**Those of us of a green persuasion are always banging on about carbon emissions aren’t we. It must drive the fossil fuel fans up the wall having to listen to people like me constantly droning on about how renewable energy might actually stop us destroying civilisation as we know it and killing off hundreds of thousands of species of plants and animals. I mean, to listen to us lot, anyone’d think we cared more about those things than we did about the relentless march of human progress and the all-important annual increase in global GDP. And let’s face it… NOTHING’S more important than an increase in GDP, is it?**

**But there’s always been a bit of a question mark, at least in the minds of some people, about one of the key claims of green energy. And it’s all to do with how the carbon emission numbers really stack up when you step away from end product comparisons like fossil fuel power plant carbon emissions versus wind turbine carbon emissions and start focussing on all the other stuff involved in producing, transporting, maintaining and ultimately disposing of those products.**

**Some argue that when you do that, the playing field levels up significantly.**

**So, are they right? Does a full lifecycle analysis of renewable energy sources versus fossil fuel energy sources reveal any nasty surprises?**

**Well, lets have a rummage around and see what we can find out.**

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

**Back in twenty thirteen a well-known climate sceptic organisation called the Global Warming Policy Foundation started touting around a study published that year that said that nuclear and fossil-fired power stations had much better Energy Returns on Investment or EROIs than renewable sources. They got quite widely panned at the time and the paper itself was rebutted by a peer review analysis from the University of Sussex that found that the authors had made “serious methodological errors which invalidate their work”.**

**Nevertheless, the whole thing highlighted the perfectly valid and very important challenge of determining whether any new apparently green technology is genuinely capable of reducing the level of greenhouse gases that are emitted into our atmosphere globally over the entirety of its lifetime.**

**In late twenty seventeen, another study was published in the well-respected science journal Nature. This one used life cycle analysis modelling, combined with an integrated assessment model that accounted for the indirect greenhouse gas emissions as a result of industrial and other economic activity modelled up to twenty fifty in eleven major world regions.**

**The goal was to provide a holistic view of future life-cycle greenhouse gas emissions of low-carbon technologies and power systems in the context of a climate change mitigation regime that would keep average global temperature increases below two degrees Celsius above pre-industrial levels.**

**The generally accepted way to make that assessment is to work out total, direct and indirect, greenhouse gas emissions per unit of electricity produced.**

**Once the researchers had crunched all the numbers, which I imagine was no mean feat, they arrived at a chart of all electricity producers in twenty-fifty and split the emissions of each technology into direct and indirect categories. Coal and gas were both assumed to be fully incorporating carbon capture and storage technologies by mid-century. Whether that really happens is still open to much debate of course, and even if it was achieved the researchers still factored in a calculation for what they called ‘imperfect CCS capture’, which to you and me means gas leaks, or fugitive emissions if you prefer the posh phrase.**

**Indirect emissions included land use and land use change, or LULUC, upstream methane from coal and gas, biogenic methane from hydropower, which mainly comes from stagnant water in reservoirs behind dams, fuels for construction and daily operations, and last but not least, a potentially negative emission number from bioenergy with carbon capture and storage, or BECCS. There’s been a lot of push back against BECCS since twenty seventeen, mainly because of concerns about destroying existing ecosytems and biodiversity to make way for monoculture plantations to produce the biomass, but we’ll park that for the purposes of this exercise, because this chart deals specifically with emissions.**

**The study provides a couple of useful numbers to compare to. It says that average fossil fuel emissions from global electricity supply in twenty seventeen were five hundred and four grams of CO2 per kilowatt hour generated. Average emissions from electricity production in a twenty-fifty, two degrees Celsius scenario will need to be only fifteen grams of CO2 per kilowatt hour.**

**Even with CCS, coal and gas are both projected to be well above the required twenty fifty average, at about a hundred and nine and seventy-eight grams respectively**

**Bioenergy works out at about ninety-seven grams, mainly as a result of land use changes, but in theory, BECCS could provide a negative offset of as much as three hundred grams for every unit of electricity produced. That’s a hotly disputed number, as I mentioned earlier. Some say the time required for crops and trees to grow sufficiently to suck all that carbon dioxide back out of the atmosphere would be too long to provide the quoted benefit by 2050, and that the carbon storage losses from tearing down existing ecosystems could cancel out many of the benefits, so I think it’s safe to say the jury is very much still out on the subject of BECCS.**

**Those upstream biogenic methane emissions from reservoirs plus the huge emissions from dam construction mean that hydropower, despite being heralded as a low carbon renewable, actually comes out at just under a hundred grams of CO2 equivalent per kilowatt hour in a full lifecycle assessment.**

