fusion energy is that it is highly efficient. Fusion reactions can produce large amounts of energy from small amounts of fuel, which means that fusion could help to reduce our reliance on non-renewable resources and improve energy security. Additionally, fusion reactions produce no hazardous waste or long-lived radioactive materials, which makes them safer and more sustainable than other forms of nuclear energy.

3. Despite these advantages, there are also challenges and limitations to fusion energy. One of the main challenges is that fusion reactions require extremely high temperatures and pressures, which are difficult to achieve and maintain. This means that fusion energy is currently not commercially viable, and significant research and development is still needed in order to make it a viable source of energy.

4. Some argue that the vast amounts of time, money and energy spent on fusion is wasted and that it should be invested into more reliable renewables such as wind, tidal, hydro and solar, which are all tried and true, but require more investment.

History and Reasoning behind fusion:

- Every single star we see in the sky is power by fusion, and when Arthur Eddington, in the 1920s, suggested that stars fuse hydrogen into helium to power themselves.. After this, and Rutherford's furthering of the atomic model, scientists wanted to replicate fusion energy on Earth.
- Experiments were carried out, but in the 80s, the Joint European Torus was commissioned to be built in Oxford, and this created the first plasmas. Jet managed to produce an output of 16MW with a heating input of 24MW, using a fuel mixture of 50% deuterium and 50% tritium.



Rendered CAD of the inside of JET by me.

. This is usually the main problem with fusion energy, as it ends up taking more energy to start the fusion process amount of energy we receive from the process. This remains the main barrier to widespread implementation of fusion energy.

Fusions Real Impact on Sustainability:

The Ultimatum for fusion is really that if it is up and running it will revolutionise the future of sustainability. Limitless energy means we can use more energy in things such as Carbon Capture and other processes which currently require too much energy to work. A Fusion power plant will be cheaper to make than a coal plant producing the same energy (2.6 vs 2.8 billion), allowing me to believer that if we get fusion to work, we will be able to fix issues mentioned, with the sheer amount of energy we will be able to harness, not to mention the countless jobs it will create around the world, increasing global sustainability.

The Potential and the Risk:

- Fusion Energy has massive potential to solve all of humanities energy crises, but the costs are astronomical. If Fusion turns out to be too difficult to recreate on Earth, it would mean massive environmental damage would have been done through the energy usage and the time wasted by talented researchers who could've worked on other sources.
- However, even if Fusion does work, and we stop greenhouse gas emissions, the amount of raw materials and resources, such as tungsten (what the main metal in my CAD is) and beryllium for the walls (What is used in JET), that have to be extracted from the ground will create potentially millions of tonnes of emissions from mining processes and processing of the materials.
- This might offset these emissions gains, and whatever the case will destroy local habitats and wildlife in the search for these materials, greatly hurting the potential sustainability of these reactors.

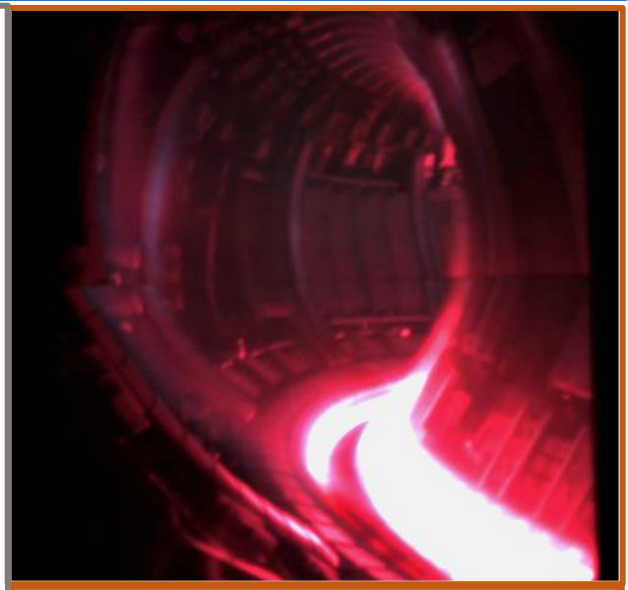


Image of the first plasmas created in the JET reactor. This is what drive scientists to pursue ITER, after which they will build DEMO, around 2050, which is planned to be the world's first fully operational fusion reactor, that produces more energy than it takes in. These first plasmas took 20+MW of Energy to create, most of which was made with fossil fuels. If this us a sacrifice for the future worth making, will be seen only in the future.

