**As you know, I talk a lot on this channel about energy storage, especially the utility scale energy storage that we’ll need if we’re going to reach the goal of 100% renewables on our electricity grids. The predominant energy storage medium right now is of course lithium-ion batteries, and I should probably take this opportunity to clarify the comments I made about them in a recent video, when I stated that, at utility scale, they’re only good for a discharge time of about four hours. Several viewers, quite reasonably, asked why that was. Surely you can simply make the battery bigger, or use more batteries to get a longer discharge time? And, well, yes you can in theory. But battery technology is always a bit of a trade-off between various criteria like the amount of energy it can hold versus how quickly it can release that energy, or how long the battery lasts versus how safe it is to operate, and of course how cheap it is to produce. If you optimize your battery to hold more energy you tend to limit how quickly that energy can be released, and if you optimize for safety you tend to limit energy density. Lithium-Ion batteries are brilliant at releasing energy instantaneously and that makes them great for frequency regulation, which is the mechanism that prevents shortages or over supply when spikes or troughs occur in demand. That’s where they are most cost effective. And that grid stabilisation cost curve generally works OK for time periods of between four and six hours.**

**But for longer duration storage, providing predictable, base load style electricity over night or over a few days or possibly even a few weeks, where you don’t really need instantaneous response times, the economics of lithium-ion just don’t stack up so well. There’s no physical reason why it can’t be done, it’s just prohibitively expensive.**

**That’s why so much development work is being conducted on modular energy storage systems that use cheap abundant materials and predominantly off-the shelf components. They don’t tend to have the instant discharge time or energy density of lithium-ion, but they can provide very long duration discharge times at low cost, often with very high cycle lifetimes and with extremely good levels of operational safety. That’s precisely the kind of combination that’s been developed over the last few years by the godfather of wind turbine technology, Henrik Stiesdal, and his team at Stiesdal Storage Technologies in Denmark. Now they’re ready to show the world what their technology can do, and they’ve chosen a very apposite name for their energy storage system : Gridscale.**

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

**Henrik Stiesdal is a Danish innovator with more than a hundred and seventy-five inventions and over a thousand patents to his name, mostly in wind power technology. The most significant of those was the so-called Danish Concept for wind turbines that he launched in 1978 and which became the industry standard, dominating the global wind industry during the following decades. He also installed the world’s first offshore wind farm in 1991 and spent many years working as Chief Technology Officer for Siemens Wind Power. So, I think we can confidently say he knows his stuff! Stiesdal Storage Technologies , or SST was founded several years ago to focus on what they call ‘high-impact solutions to climate change.’**

**The Gridscale Energy Storage system is just one of those solutions, and I recently had the opportunity to chat via Zoom with the Project Manager Bo Birkemose to learn more about how it all works.**

**Bo explained that there are two processes in the system – unsurprisingly, the first process charges the system up and the second process discharges it. The essential principle is the movement of heat energy in air from one large storage cylinder to another and back again, with a method of intercepting the energy at some point as an output that can do some useful work.**

**So, lets jump into the system at the start of the charging process. What we’ve got here is two cylinders containing crushed rocks, usually basalt, but other materials could be used depending on what’s available in any given geographical location.**

**At this stage of the process the air and crushed rocks in the first cylinder are at a temperature of 385 degrees Celsius and the air and crushed rocks in the second cylinder are at a temperature of 75 degrees Celsius.**

**The hot air comes out of the top of the first cylinder and goes through a compressor which super heats it all the way up to 600 degrees Celsius. That super-heated air is then pumped into the second storage cylinder where it transfers its heat energy into the crushed rocks. At the same time, the cooler, 75 degrees Celsius air is being drawn off from the bottom of the second cylinder and run through a heat exchanger to reduce its temperature to about 25C. That air then goes through a turbo expander which drops the temperature right down to minus 30 degrees Celsius. Then that very cold air is fed into the bottom of the cold storage cylinder where it replaces the hotter air that’s being pulled out of the top. That push and pull of air in both cylinders produces very steep temperature gradients between hot and cold that ensure energy losses are minimised in the system.**

**Once the process is complete, we have a fully charged hot storage cylinder full of crushed rocks storing heat energy at 600 degrees Celsius, and a cold storage tank sitting at minus thirty degrees Celsius. Internal insulation ensures that the temperature of the rocks is maintained with very minimal thermal transfer. In fact, even when the rocks inside are at 600 degrees Celsius you could place your hand on the outside wall of the cylinder, and you’d find it was at more or less the same temperature as the surrounding ambient air.**

