**Way back in the mists of time, probably about five thousand years ago or so, some ‘smart alec’ in the pot making department of ancient Egypt, or possibly Sumer in Mesopotamia, or Greece, or maybe even China, no-one really knows, but SOMEWHERE, some ‘smart alec’ realised that if they made a big heavy disc and connected it to the table that they were making things on, they could spin the whole thing, which made it much easier and faster to shape the pot. Sounds very simple to our modern minds, but at the time it was nothing short of revolutionary …you see…revolutionary…cos it’s…it’s a wheel.**

**Anyhoo the principle… of a heavy spinning disc was used many times over the following centuries, and by the time the industrial revolution came along, it was embraced enthusiastically into ALL SORTS of machinery, with its fancy new name…the flywheel. They were perhaps MOST useful as a means to smooth out the up and down fluctuations of crankshafts in reciprocating engines, but they were also pretty handy for providing a bit of extra oomph to things like power hammers and riveting machines. And in the guise of a gyroscope, they proved to be an invaluable stabiliser for sensitive instrumentation like ship navigation systems.**

**Then in the middle of the twentieth century, some engineering types started to think about flywheels as a possible way to store and release a bit of energy that could be converted into ELECTRICTY to do some useful work. An early example is this rather quaint thing called a Gyrobus, which carried a large flywheel that could be charged up for a couple of minutes at each bus stop, causing it to rotate at three thousand RPM, delivering enough electrical energy to drive the bus at sixty kilometres, or thirty-seven miles an hour for about ten minutes or so – more than enough to get to the next stop.**

**And now, as we scramble to find efficient, economically viable, and environmentally friendly ways to store intermittent energy generation from renewables like wind and solar for large utility grids, this age-old technology appears to be enjoying something of a resurgence.**

**Hello and welcome to Just Have a Think**

**Once the world had got its mind around the idea that electricity was definitely something useful, around about the start of the last century, the next challenge was to reach some kind of nationally and internationally agreed method of generating it in the first place. It was generally agreed that the cheapest and easiest way was to burn something to heat up water until it became steam and then send that steam across a turbine that could drive an electrical generator. It was a great system because it worked whether you were burning coal, or gas or even generating heat via a nuclear fission reaction. And of course, if you were lucky enough to have local geography that allowed for the building of dams, you could just let the water from a reservoir flow straight across a turbine and do away with the burning part all together. Whichever way it was done though, there was always a very heavy ‘spinny’ thing in the system. Those heavy spinny things had the extremely useful characteristic of inertia. In other words, even after the flow of steam, or water stopped, the big heavy turbines would carry on spinning for quite a long time afterwards. And that was a feature that grid operators could make good use of to smooth out the spikes in grid demand in a process known as frequency regulation. Frequency is a function of the speed that the turbines are turning, but it’s also a function of energy demand on the grid, which has to be precisely matched by supply in real time. If the demand spikes higher than supply, then the line frequency will drop. If it deviates too far below 60 Hertz in countries like the US or 50 Hertz in some other parts of the world, then there’s a risk of brown outs or in worst case scenarios even a complete system collapse.**

**When renewables like wind and solar came along they posed an additional challenge for grid operators with their extremely variable power outputs and intermittency. The most widely employed solution to that problem is to use energy storage like grid scale lithium-ion batteries, which can respond instantly to variations in grid frequency for just long enough to keep everything nicely balanced, allowing grid operators to jiggle things around a bit to properly accommodate the spike.**

**But some clever engineers in the energy industry applied a bit of lateral thinking and realised they could, in theory, build standalone flywheels that could emulate the useful inertia characteristics of the old fossil fuel driven turbines that were being replaced. Advanced energy storage flywheels basically consist of a giant rotor, suspended by magnetic bearings inside a vacuum chamber, providing an almost friction free environment that allows a fully charged up flywheel to rotate continually with very little added energy input needed.  If the grid needs a quick injection of energy to get it over a frequency drop, operators can engage a generator to tap into the flywheel rotor and push out electricity. And if demand drops unexpectedly, then the unwanted electrons being generated by the power plant can be sent to the flywheel to get it spinning up again, taking the frequency spike out of the grid system.**

**Clever stuff, eh? In twenty-twenty, an American company called Beacon Power built what was at the time the world’s largest**[**flywheel energy storage**](https://en.wikipedia.org/wiki/Flywheel_energy_storage)**system in Stephentown, New York. It has a generating capacity of twenty megawatts, which is produced via no fewer than two-hundred carbon fibre flywheels levitating in a vacuum chamber similar to the one I just described. In this case, the flywheels can steadily discharge one megawatt of electricity for 15 minutes, helping to reduce New York’s dependency on hugely expensive and inefficient gas peaker plants to get over spikes in demand.**