Artificial Intelligence

What is AI?

- **AI, or artificial intelligence, refers to the ability of a computer or machine to mimic or simulate intelligent human behaviour.**
- **This can include tasks such as problem solving, learning, and decision making.**
- **AI is often implemented through the use of algorithms, which are sets of instructions that enable a computer to perform specific tasks.**
- **Some examples of AI include virtual assistants (like Alexa), machine learning systems, and autonomous vehicles.**
- **AI has the potential to revolutionize the entire world, with it's capabilities, but it's relation to this PowerPoint is how it can be used to transform sustainability.**

Weather and Climate Prediction:

- AI has the potential to improve the accuracy of weather and climate predictions, which can help with sustainability in several ways. For example, more accurate predictions can help farmers make better decisions about when to plant and harvest crops, which can increase crop yields and reduce waste.
- Accurate predictions can also help utilities better manage energy demand, which can reduce greenhouse gas emissions and improve air quality. Additionally, accurate predictions can help businesses and individuals make better decisions about how to reduce their carbon footprint, such as by choosing to carpool or use public transportation instead of driving alone.
- This also has an impact in renewable energy, such as wind farms and solar farms, as with more accurate weather prediction and we can more accurately predict when winds will be strongest, or if the wind will be too strong for the turbine to be stable. With Solar farms, their energy production can be maximised by more accurately predicting cloud cover, and the grid can take energy from other sources of power when this is the case

Smart Lighting and Grids:

- AI can improve sustainability using smart lights and grids by optimizing energy usage and reducing waste. For example, AI can be used to monitor and control lighting systems, ensuring that lights are only used when and where they are needed. This can help reduce energy consumption and reduce the demand on the power grid.
- Additionally, AI can be used to optimize the operation of the power grid itself, by predicting and responding to changes in demand and implementing energy-efficient control strategies. This can help reduce energy waste and increase the overall efficiency of the power grid. Furthermore,, by using AI to monitor and control lighting and power systems, we can reduce our carbon footprint and reduce our impact on the environment.
- An indirect benefit from the reduce in demand for the power grid, is reducing pressure on the government to construct new fossil fuel based power stations which can very quickly respond to demand, in ways that renewables can't. This reduced pressure means world governments will be more likely to invest in renewables instead of opening new coal mines in 2022, like in the UK (Though this will provide short term jobs for the people in the area, but that's a tangent from sustainability)

Monitoring the World around Us:

This is one of the incredibly important ways AI can improve sustainability by monitoring the world around us in a number of ways.

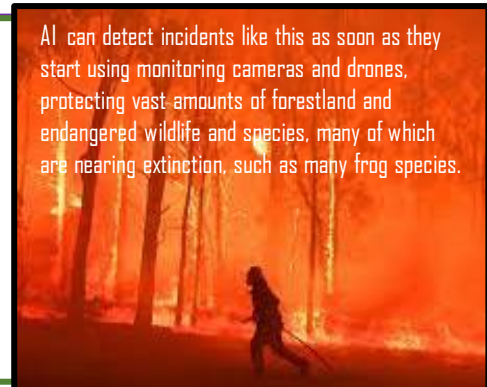
- For example, AI can be used to monitor air and water quality, identify and predict environmental hazards, and track resource usage and waste production. By constantly monitoring the state of the environment, AI can help ensure that we are making the most efficient use of our resources and taking steps to protect the planet.
- Additionally, AI can be used to develop and implement sustainable practices in industries such as agriculture, transportation, and energy production. This can help reduce our impact on the environment and promote long-term sustainability. This can also be used in countries prone to forest fires, like Australia, detecting them the instant they start, which can save millions of hectares worth of tree cover, and prevent the release of massive amounts of trapped carbon into the atmosphere.