**To discharge the system, air is pumped out of the hot cylinder and passed through another turbo expander. That works a bit like a turbocharger in a car engine, sending the air across a generator to produce electrical energy. That energy transfer reduces the heat of the air from 600 degrees Celsius down to 385 degrees Celsius, at which point it gets sent into the top of the cold storage cylinder. At the same time the minus 30 degrees air is being pulled out of the base of the cold cylinder, producing that steep temperature gradient I mentioned earlier. The cold air goes through another compressor which is mechanically driven by the turbo expander. The compressor heats the air up to 75 degrees Celsius and pushes it into the bottom of the hot storage cylinder as the very hot air is coming out of the top, again maintaining the steep temperature gradient that the system needs to optimise efficiency. So, when the system is fully discharged, we’re back to our original state with a cold cylinder containing air and rocks at 385 degrees Celsius and a hot cylinder containing air and rocks at 75 degrees Celsius.**

**Bo told me that one of the most important developments they’ve been working on for many years is in producing an internal insulation material that can flex with the expansion and contraction of the rocks as they get heated and cooled. If you didn’t have that flexibility then as the rocks cooled and contracted, they would settle towards the bottom of the tank, and then as they expanded with heat, they’d cause a very unwelcome deformation of the cylinder walls. The exact make up of that insulation material is proprietary information, so I can’t tell you what it is, but it’s one of the main elements that makes this system viable.**

**The compressor that drives the system will be powered by renewables like wind and solar, and the overall round-trip efficiency of the system is sixty percent. Gridscale are aiming to cover both the 12-to-18 hour discharge duration and the 3-to-7 day discharge duration, depending on the number of storage tanks in any given configuration.**

**That modularity is what keeps the cost right down compared to lithium-ion batteries, because the storage tanks are the least expensive component in the system. That means that the higher the capacity of the system, the more cost effective it becomes. So, you won’t be seeing these things in your back yard or basements folks. They’re very much a utility scale energy storage solution.**

**It’s also important to point out here that Gridscale are not attempting to compete with Lithium-Ion batteries in the four-to-six-hour discharge period. Lithium-ion batteries already do a brilliant job in that space and their instant response time is crucial for coping with spikes in energy demand on the grid. So, the two systems will sit very happily alongside each other, with lithium-ion kicking in instantaneously and allowing the Gridscale system a few minutes to get going. Then, once the Gridscale system is at full speed it can provide that longer duration steady discharge which provides energy for the grid and also recharges the lithium-ion batteries.**

**A very neat solution!**

**The system will be rated and certified for 10,000 cycles, but in theory there’s no reason why it couldn’t keep going for much longer than that.**

**In Autumn 2021, Stiesdal will commence installation work on their first operational demo plant at a place called Rødby on an island called Lolland in the Baltic Sea, where their system will be charged up using surplus power from the island’s wind and solar farms.**

**As early as 2006, Lolland was already producing 50% more power from wind than it needed, and today it’s producing twice as much as its residents can use. There’s no infrastructure to send that power to the mainland, so it either has to be used for something else, like making hydrogen from electrolysis, or else it has to be stored, which is where the Gridscale installation comes in.**

**The Rødby site is also very close to a district heating network, so there’s a possibility to connect the expelled heat from the discharge side of the Gridscale system into that district heating network too, bringing even greater efficiencies to the overall set up.**

**The site is scheduled for completion by the end of 2021. Operations will commence in the first quarter of 2022 and test results will be available for assessment in quarter two.**

**As any regular viewer of this channel will now, Stiesdal are entering an already very competitive market. We’ve looked at several long duration storage solutions [show on screen] over recent months and there are more coming to market all the time.**

**That level of competition is of course a very good thing, not only for end consumers like you and me, who will get the benefit of less expensive electricity, but more importantly it’s great for accelerating the move away from fossil fuels and towards national grids powered by one hundred percent renewable technologies.**

**If you’ve got views on these types of energy storage systems of if you work in the industry and have direct experience of them, then why not jump down to the comments section below and leave your thoughts there. And if you want to learn more about the Gridscale system itself, then you can follow the link up there to jump over to the Engineering with Rosie channel to watch Rosie’s site visit to Stiesdal’s test facility.**

**That’s it for this week though. As always, a big thank you to the folks at Patreon who keep these videos completely independent and ad-free. And a quick shout out to the folks who’ve joined since last time with pledges of ten dollars or more a month. They are**

**Nathan Pickett**

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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.**