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Personal Background: I am a Senior Research Scholar at Princeton University. I am also the Technical Director for Agriculture, Forestry and Ecosystems at the World Resources Institute, a global environmental think tank with over 1,700 staff in twelve countries including the Netherlands. I have published dozens of peer-reviewed articles addressing global land use, agriculture, climate change, forestry, and biodiversity, including soon to be my seventh paper in the top journals of *Nature* or *Science* discussing bioenergy. Among other works, I was the lead author of a vast report for the World Bank, the UN and WRI addressing how to meet rising global food needs while combating climate change.

Recycling v. bioenergy: At some level, the need for this hearing is surprising because policies encouraging the burning of trees for energy undercut the great efforts people in the Netherlands and most of the world now make to recycle paper. Thirty years ago, governments debated whether to develop paper recycling programs or to burn used paper as bioenergy. Governments correctly recognized that the higher value was to recycle paper, so they could save the trees. Wood pellets burned by utilities for energy mostly use the same grade of wood (pulpwood) as paper. Whether to recycle or burn paper is therefore the same question as whether to save or to burn trees for bioenergy. Governments in Europe, Asia and parts of the U.S. now devote large financial and human resources to recycle paper to save trees so the same governments can also devote more resources to burn them.

Mostly consensus scientific views: A vast number of scientists and scientific bodies have now informed public officials that harvesting wood to produce energy – as opposed to using wood waste – will increase carbon in the atmosphere for decades to centuries and *will do so regardless of whether forests are managed sustainably*. Examples include a letter to the European Parliament from roughly 800 scientists, including a Vice-Chair of the IPCC and a Nobel Prize winner; a letter from 500 scientists to numerous Presidents led by a winner of the U.S. Medal of Science, and opinions of the European Academies' Science Advisory Council; and the Science Committee of the European Environmental Agency. In fact, in its own Forest Strategy for 2030, the European Commission acknowledges (page 5) that these harvests increase carbon in the atmosphere at least for decades.

Why harvesting and burning wood increases global warming for decades to centuries: The reasons for these estimates are obvious and confirmed by numerous peer-reviewed scientific papers analyzing many types of forests, harvests and forms of energy use. First, when wood is harvested, at least half of a tree's carbon is lost and emitted to the air in the process of turning the remainder into wood pellets. Much of a dead tree is left behind to emit carbon as it decomposes in roots, stumps and branches, and drying wood and making wood pellets loses and therefore emits more. The wood pellets that do reach a power plant also burn less efficiently and emit more carbon per kilowatt hour than even burning coal and far more than burning natural gas. Altogether, the emissions per kwh are 3-4 times the emissions from using natural gas. This is called the "carbon debt."

Trees grow back, but the trees if not harvested would also continue to grow. It takes some years for regrowing forests to grow faster. It takes many more years before the trees harvested in the first year for bioenergy regrow enough just to pay back the "carbon debt" and just equal the emissions of using fossil fuels. Because carbon debt remains from newer harvests, it takes even longer for the whole system just to be equivalent to fossil fuels and therefore even many years longer to reduce emissions

meaningfully. All in all, as scientists repeatedly emphasize, it will take from decades to centuries even to match the emissions of burning fossil fuels, and in that time, bioenergy makes climate change worse.

Managing a forest "sustainably" does <u>not</u> avoid this increase in emissions. Some claim that if foresters only harvest the annual growth of a forest, this wood is "carbon neutral"; in other words, the carbon emitted by burning wood can be ignored. The claim is that so long as the harvests don't reduce the stock of carbon relative to last year's forest stocks, the wood harvest is "carbon-free."

Anyone with a pension can easily understand why that is not the case. People's pension funds grow each year because people divert some of their pay into them and because invested funds earn a profit. But if I take the money added to your pension fund in 2023 and use it to go on holiday, can I claim that I have not made you poorer because your pension stays the same size it was in 2022? If I didn't take that money, you would be richer. (If anyone claims otherwise, I'd be happy to receive the growth in their pension funds from now on.) Forests are also growing, accumulating more carbon. If we burn up that growth, we are still adding more carbon to the air than if we had not harvested them.

