

FIVE MINUTES INTO THE FUTURE

Horizon scanning real tech for your game

Volume 1.1

The Wireless Photosheet Array

Disclaimer: A little knowledge is a dangerous thing

Each issue of 5 Minutes into the Future (5MF) looks at one real world developing technology and tries to make it something

fun to add to your games. But I am not a scientist. Or a technologist. I am almost definitely dumbing things down to a level I understand, or unwittingly misinterpreting the science and theories involved in the technologies presented.

I am also making stuff up about crazy impossible impacts of the technology, to make it interesting for your games.

So, please! Don't treat anything in here as truth!

If you have a better understanding than me, by all means get in touch on our Discord server (see the sidebar or footer) and explain it to me, I'd love to learn more.

If you want a better understanding than I can provide, go check out the links I give for the source material – I would always encourage everyone to broaden their own learning.

Oh, and there is no implied challenge or slight to any person or organisation about the technologies I cover or the game systems I give added rules for. I love the systems, and I am amazed and awed by the tech – if I wasn't, I wouldn't write about it. If you believe there's a permission I need, or a credit I've missed, please get in touch.

Otherwise, enjoy issues of 5MF for what they are, some (hopefully) fun stuff to include in your game that are more interesting because they have roots in the real-world.

Wanna chat?

Get over to our Discord server <https://discord.gg/bE5zCgH>

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Technology Volume 1.1:

The Wireless Photosheet Array

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What is Five Minutes Into the Future?

Five Minutes Into the Future (5MF) are a series of short guides scanning the horizon for cutting edge technologies being developed in the real-world right now. Each issue will present one piece of nu-tech and some ways that you can use it in your roleplaying games.

5MF is largely system neutral, and suitable for a variety of modern and near future genres, including:

- modern,
- heist,
- espionage,
- technoir,
- near future,
- superhero,
- cyberpunk,
- modern horror,
- hard sci-fi, and
- (post)-apocalyptic.

Finally, I finish each guide with just a little bit of crunch so you can use the technology in a handful of popular, different systems.

What will 5MF be like?

Each 5MF guide will present one technology that is in development right now (as of the date of release).

You'll get a break down of what the technology does, or what the creators hope it will do, at least. I try to stick close to reality here and discuss what makes this interesting and important without getting too bogged down in the science.

Then I get into the realms of speculative fiction and present some possible implications of including the nu-tech in your game's setting, covering three different levels of integration:

- bleeding edge tech,

- high tech, and
- accepted tech.

For each level of integration you'll have some story hooks for using it in your games in a selection of genres. All of which is system neutral and easy to mix and match.

Finally, you'll get some rules crunch for using the technology, or related ideas (like relevant character options), in your games. You will see rules for:

- Fate,
- Powered by the Apocalypse, and
- 5e modern D20 systems.

If you'd like me to feature another specific game system, please get in touch on the Discord (link below). Can't promise to oblige, but I'm happy to try!

NB: Rules presented will generally be for the core rule systems, for licence reasons. For Powered by the Apocalypse games I'll list which specific game the crunch is for as they don't share a common set of rules.

What is the technology?

This issue's technology is the Wireless Photosheet Array.

Why is it important?

The photosheets use carbon dioxide, sunlight, and water to produce a clean solar fuel, like a plant leaf uses photosynthesis to create energy.

What is the background to the technology?

Cambridge University, in the United Kingdom, in partnership with the University of Tokyo, Japan, have been conducting research for over a decade to make an artificial form of photosynthesis

(the process that plant leaves use to turn sunlight, water, and carbon dioxide into energy). The goal being to create sustainable, carbon-neutral, and practical solar fuel production.

How does the technology work?

Researchers at Cambridge University, in the South of England, have recently (August 2020) as part of the international group, created a 'photosheet' capable of turning carbon dioxide into oxygen and formic acid.

The standalone, wireless (meaning it requires no additional wires, components or electricity to work) photosheet is packed with cobalt-based photocatalysts while the sheet itself is made from powdered semiconductors and has a burnished, golden appearance.