AI in Electric Vehicles and Sustainability:

I. The implementation of AI in electric vehicles (EVs) can improve sustainability in several ways. For example, AI can be used to optimize the performance of EVs, allowing them to be more energy efficient and have longer driving ranges. This can help reduce the need for frequent charging and make EVs a more practical and sustainable option for transportation.

II. AI can also be used to improve the charging process for EVs. For instance, AI-powered systems can monitor the availability of charging stations and route EVs to the nearest available station, helping to avoid congestion and reduce the amount of time spent charging. This can help make the charging process more efficient and reduce the overall environmental impact of EVs.

III. Additionally, AI can be used to develop new technologies and materials for EVs, such as lightweight batteries and more efficient motors. This can help improve the overall sustainability of EVs by making them more energy efficient and reducing their environmental impact. By leveraging the power of AI, we can accelerate the development of sustainable EV technologies and help make EVs an even more viable option for reducing our carbon footprint.



Bio-Plastics and Hydrogen

What are Bio-Plastics and what makes them better than Conventional Plastics?

Put simply, Bioplastics are a type of plastic made from renewable resources, such as corn starch or sugarcane, rather than fossil fuels. This makes them a more sustainable alternative to traditional plastics, which are derived from non-renewable resources and can take hundreds of years to break down in the environment. There are many different companies working on Bioplastics, and these provide a fantastic alternative to things such as paper/plastic straws, drinks holders, plastic cups and other 'disposable' items.

Bio-Plastics in Straws (Influenced largely by my opinions):

Recently, there's been a large trend of switching to paper straws as an alternative to plastic straws, so many of which end up in our ocean, killing wildlife and polluting it.

However, getting more personal, I severely dislike paper straws due to them effectively melting in the mouth, even if you don't chew them, making them undrinkable. This is where the inspired use of bioplastics can come in.

I personally have tried a variant of sustainable straw, that was edible, didn't dissolve in the drink, didn't change the flavour of the drink (and tasted great). This is wonderful for sustainability, as it replaces plastic straws and the harm they cause, with a sustainable alternative which doesn't compromise function and that aspect is so important, yet in my belief, is often forgotten, which is what makes bio-plastic straws so wonderful.

Other Common uses of Bio-Plastics:

Bioplastics can be used in a wide range of applications, including packaging, textiles, and medical devices. These are detailed further below:

- Packaging: Bioplastics are often used in packaging materials, such as bags, bottles, and containers. Because they are made from renewable resources and can be composted, bioplastics can help reduce the amount of plastic waste that ends up in landfills. This very heavily reduces the environmental impacts of littering, due to how fast these biodegrade.
- Textiles: Bioplastics are also used in the production of textiles, such as clothing and accessories. Due to bioplastics being biodegradable, they can help reduce the environmental impact of the fashion industry, which is known for generating large amounts of waste.
- Medical devices: Bioplastics are often used in the production of medical devices, such as implants and surgical instruments. Being biocompatible and biodegradable, bioplastics can be safely used in the body and many can be broken down by the body's natural processes.

General Advantages of Bioplastics:

1. One of the main benefits of bioplastics is that they can be composted, unlike traditional plastics which typically end up in landfills where they take many years to break down. This means that bioplastics can be broken down into organic material that can be used as fertilizer, rather than contributing to pollution and waste, also giving a positive aesthetic impact to city centres and built up areas, as these will biodegrade if thrown on the ground, instead of staying there for centuries, or until someone picks them up.

2. Another benefit of bioplastics is that they can help reduce greenhouse gas emissions. As they are made from renewable resources, the production of bioplastics generates fewer emissions compared to traditional plastics. This can help to combat climate change and reduce the impact of human activity on the environment.