**Construction and daily operations do result in some greenhouse gas emissions over the lifetime of a NUCLEAR power plant, but even so, nuclear technology comes out at only four grams of CO2 per kilowatt hour in this analysis. The one element of uncertainty here is how we choose to dispose of nuclear waste in the future. Some countries are building very large and very deep underground vaults to hold their radioactive waste material. That kind of construction involves vast amounts of concrete, steel and other materials, as well as huge quantities of energy to get it all constructed, so the genuine lifetime emissions costs of nuclear may well prove to be higher in real world scenarios.**

**Then we come to wind and solar photovoltaics, which you can clearly see have far lower lifetime emissions than the fossil fuel options. Solar PV comes in at six grams per kilowatt hour and wind is only four grams. The vast majority of those embedded lifecycle emissions come from the construction, and deconstruction of the panels and turbines themselves, but contrary to the claims made by the critics of these technologies, those emissions come nowhere close to equalling the enormous amount of greenhouse gases produced by coal and gas, even with carbon capture and storage. And as renewable technology continues to rapidly improve, so those emissions will come down still further.**

**In twenty-twenty one, a more detailed analysis of lifecycle emissions from wind power was published by none other than Bernstein Research, who describe themselves as Wall Street’s premier sell-side research and brokerage firm. Hardly an archetypal environmental activist group, eh?**

**Wind turbines use steel for their towers and both concrete AND steel for the foundations, and of course composite materials like glass fibre and carbon fibre for the blades. Unsurprisingly then, construction using these materials makes up the vast majority of the lifecycle carbon footprint for wind power. About eighty six percent in fact, compared to only one percent for coal, which obviously does most of its environmental damage during operation.**

**The Bernstein report looked at a present-day comparison between electricity generation from fossil fuels and renewables. Coal and gas don’t yet have those carbon capture facilities in place, which means emissions from coal currently run to about a thousand grams per kilowatt hour of electricity generated and gas produces about four hundred and fifty grams per kilowatt hour. Solar PV comes in at forty-four grams today and the less well-known technology of concentrated solar power produces twenty-seven grams per kilowatt hour over its lifetime. But both onshore and offshore wind are already challenging nuclear power as the lowest carbon footprint technologies available, even after all lifecycle emissions are taken into account.**

**The report highlighted even more recent analysis from the turbine manufacturers themselves, which puts the life-cycle emissions of wind even lower than nuclear.**

**Siemens Gamesa calculate life-cycle emissions for one of their eight-megawatt offshore wind turbines at just six grams per kilowatt hour.**

**Vestas reckon that a typical 42 megawatt onshore wind farm now has life-cycle emissions of between five-point-six and seven-point-three grams per kilowatt hour.**

**A lot of that improvement comes from the sheer size of the turbines themselves and also from the far more sophisticated and energy efficient shape of the blades. The Bernstein report shows us the size of a typical turbine blade in 1979, against a typical turbine in twenty nineteen. Quite a difference! And because the turbine power rating scales with the swept area of the blade, materials intensity and therefore carbon footprint per unit of electricity reduces significantly as the blade size increases.**

**The report concludes that taking the whole lifecycle analysis into account, emissions from wind energy are less than one or two percent of fossil fuels, and there’s scope to get that down even more as carbon emissions from steel and cement production reduce significantly in the coming years. Companies like Hybrit in Sweden are using Hydrogen to replace coal in the reduction of iron ore, and others like Carbon Cure and CarbiCrete are developing technologies that’ll embed CO2 into cement rather than emitting it as part of the production process.**

**And recycling is improving all the time too. Eighty five percent of expired wind turbine materials are already recycled, and the large turbine manufacturers are aiming to get that to a hundred percent. In fact, Siemens Gamesa recently launched what they claim to be the world’s first one hundred percent recyclable blade, and Vestas are on track to get there by 2024. Once those technologies are embedded in the industry and similar recycling rates become widespread in the solar PV world, then one of the major barriers to mass adoption will have been overcome.**

**Now, despite these findings, I know this topic remains a subject of much debate and disagreement. No doubt you’ve got your own views on the relative benefits and drawbacks of each energy generation technology. If you do, then why not jump down to the comments section below and share your thoughts there.**

**That’s it for this week, though.**

**A massive thank you, as always, to our fantastic Patreon supporters who keep these videos ad-free and completely independent. And there’s just time to give a quick shout out to the folks who’ve joined recently with pledges of ten dollars or more a month. They are**

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**And of course, a huge thank you to everyone else who’s 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**