As the Abstract for the research paper states:

This technology integrates lanthanum- and rhodium-doped SrTiO₃ (SrTiO₃:La,Rh) and molybdenum-doped BiVO₄ (BiVO₄:Mo) light absorbers modified by phosphonated Co(ii) bis(terpyridine) and RuO₂ catalysts onto a gold layer.

The whole thing is apparently quite cheap to make, a previous version used expensive components from existing solar cells, but for this version the photocatalyst chemicals can be produced economically at scale. This golden prototype is only about 3 inches (20cm) squared, but they expect to be able to ultimately produce photosheets of several metres squared. With these photosheets they hope to make efficient solar arrays for use in renewable energy farms.

Formic acid, the solar fuel produced, is a fuel in itself that can be easily stored in solution, or can be used as a building block to create hydrogen and other fuels. Previous solar fuels had been gaseous and

were difficult and expensive to store and transport.

The problem up until now with creating sustainable fuels is that they have caused a lot of unwanted byproducts which have to be dealt with. However, the new photosheet reaction is highly selective, with a high solar-to-formate conversion efficiency of around 97%. This means there is almost no byproducts or waste heat in the process, just a release of oxygen.

What is next for the technology?

The researchers are continuing to experiment with different photocatalyst materials in an attempt to improve the amount of formate that can be produced so it can be viable on a commercial scale, and also to see if they can create different or better solar fuel outputs.

Where can I find out more?

Check out the links below for more information:

<https://newatlas.com/energy/wireless-photosheets-co2-sunlight-clean-fuel/>

<https://www.cam.ac.uk/research/news/wireless-device-makes-clean-fuel-from-sunlight-co2-and-water>

Implications for your game

It's clear that in the real-world wireless photosheet technology has the potential, once improved, to:

- Help reduce dependency on fossil fuels,
- Be (at worst) a carbon-neutral technology, and at best facilitate a reduction in carbon, and

- Be cheaper and cleaner than most other liquid fuel sources.

Which is all great, but how does that work for your setting and make for a more interesting game?

Bleeding edge tech

(Bleeding edge technology is the newest tech, clearly more advanced than anything else available, and gives a significant advantage to those who control it).

Perfecting wireless photosheets is the first step to introducing them into the world and at this stage they are almost unheard of, making any place that uses them unique and worthy of describing to your players. For example:

- A billionaire's yacht might be coated in distinctive golden photosheet, or
- The newest, tallest, most luxurious hotel might have a roof array of photosheets, or have it worked into a distinctive golden design on the glass walls.

Espionage

Wireless photosheet technology could first impact your setting even before it is perfected. As a technology that potentially provides cheap, clean fuel it sets itself against serious vested interests.

In an espionage game, energy corporations and oil companies have millions to spend working against the research. They can buy politicians and officials to undermine the research with bureaucratic red tape, introduce laws that hamper its development and make deals which see rival but pie-in-the-sky, dead-ended technologies favoured for grants, leaving the wireless photosheet research underfunded. In a politically active game players could need to swing key votes by hook or by crook, and uncover official corruption in government, business or in the esteemed Universities themselves.

Many nations may also be deeply affected, oil rich ones standing to lose trillions, and resource poor ones being desperate to get the new technology. Long-standing allegiances could easily shift, with allies split and enemies thrown together. The use of multiple 'state sponsored actors' (spies, agents and hackers) becomes likely, to steal research, and blackmail (fictional) researchers, students and technicians into giving them access. Kidnapping and even murder may follow unless the player characters can prevent it.

Superhero

In a superhero setting the wireless photosheet becomes a powerful prototype, a single working model of incredible efficiency.

But have the (fictional) researchers dabbled with things beyond human understanding in their quest for better photocatalysts?

The prototype could be a part of a superhero's, or supervillain's gear. The thin golden wireless photosheet requires no electricity or connection of any kind to produce liquid fuel from incidental ingredients and so could easily be the power source for rocket packs and boots, flamethrowers, supermobiles, robots and powered armours.

The wireless photosheet could even become part of an origin story for a hero or villain. An accident with the formic acid or other fuel leaving them scarred. Or an explosion from using an unstable photocatalyst causing the gold photosheet to permanently bond with their flesh, wirelessly infusing them with solar fuel... (cue fire or light based abilities).