**But of course, advances in technologies like these never stand still, do they? And in April twenty-twenty-two, 5:41 the German technology giant Siemens completed production of the world’s largest SINGLE flywheel - a one-hundred-and-seventy-seven-ton behemoth that’ll be installed at the Moneypoint power plant in County Clare in Ireland. It’s part of an ambitious project being run by the Irish energy company, ESB, to transform Moneypoint from a dirty coal fired facility into a renewable energy hub of the future, with a range of renewable technologies deployed over the next decade, including floating offshore wind and green hydrogen production and storage that’ll have the capacity to power one-point-six million Irish homes. The flywheel, or ‘synchronous compensator’, as it’s more technically known, will be capable of providing four thousand mega-watt seconds of inertia, which is twice as much as the current Moneypoint plant turbines can produce.**

**But surely, I hear you ask, all this grid frequency regulation is precisely what LITHIUM-ION batteries are there to do isn’t it? And, well, yes. It is. So why are we bothering to introduce yet another solution to a problem that appears to have already been solved?**

**Well, the makers of these systems point out various advantages of flywheels versus lithium-ion batteries. They have round trip efficiencies of ninety to ninety five percent, which is comparable to an average lithium-ion battery, but they typically use simple and abundant raw materials that are fully and easily recyclable and have fewer environmental impacts than the rare earths and metals that go into lithium-ion. They can be charged up in a couple of minutes or so, and there’s effectively no limit on how many times they can be cycled in a day. There’s pretty much negligible degradation over their operational lifetime too, so they last for decades. They can operate in a very wide temperature range, from arctic freeze to Saharan swelter and they’re completely safe in operation, with no chance of any inconvenient random combustion. Operation and maintenance costs are pretty low too, because there’s really not that much to maintain.**

**On the downside, they don’t quite have the energy density of lithium battery systems, and they have very high idle losses, otherwise known as self-discharge rates. Despite great efforts to eliminate friction in the system, even the best flywheels wind down from full speed to standstill within a day or so. And they’re relatively expensive to install as well. According to the International Renewable Energy Agency, or IRENA, by twenty-thirty the average cost of a flywheel installation will be around four thousand dollars per kilowatt hour. That doesn’t stack up too well against lithium-ion, which IRENA says will typically have installation costs of less than a thousand dollars per kilowatt hour by the end of the decade. So, we’re not talking about a fundamental market disruptor here, but perhaps something that can work alongside batteries in specific scenarios. And that’s exactly what Dutch energy storage specialists S4 Energy and the Swiss-Swedish manufacturer ABB set out to achieve with the October twenty-twenty-two launch of a HYBRID battery and flywheel energy storage system that aims to achieve the best of both worlds. The installation is located in a place that is spelled like this and is almost certainly not pronounced Heerhugowaard. Anyway, it's a power plant in the North of Holland and it’s connected to a nearby windfarm. The new kit combines a ten-megawatt battery system with a three-megawatt flywheel, providing a total energy storage capacity of around nine megawatt hours, with a cycle efficiency of more than ninety-two percent and an operational lifetime of well over twenty years, or more than a million cycles, giving it a claimed levelised cost of storage of between two cents and twelve cents per kilowatt hour, depending on the application.**

**At the other end of the scale there’s this approach from another European firm called Storenetic. They’re making small modular flywheels with power ratings up to a hundred and thirty kilowatts that can be hooked up together and housed inside a specified number of standard shipping containers, depending on the clients requirements. They may be individually small, but they can each rotate at up to forty-five-thousand revolutions a minute, which means they can still effectively store a very useful amount of energy that can be discharged in milliseconds for frequency regulation. This kind of modular design can be linked to a wind farm or solar PV array, and it opens up the potential for domestic and commercial buildings with solar PV installations to feed excess generation into a local flywheel storage facility, and pull energy back out again when required, all of which could significantly help to reduce their own energy bills and smooth out fluctuations on the centralised grid. In days gone by, grids often had to ask big manufacturers to increase or decrease their production levels and energy demand if there were big spikes happening on the grid. With this kind of local flywheel system, those manufactures may no longer need to factor those random requests into their production schedules, which of course will make their overall operation that bit more efficient.**

**I don’t think anyone’s rushing for phrases like ‘gamechanger’ or ‘transformational breakthrough’ when they start describing these flywheel installations, but they do look like a very smart piece of relatively simple and environmentally friendly technology that will quietly perform a critical role alongside all the other technologies that national grids are rapidly developing in order to accelerate the transition away from fossil fuel combustion, which in the case of the UK grid, is targeted for completion by twenty-thirty-five.**

**So, let’s see what you think about all this. Are you a grid engineer or designer? Maybe you’ve got first-hand experience of flywheel energy storage and have some nuggets of insight that you can share with us all. Or do you just have strong views one way or the other about the rapid transition towards more sustainable energy generation. Whatever your view, why not jump down to the comments section below and leave your thoughts there.**

**That’s it for this week though. A massive thank you, as always, to our amazing Patreon supporters who help me keep these videos completely independent and free of ads and sponsorship messages. And I must just give a shout out to some folks who joined recently with pledges of ten dollars or more a month, They are**

**Terry O’Reilly**

**Joakim Iveroth**

**Norm Zemke**

**Lukas G.**

**Pgm 98387**

**John Mathers**

**Charles Donkin**

**John Dodd**

**And of course, a big thank you to everyone else whose joined since last time too.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.**

**See you next week**