This is not only a physical reality, but this forest growth is built into estimates of future warming. Forests are regrowing in Europe and the U.S. in part because we cleared so many forests in the past. (Among other changes, replacing horses with cars freed up vast areas of land to reforest that were previously used for feed.) Climate change also makes forests grow faster. Scientists believe that 25% of the carbon dioxide people emit is quickly removed from the air because it stimulates faster forest growth. This "forest carbon sink" is not disposable. Without it, climate change will be <u>much</u> worse.

Wood pellets are primarily made from stem wood not residues. You often hear claims that wood pellets only use residues. That is not true. Pictures from the websites of wood pellet facilities (below) show great piles of logs surrounding them. If you stand outside a wood pellet facility (pictures below), you see the same logs entering them as enter a paper mill. The "residue" claim is based on the misleading idea that pulp-quality logs are waste products. As shown in an attached graphic, the global demand for paper and cardboard is growing rapidly. The U.S. produces one quarter of this pulpwood. If this pulp-quality wood is diverted to bioenergy, more trees must be cut down to replace it.

Bioenergy with carbon capture and storage (CCS) from harvested wood, so-called, BECCS, is both more expensive and much less effective than even applying CCS to coal or natural gas. The theory behind BECCS starts with the idea that burning biomass itself is carbon neutral, i.e., does not "count." Under this theory, if this carbon is then captured and put underground through CCS, BECCS produces "negative emissions." But for reasons I've explained, the carbon emitted by burning wood does increase warming just like any other carbon. If CCS captured 85% of the carbon emitted, it would reduce *direct* power plant emissions by that amount only; adding CCS to bioenergy does not make it carbon negative.

In fact, BECCS using wood must be worse than applying CCS to other fuels. Applying CCS to biomass is even more expensive than applying CCS to natural gas (or even coal) because biomass emits more carbon per kwh of electricity. Capturing 85% of this carbon therefore requires more machinery and energy and still allows some more carbon to escape up smokestacks.

BECCS also captures less than half of the carbon emitted *overall*. Nearly all the emissions from burning coal or natural gas occur in the power plant, so CCS might reduce their emissions by almost 85%. But as discussed above, when harvesting and burning wood, half the carbon is emitted to the air before the wood pellets are burned, e.g., in decomposing roots and in making wood pellets. CCS would not capture

this other carbon. Even if BECCS were to capture 85% of the carbon emitted up the smokestack, the total carbon captured would only be 85% multiplied of 50%, i.e., 42.5% overall.

Not all disagreements between scientists are scientific disagreements. It is true that some scientists from forestry schools or bioenergy departments claim that harvesting wood "sustainably" makes bioenergy carbon neutral. This is not a scientific calculation; it is an issue of logic. This is the same question as in the pension fund example, and all can decide for themselves. "Sustainable" wood harvest allows bioenergy to go on indefinitely, but it still adds carbon to the air for decades to centuries for reasons discussed.

Some foresters and bioenergy scientists also claim it is fine to increase carbon in the atmosphere for 100 years so long as it is eventually reduced when all the forests fully regrow. This too is an issue of policy. A policy to burn wood essentially tells people to pay more money for their electricity or heat so climate change will be even worse both for them and their children. Bioenergy from harvesting trees means you are making massive forest fires in Europe or floods on the Rhine worse for at least decades. And this policy would not even help our grandchildren. Much of that extra heat would enter the oceans with permanent consequences. Melted ice sheets would not unmelt in the future.

Perhaps most importantly, the alternative to burning wood should not be fossil fuels but solar or wind: they reduce emissions almost right away and are massively more land efficient. Even assuming very high yields for fast-growing trees (rather than harvesting normal forests), one hectare of solar cells will produce roughly 200 times more electricity or heat for homes than bioenergy; it would also power a car 300 times farther (see table below). If the world had 300 hectares of good land it could spare, it would generate hundreds of times more greenhouse gas reductions using solar cells than bioenergy.

The belief in bioenergy from wood is based on a misinterpretation of IPCC guidance. To count global emissions and only for that purpose, IPCC guidance on national reporting tells countries that they can ignore emissions from burning wood in their energy accounts so long as they count this carbon when harvesting trees. That was a practical rule so countries would not have to separately estimate the emissions from decomposing wood and those from wood products and bioenergy. This rule does not make bioenergy good. It means that when wood is harvested anywhere in the world and burned in the Netherlands, emissions increase globally even if the Netherlands reports less.