Supervillains, aliens or characters from alternative worlds could try to steal or acquire the photosheet to power strange technologies like dimension gates to get

home, re-make the world in their image, or bring invading armies to earth.

In a superhero setting, whoever controls the cutting edge technology of the wireless photosheet has a distinct advantage, and having different sides compete for it could be a great story. Different factions of superheroes can be set up to start duking it out for control – because superheroes never discuss minor differences sensibly when they could instead get into a rumble!

High tech

(High tech is slightly more available than bleeding edge tech, and all well-monied groups have access to the technology but it isn't yet common enough that it turns up on the street).

The next step is where the photosheet becomes merely high tech – it's no longer a deciding factor in conflicts because all reasonably well financed groups have access to it. Instead of spies fighting over it, they fight using it, examples might include:

- Special fold-out briefcase sized photosheet arrays providing emergency sources of fuel in the wilderness,
- Drones become long-range because they produce their own solar fuel,
- Tanks and specialist military vehicles might be equipped with a photosheet roof to keep them running, and
- Golden photosheet tinged fighter jets no longer need to do mid-air refueling, allowing longer flights and increased combat mission time.

Post apocalypse

It may seem strange to talk about having high tech in a post apocalyptic setting, but this is the right level for wireless photosheet technology to be integrated into society prior to your apocalypse. It means that fuel and energy sources are still scarce after the apocalypse, but enough survivors know about wireless

photosheets that the prospect of finding a working one is a major event that can easily upset the balance of power in the entire setting.

Introduce a working photosheet into your post-apocalyptic setting with care, as whoever ends up controlling the photosheet can power vehicles, generators and whatever devices aid survival in your version of the apocalypse – whether that's electric fences, electric lights, recharging the batteries of Geiger counters, air filtration systems, ammunition manufacturing, water extraction or who knows what other crazy contraptions.

However, as a GM you can still regulate how much power a photosheet can provide by reducing the level of one or more of the key ingredients required to make the formate.

With less people, animals and pollution carbon dioxide levels should fall, though there are potentially ways to create it in small amounts – hooking up the photosheet to an air filtration system for a big (underground bunker?) community, for example.

With less water, communities might have to decide whether to prioritise powering the photosheet array or having enough to drink and create food. Even using recycled water might be too much of a sacrifice if the community needs every drop just to live.

With less sun there is less to power the photosheet. However, we aren't talking just clouds or fog, as non-visible spectrum rays still penetrate and provide sufficient energy.

Something like a nuclear winter though, with clouds of dust that reflect the light back out into space would make it much harder to get enough light to power the photosheet.

Technothriller

In a technothriller genre setting, technological advance is front and centre and driving tension in your stories. So, the wireless photosheet has to be being used to achieve something questionable, like powering a frozen warehouse used to store

illegally harvested organs sold to powerful people who won't wait on donor lists.

It's also possible to explore the tensions that might be caused by a swift introduction of the photosheet technology as a backdrop to your game. It might begin with seismic shifts in the stock market as oil prices plummet and investments and banks linked to it are dragged down. Then, job losses all the way through from oil companies to petrol/gas stations to domestic electricity companies, car companies and more all begin to topple. Logistics and distribution chains begin to falter and shortages begin. The collapse of the old fossil fuel infrastructure may also outstrip the new technology's ability to provide replacement energy, leading to energy shortages, brown-outs, energy riots, abandoned vehicles etc.

All of which can make for an amazing backdrop for your game even if it doesn't specifically relate to the adventure. However, don't forget how these things might impact on your PC's lives. Their homes and base of operations losing power (or being targeted by opportunistic and desperate people who see they still do have power). The inability to get items due to logistics problems. Loved ones and allies caught up in rioting as protesters, bystanders or maybe even people perceived to have caused the problem.

Perhaps the characters even get out amongst those affected and try to bring the community together to support each other. And of course, eventually supply will move to meet demand, and perhaps the characters are involved in that too – fitting new photosheet arrays, organising fuel

distribution to areas that need it most. They must also protect the fuel deliveries from criminals, desperate citizens who won't wait their turn and those who want the new technology to fail. And, of course, the PCs should uncover the inevitable conspiracy that set about to cause the crisis, to profit from the chaos. Finally, new infrastructure develops to support the new tech, with new jobs and prosperity.

