**Here’s a fun fact for you…**

**Between twenty eleven and twenty thirteen, China used more cement than the USA used in the entire twentieth century.**

**And they’re still going gangbusters now they’ve got through their pandemic lockdowns. In twenty-twenty-one they produced two-point-five billion tonnes of the stuff. That’s more than the rest of the world put together. And that’s a problem because with current production methods, every tonne of cement production results in a tonne of carbon dioxide emissions.**

**It's not just China though, obviously. As a relatively cheap, extremely strong and incredibly versatile material, cement, or more accurately the concrete it’s made from, is ubiquitous all over the world. In fact, it’s the second most consumed product on earth, beaten only by water!**

**In total, concrete accounts for eight percent of all global carbon dioxide emissions.**

**So, it’s a problem, and to be fair it’s a problem that the cement industry is acutely aware of.**

**The question is, what are they doing about it?**

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

**We had a look at the cement manufacturing process in a video a couple of years ago, and it’s probably worth a quick recap here.**

**The first step is to grind up limestone, otherwise known as calcium carbonate, with additional materials like clay, slate, silica sand and iron ore and throw it all into a massive rotating kiln at something like fifteen hundred degrees Celsius.**

**The kiln is tilted at an angle, and as the mixture goes from the higher end to the lower end, various elements are driven out to form a new substance at the bottom end called clinker, which comes out of the kiln as little grey balls about the size of marbles. A small amount of gypsum and limestone gets added in with the marbles and then they all get ground up into the fine powder that we know as Portland Cement. The chemical reaction for that process looks like this**

**5CaCO3 + 2SiO2 —> (3CaO,SiO2) (2CaO,SiO2) + 5CO2**

**With carbon dioxide as one of the main outputs.**

**And to get to the high temperatures required by the kilns, fossil fuels like powdered coal are often used, which results in even more CO2 emissions.**

**In 2020, member companies of the Global Cement and Concrete Association produced what they described as their road map to Net Zero production by twenty-fifty. Those companies include the world’s largest cement manufacturers like Lafargeholcim, Heidelberg, AND China National Building Materials.**

**The road map is a forty-eight-page document containing graphics and charts like this one showing the intended trajectory for the industry’s emissions reductions. (page 9)**

**Apparently, according to the wording of the chart, they are currently two years into what they call ‘ the decade to deliver’.**

**But, judging by the very next graphic in the document, no less than fifty eight percent of those reductions rely either on designers and architects coming up with smart ways to use and re-use concrete in construction, or on the largely unused and unproven concept of carbon capture, utilisation and storage, otherwise known as CCUS.**

**Another six percent of carbon reductions are attributed to concrete’s propensity to absorb a bit of carbon dioxide back into its structure over long periods of exposure to the elements. Five percent relies on the decarbonisation of electricity by grid operators, and eleven percent will apparently come from greater production efficiencies and quality control. That means that only twenty percent of the total decarbonisation proposed by the global cement industry is planned to come from actually decarbonising the cement material itself.**

**But more and more zero carbon, or ‘Green’ cement technologies are now being developed around the world, and several of them are already in production and being used. So how do they work, and can they shift this percentage by becoming market disruptors in the construction industry? (animate the chart on page 10 to show the 11% growing and the others shrinking)**

**Solidia is a start-up company based in New Jersey. They produce cement in traditional kilns but with a fifty : fifty ratio of sand to limestone instead of two thirds to one third. That means the reaction can run at a much lower temperature which reduces energy use by about thirty percent and greenhouse gas emissions by as much as forty percent.**

**During the curing process, carbon dioxide is injected into the mix instead of water. That reduces the reaction time from more than a week to only twenty-four hours. The injected CO2 is then trapped in the final solid product, resulting in a claimed net overall CO2 emissions reduction of up to seventy percent.**

**The product has already been used all over the world, but still at relatively small scale. The biggest limitation of this technology right now is that it can only be produced in a factory environment to make blocks of cast concrete. That’s fine for things like paving slabs and breeze blocks, but it’s no good for ready mix pourable concrete, which currently makes up almost seventy-five percent of all concrete used globally.**

**Solidia are mindful of this though and they say they’re working hard on the development of a ready-mix version, to bring to market very soon.**

**Another way to tackle the problem is to take a bottle of CO2 gas to a concrete mixer and simply inject it into ready mix material. That’s essentially the strategy of a company called Carbon Cure. They source their CO₂ from industrial emitters, purify it and then distribute it to concrete sites in pressurized tanks that can be regularly refilled, just like your soda stream cannister at home. As it’s injected into the fresh concrete, a mineralization process embeds it permanently into the material. The additional CO2 in the mix has the handy benefit of increasing the compressive strength of the concrete. Carbon Cure claim that seventeen kilograms of CO2 can be saved for every cubic metre of concrete produced. Their website tells us that more than 3 million truck-loads of their concrete has already been used in the construction industry, saving nearly two hundred thousand metric tons of CO2 emissions so far. Technically this is one of those CCUS methods that I mentioned earlier, so it’s still not fundamentally altering the way that cement and concrete are produced in the first place, which arguably means it’s open to a bit of figure fudging, but if it's implemented correctly the way the Carbon Cure have designed it then there’s a good chance they could meet their stated goal of removing five hundred million tonnes of CO2 per year from the exhaust stacks of industrial polluters. That’d be the same as removing a hundred million cars from our roads.**