3. In addition to their environmental benefits, bioplastics can also have economic advantages, linking with sustainability. Because they are made from renewable resources, bioplastics can help to create new jobs and stimulate economic growth in rural areas, and these people with more wealth are more likely to buy sustainable products, switch to the oftentimes more expensive Green Energy, and become more educated, allowing more minds going into the development of new sustainable tech.

How is Hydrogen linked to Sustainability?

There are two main ways in which Hydrogen can transform our sustainability as we go into the future.

1. Firstly is it's use as a clean and renewable fuels source. When it's burned, hydrogen reacts with oxygen to produce water, which means that it generates zero emissions. This makes hydrogen a potential alternative to fossil fuels, which are of course, the main source of greenhouse gas emissions in today's world and the largest contributors to climate change

2. Secondly, Hydrogen is linked to sustainability through it's use in fuel cells. These are devices that use hydrogen and oxygen to produce electricity, without generating emissions, resembling a mini hydrogen powerplant, but one that can be used to power vehicles, buildings and other applications without generating greenhouse gases, with vehicles being an especially interesting case.

Current Limitations of Hydrogen Based Technology:

- Production: One of the main challenges with hydrogen is that it is not naturally occurring, so it must be produced through a process known as electrolysis. This process requires a significant amount of electricity, which can be expensive and may not be readily available in some locations. Additionally, hydrogen can also be produced from fossil fuels, which defeats the purpose of using it as a renewable fuel, especially if the electricity for electrolysis comes from burning fossil fuels.

- Storage: Another challenge with hydrogen is that it is difficult to store and transport. Hydrogen is a gas at ambient temperature and pressure, so it must be compressed or liquified in order to be stored. This can be expensive and can reduce the efficiency of hydrogen-based systems, brining the same sustainability problem seen in production.

- Safety: Hydrogen is highly flammable, which can make it dangerous to handle and transport. This can be a barrier to the widespread adoption of hydrogen-based technologies, and can cause disasters in local environments, if there are large leaks.

- Infrastructure: In order for hydrogen to be used as a fuel, there must be a infrastructure in place to produce, store, transport, and distribute it. This infrastructure does not yet exist in many places and the construction of this infrastructure may release many greenhouse gases, and be a cost barrier for wide-spread adoption of the technology.

Hydrogen Fuel Cells:

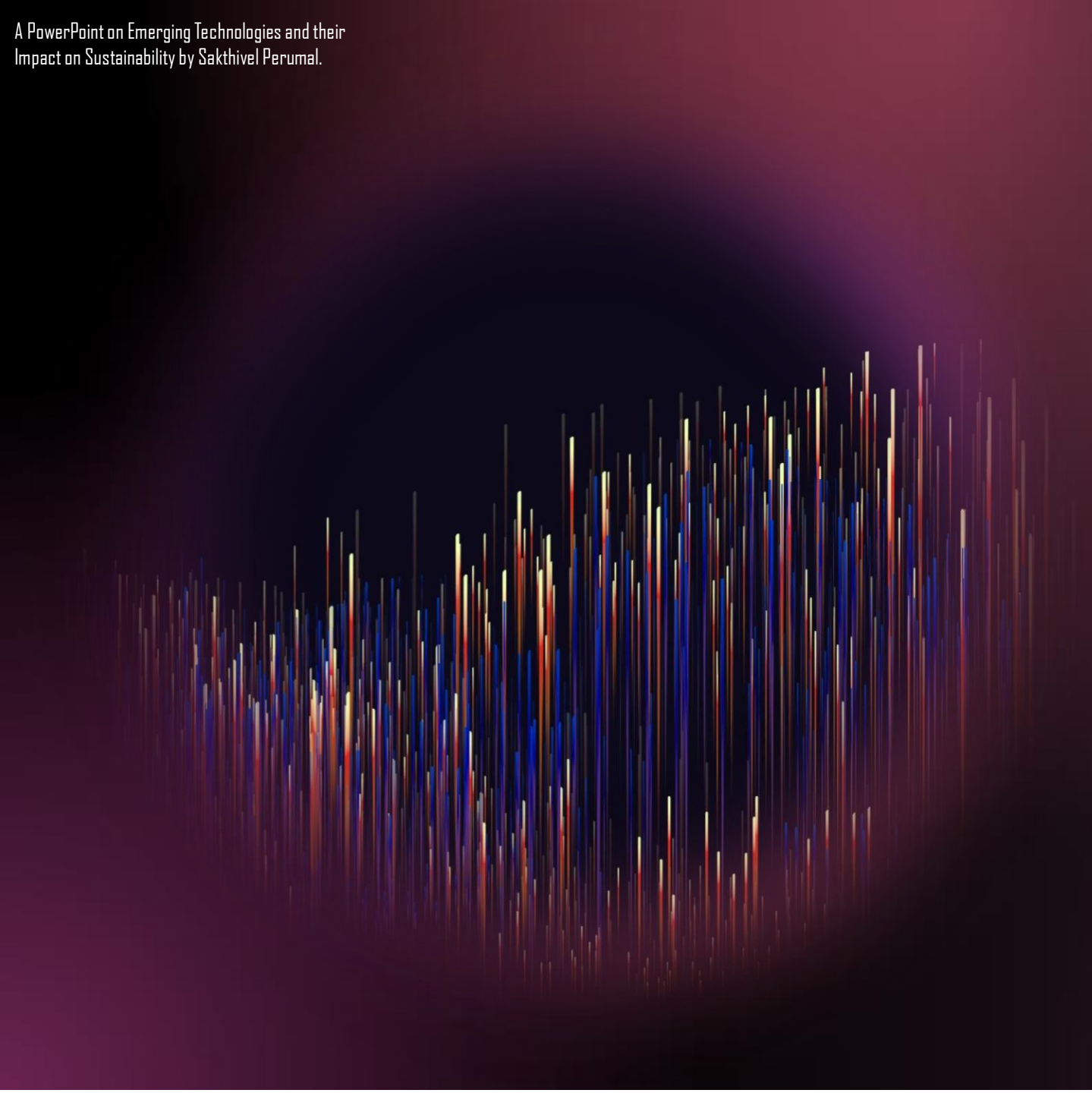
These are the most exciting part of upcoming Hydrogen technology, and the one with the highest chance to impact sustainability in a real way, due to their use in vehicles.

- One unmentioned major benefit of Hydrogen fuel cells is their energy efficiency compared to regular combustion engines. Hydrogen fuel cells are able to convert a lot more of their energy from their fuel into usable electricity, as they operate at a higher thermodynamic efficiency, and skip the steps of converting fuel into heat, then mechanical energy, and then electricity as some modern Hybrid cars do.

- Their efficiency over batteries in cars is contested, but they have the potential to be more sustainable than EVs, though the problem for both lie in how the energy to make electricity for electrolysis, or to power the EV is made.

Use in Buildings:

- Hydrogen Fuel Cells can be used in Combined Heat and Power systems to generate both heat and electricity, which can power a building and provide hot water for radiators.
- This can be more efficient than using separate systems for electricity and heat, and can help to reduce energy waste and improve the overall sustainability of a building.



Conclusion

- In conclusion, emerging technologies such as Battery Technology, Fusion Energy, Artificial Intelligence, Bio-Plastics and Hydrogen Technologies have the potential to greatly improve sustainability and address the challenges of climate change.
- By investing in research and development, implementing policies that support the adoption of these technologies, and working collaboratively on a global scale, we can create a more sustainable future for ourselves and future generations.
- It must be stressed that sustainability doesn't come with any of these alone. All of these ideas and more, along with social changes in general human lifestyle are what allow these technologies to really make an impact on our planet, defeat climate change, retain more resources for future generations and make our world, in every sense... **more sustainable.**

THANK YOU VERY MUCH FOR READING