Accepted tech

(An accepted technology is one which has now been fully absorbed into

everyday life and is now unremarkable for the people in that society, being adapted and modified to fit a variety of lifestyles and needs).

Finally, the wireless photosheet becomes an accepted technology, part of the landscape, appearing everywhere, being adapted and developed to fit a variety of purposes from the mundane to the outlandish.

- Cars are fitted with golden photosheet roof panels that make having to refuel a thing of the past.
- Every tall, modern building is tipped with gold photosheet arrays catching the sun as you stare across the cityscape.

Hope-punk

Yep, wireless photosheet technology has definitely improved this setting. Not everything is perfect obviously, but cheap, clean energy has bought society forward, ready to face new challenges.

That's the 'hope' part of a Hope-Punk setting using photosheet technology...

And the 'punk' part? It's because now the technology is in the hands of the masses. Tinkerers and street mechanics can mess around with the photosheet arrays to produce all sorts of things.

Some will be messed up, as people sometimes are; like the serial killer storing kidnapped victims in suspended animation powered by wireless photosheets until he's ready to kill them. Or the organised crime drug-factories and houses growing cannabis tended by modern day slaves that use photosheet arrays to generate the huge amounts of power needed without alerting the power grid.

Other uses though show ingenuity. Cheap housing made from stacks of shipping containers and scaffolding, made into bearable communities because they have sufficient energy to power their homes and grow their own food. Self-sufficient 'bio-domes' forming a positive feedback loop where occupants provide the ingredients to power the photosheet arrays and the array gives them sufficient energy to continue to live.

Maybe humankind is now living in space. Hundreds of micro-ships orbiting earth or crossing the vast void, using their own expelled carbon dioxide, the power of the sun and their own recycled water or maybe mining ice from asteroids and meteors, to have a photosheet array power everything – bootstrapping their way to new planets in the solar system. Private, reusable space-planes fueled by solar formate from their own photosheets launch dozens of new ship capsules every week into space before they slowly peel away into the blackness.

Techno-horror

In a techno-horror setting the wireless photosheet could be used to empower or release the horror. For example, using photosheet arrays to power lighting and equipment in a remote underground archaeological excavation only to have equipment begin to fail. Trapped in the dark, with rising water when lights and pumps sputter and stop, the players discover something inside the excavation is drawing all the power to it. For this to be

even more creepy, prior to the failure the GM should emphasise how reliable and well-trusted this technology is now.

Alternatively, the photosheet can be used as part of the solution to a horror adventure. At its most basic, a photosheet array producing formic acid becomes a source of fuel for fire-based improvised weapons for PC's to defend themselves or to fool-hardily go hunting whatever horror the GM has concocted. Of course, a photosheet array can also be the epicentre for a nice big explosion that is the final, desperate attempt to finish off, or escape from, the horror.

There are plenty of other ways ingenious players (or devious games masters) can utilise photosheet technology in a techno-horror as well. Such as, having a local source of power to keep important technology running, or kit-bashing a replacement power source for a damaged vehicle to fight or escape from the horror. And of course any horror with an affinity for power, or fire, finds the wireless photosheet an amazing opportunity to grow it's abilities. As GM, denying players the asset can also be scary – darkness is a classic horror element and denies the photosheet of it's key power source, sunlight.

Finally, consider a different sort of horror, ecological disaster from mass formic acid spills, giant hydrogen explosions or other unforeseen consequences of the technology.

Rules and game information

So far everything has been system agnostic advice, but here's where you get some tools to help embed the wireless photosheet into your game.

Below are rules for Fate, Powered by the Apocalypse, and a 5e D20 modern system. (And if you would like us to consider giving information for other

systems, please contact us on the Discord).

But first, here are some generic rules that can apply to most games.

Wireless photosheet array

- Every 1m squared of array produces enough formate in 1 hour to power something for 1 hour. As long as conditions are suitable (sunlight and water and carbon dioxide are available).
- Power production is generally limited to the, average, 10 hours of good, 'useable' daylight each day. GMs should feel free to alter this but keeping it at 10 keeps things simple.
- Well-maintained, efficiently installed arrays may be able to produce more than 1 hours worth of power each hour per 1m square (but this should probably a function of PC rolls or special abilities, or powerful prototypes or upgrades).