**CarbiCrete is another name you may have heard of. They use a system called carbonation activation, which eliminates the need for cement in concrete altogether by replacing it in the mix with ground steel slag, which is a by-product of the steel-making industry. Their concrete mix is poured into moulds and cured using CO2. That curing process solidifies the CO2 and binds it together with the steel slag granules, which gives the concrete its strength. Just like Solidia, Carbi Crete’s technology is currently limited to pre-cast slabs and components, but it does represent a fundamentally different method for producing a concrete binder which eliminates the high carbon Portland cement used today. Carbicrete claim to capture about two kilograms of CO2 in a standard size concrete block which, in a typical US production facility making concrete masonry units or CMUs, would mean a reduction of twenty thousand tons of carbon dioxide emissions plus a saving of four point four million litres of water and the avoidance of thirty-three thousand tonnes of landfill.**

**A couple of new names have joined the fray recently too.**

**Sublime Systems was founded by an MIT electrochemist called Leah Ellis and an entrepreneur called Yet-Ming Chiang. They say they’ve addressed both the carbon emissions from the cement calcination process AND the carbon emissions from the heating sources by developing an electrochemical solution that can do the job at ambient temperature.**

**Industrial electrochemical processes are already used in the production of materials like aluminium, hydrogen, chlorine, magnesium and copper. Sublime’s electrochemical process converts limestone into lime at room temperature. That significantly reduces the energy input requirement, and it makes it far easier to capture the resultant CO2. And because the process is entirely electrical, it can potentially be powered by 100% renewables, making the whole thing carbon neutral.**

**It's still early days. The company currently produces at a rate of only kilograms per hour, but they’re in the process of scaling up to tonnes per hour. Ellis and Chiang are pragmatic though. They know it will take time to change attitudes within the industry.**

 **“The challenge is humbling,” Ellis said in this recent interview, “But the opportunity is enormous.”**

**Brimstone is yet another US start-up with yet another concept for solving the carbon emissions problem. Their process is exactly the same as a traditional Portland cement manufacturer except that Brimstone don’t use limestone as one of their raw materials. They use different rocks that contain calcium. Basalt is one example that most of us have probably heard of, but there’s lots of different types and in total they’re actually much more commonly available than limestone. These rocks are calcium silicates not calcium carbonates, which means they don’t release carbon dioxide when they’re converted into cement.**

**So, if it’s that simple to fix the problem, why don’t all cement makers use these rocks then? Well, it turns out that the final cement product that gets into concrete contains a good percentage of fly ash, which is a waste product from burning coal. So, historically there’s been a useful symbiotic relationship between the cement industry and the fossil fuel industry to make some economic use out of an otherwise redundant waste stream. And of course, when nobody cared about CO2 emissions and global warming, there was absolutely no incentive whatsoever to upset what was a nice cosy relationship between two major industries. There is now though, not just because of climate change but also because the reduction in coal burning means fly ash is becoming harder to source and therefore more expensive. The proprietary process that the Brimstone team have developed actually co-generates fly ash at the same time as Portland cement from a single rock at a single site. Their research was initially carried out at the Lawrence Berkeley National lab and funded by the US Department of Energy, but more recently they’ve won investment from several venture capitalists including Bill Gates’ Breakthrough Energy Ventures. Brimstone don’t provide exact costing for their process, but they claim it’s significantly cheaper than existing methods. The company is building a pilot plant as we speak which may produce about a thousand tonnes of cement per year, but the real plan is to licence their technology to as many existing cement makers as possible all over the world with the aim of decarbonising the industry as quickly as possible.**

**So, you know, in theory it’s all there for the taking. It just needs existing cement manufacturers and the global construction industry to genuinely throw its weight behind these relatively small-scale start-ups, put some serious funding in place and start utilising these low carbon alternatives straight away. It’ll also require rapid testing and integration into building codes all over the world so that traditionally very conservative, and quite rightly, very safety conscious developers can have the confidence that these products are a robust and durable plug-in replacement for traditional concrete.**

**If you’ve got news or views on these potential market disruptors, then why not jump down to the comments section below and leave you thoughts there.**

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

**Sim Kennedy**

**Lockwood Carlson**

**Joanna Beer**

**Barbara Howe**

**Pucchu**

**Benoit Gilbert**

**Tim Humphreys**

**Richard Vickers**

**Jamie Wilson**

**Winfried Theis**

**Alex Malet de Carteret**

**Douglas Wilson**

**And**

**Craig Lambie**

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

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**Patreon dot com forward slash just have a think.**

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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**