For example: a 7m square photosheet array will produce enough formate every hour to power one thing for 7 hours (or 7 things for 1 hour etc). So, in an average 10 hour day of production it will produce 70 hours worth of power. And if a PC were to double the array's efficiency it would be 140 hours of power produced every day.

Herein lies a lesson: sensible people (read: NPCs) do not leave large amounts of liquid formate fuel lying around for pyromaniacs (read: PCs) to blow-up.

This fuel is being produced for a reason and should probably be quickly put to use powering generators, charging items, vehicles, building systems, or being readied for use powering things during the hours of darkness etc.

If your game takes place over years you could also show how fuel production becomes more efficient over time.

Array size

- A 1m square array is a portable, large suitcase sized affair. Or is embedded into a vehicle, generator or other item which cuts out production once the tank is full.
- A 2m square array (producing 2hrs of power for something for every hour in use) is a full solar array and is the largest 'field' variety available, it can also be integrated into a mid-size building or very large vehicle.
- Anything larger than that is embedded in huge skyscrapers or is part of a power generating 'farm' for a community, it probably has overrides and fail-safes to prevent explosions as well as regular, hefty power use.

Setup

- To setup an array requires a fairly easy science or technology type roll (depending on your system).
- If an NPC set it up you probably don't need a roll just assume a standard setup, as above.

Efficiency

- If your system has different degrees of success then higher degrees can increase the efficiency of the array by 1 per degree (feel free to establish a maximum, we suggest double).

For example: One extra degree of success means a 2m square array produces 3 hours of power for something per hour of use, but can't produce any more than 4 hours of power per hour regardless of the roll.

Fuel space

- The formate required to power something for 1 hour is roughly the size of a large jerrycan. A normal person would be encumbered carrying more than 2 hours worth,

and at maximum can carry 4 hours worth.

- Most vehicles and portable generators have a fuel tank big enough to hold fuel for 5 hours.
- High performance, unusual, or heavy combat vehicles generally have enough fuel space for 4 hours, but burn through it twice as fast requiring refueling every 2 hours.
- Long distance vehicles generally have enough fuel space for 10 hours.

Destroying things

- When it comes to burning things using the fuel, each 1 hour of fuel burnt provides a +1 bonus to the damage it causes. When you have spent all the bonus the fuel runs out. E.G. 4 hours of fuel (the max that can be carried) could be used by an improvised flamethrower as two attacks using +2 damage, and one attack using +1 damage.
- Blowing up an array or supply of formate works similarly but add the total hours of fuel available as a bonus to any damage caused. E.G. Blowing up 5 hours of fuel adds +5 to the damage caused by the explosion.

Fate

Photosheet array

The photosheet technology has the following Aspects:

- Powerful formic acid
- Wireless standalone technology
- Fragile photocatalysts

Setup

Make a successful average (+0) Crafts (or Mechanics or Engineering if you have adjusted the default skill list) roll at the time the array is setup, or any time it is adjusted or repaired.

Efficiency

Each step up the Fate ladder on the setup roll improves the number of hours worth of power produced each hour by one.

Each step down the ladder reduces the efficiency by one (so, a 1m square array installed in a mediocre (-1) way would only produce 1 hour of fuel every 2 hours).

Damage

If using the formate as a weapon, or creating an explosion then the hours of power expended add a bonus to the number of shifts applied on a successful roll (not to the actual attack roll).

The GM can also decide to use the hours of fuel as shifts against a player who fails the roll – dangerous stuff.

For example: There is a 2m square photosheet array which was installed by a PC who did a good (+2) job. This array would normally produce enough fuel every hour to power something for 2 hours, but it's installation is very efficient and so every hour it actually produces +2 = 4 hours worth of fuel. Fuel was last collected 3 hours ago meaning there is 12 hours worth of fuel available. You plan to use the whole lot to blow up the store of formate. Make the attack roll as normal, and if it beats any defence roll, add +12 to the number of shifts inflicted. Kaboom.

Stunt: Efficiency Expert

The character is an expert at tinkering to get the best out of technology. The character ignores any limitations on how far an item can be pushed by their tinkering. (For the photosheet array they would ignore the rule that the maximum efficiency is double the size of the array).

Powered by the Apocalypse: (Apocalypse World)

Move: Percussive Maintenance

This is an advanced move available to be picked up by anyone controlling a Wireless Photosheet Array.

When you spend time banging and clashing around the photosheet array, something begins to work. During the daylight, roll +Hard

On a 10+

You manage to coax out the fuel you wanted. Gain hours worth of formic acid fuel equal to time you spent (in hours) multiplied by the size of the array (in metres square).

On a 7-9, choose one:

- It takes twice as long to get the amount from 10+ (unless you run out of daylight before you get that much).
- You get half as much in the time as you would have if you'd rolled 10+.
- You get as much as you would from 10+, but something breaks or someone is coming for it.
- You get as much as you would from 10+, but are left with a serious shortage of water (or possibly... sunlight).
- You get as much as you would from 10+, but are burned by the formic acid, take 3 harm.

Formic Acid/Fuel

Each 1 hour worth of fuel

- Is worth 1 barter
- Causes 1 harm when used as a weapon/explosive. This is cumulative for multiple hours worth of fuel.

Formic acid has the following Tags:

- Messy,
- Close,
- Area,
- Loud,
- Burns,
- Improvised, and
- Reload.

5e modern D20 rules

Wireless photosheet array

Technology level

The technology level and availability for the photosheet array is;

- As bleeding edge tech (level 2, Very Rare)
- As high tech (level 2 / 3, Rare)
- As accepted tech (level 3, Uncommon)

Using an array

- To setup or adjust an array requires a DC 15 Intelligence (Engineering) check, to produce 1 hours worth of fuel every hour, per metre square.
- With each +5 DC beaten add +1 hours worth to the fuel per hour (so DC 20 on a 1m square array would produce 2 hours worth of fuel per hour).
- Fuel from an array can be used to charge Battery Cells:

Basic (10 cells = 1 hours formate),

Medium (1 cell = 1 hour formate),

High (1 cell = 3 hours formate).

Using formate as an explosive

- To use the fuel produced explosively requires either an Intelligence (Engineering) sabotage check or Intelligence (Demolitions) skill check. The DC will vary

depending on the method used, but DC 15 to 18 is probably right.

- Formate has the following profile: 1 hours fuel = 1D6 fire damage, explosion 5ft, ignition detonation type with sympathetic response. Add +1 damage for each additional hour of fuel being use.
- No more than 5 hours of fuel can be stacked in a 5ft area – thus increasing the size of sympathetic explosion.
- GM's could decide, as a modern fuel, liquid formate doesn't combust easily, in which case remove the ignition detonation feature and replace with explosive detonation (i.e. only another explosion will trigger a formate explosion).
- Formate follows all the usual rules for demolition.

Using formate as a fire based weapon

- The GM may require either an Intelligence (Engineering) sabotage check or Intelligence (Demolitions) skill check to get the formate to combust before any attack roll is made, or can include the activity as part of the attack roll.
- Treat use of flaming formate as a flamethrower. If you have a means of spraying the fuel you target a 20-foot cone emanating from you (if the flamethrower is improvised the roll is made with Disadvantage). If it is being sprinkled or thrown reduce the cone to 5 or 10ft.
- Damage caused by 1 hours worth of fuel being set on fire is 1D6 (fire), with +1 damage per extra 1 hour of fuel used in the attack.
- The DC for the Dexterity saving throw to get out of the cone equals 8 + your Dexterity modifier + your proficiency bonus (if you are proficient in either the weapon or the Photosheet Array).

- Making the save still inflicts half damage. Any target that failed the save is set on fire and suffers half the inflicted damage again at the beginning of your next turn.

Optional class trait: Output Tinkering

(This assumes a tech focused class who have a class feature that gives them a set number of uses, or points available to use between rest periods).

- By spending 1 point (and making constant adjustments for 3 turns you can double (or halve) the output of any machine for the next hour. After which you cannot use this trait again until you take a short or long rest.
- Additionally if you rest near a machine you have altered the output of, then you can collect spare parts worth 10 (in your preferred currency) per short rest, or 20 in a long rest. These amounts are cumulative with any amounts of spare parts gained from other class abilities.

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