Some people claim this rule makes bioenergy wood in the Netherlands good for the climate because the emissions are counted elsewhere. It doesn't. It means the Netherlands is increasing carbon emissions globally (and even physically in the Netherlands); it just gets to claim otherwise.

Some claim this is okay because countries supplying the wood should reduce other emissions to compensate. There is no guarantee of that. Under the Paris Agreement, countries shape their own commitments, and given how hard it is to eliminate emissions, the world cannot afford to increase emissions even more. Regardless, all bioenergy subsidies would do is charge people in the Netherlands money to increase emissions so that other countries might spend yet more money to mitigate them.

The potential environmental consequences of burning wood are also vast. This debate matters. If it is a good idea for the Dutch to burn wood for energy, it is a good idea for others to. But even to produce just 2% more of the world's energy from wood would require that the world double the commercial harvest of wood. The Netherlands should not pursue such a path.

Picture reproduced from websites of U.S. wood pellet manufacturers

General Biofuels

Georgia Biomass website

Pictures taken by me in North Carolina, United States

Truck entering Enviva Wood Pellet Plant, North Carolina

Truck entering nearby pulp mill.

What forest residues look like

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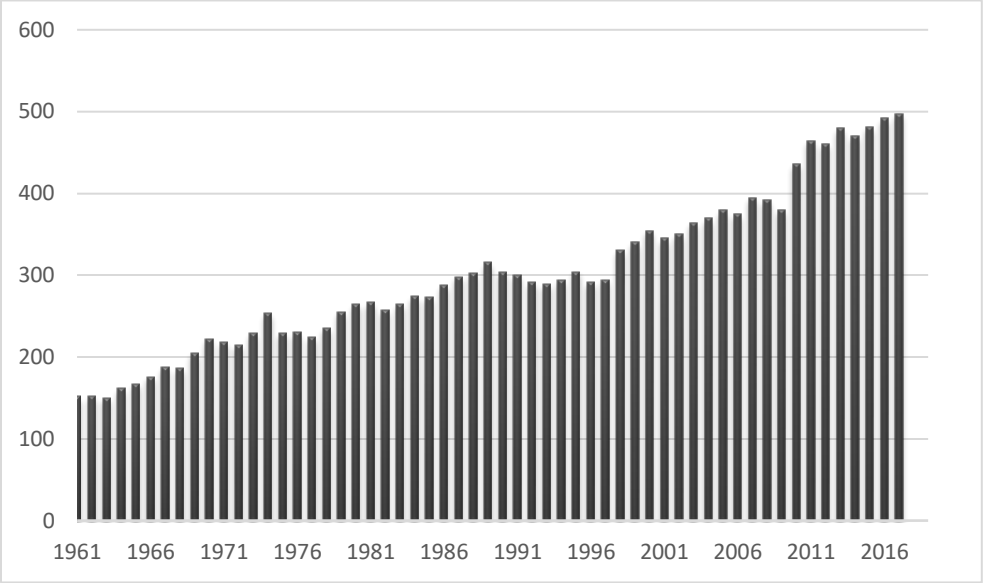
Global Pulpwood Consumption (million metric tons)



Source: FAOSTAT 2019. The unit is converted from m^3 to metric tons using a 0.7 t/m^3 factor.

Table on Solar Radiation and Therefore Land Use Efficiencies of Bioenergy from Fast-Growing Trees on Productive Land Versus Solar Pathways

(from *Energy Policy* 110:434-446 (2017)

Comparison of efficiencies of different bioenergy pathways and solar equivalences (for land achieving 0.2% photosynthetic efficiency (solar to energy in biomass)).

Bioenergy pathway	Photosynthetic efficiency	Bioenergy conversion efficiency	Total solar to bioenergy conversion efficiency	Solar equivalent pathway	Net solar conversion efficiency	Ratio of solar to bioenergy efficiencies
Cellulosic ethanol	0.2%	45%	0.1%	PV	11%	122
Electricity	0.2%	30%	0.1%	PV	11%	183
Residential heat	0.2%	90%	0.2%	PV + heat pump	33%	183
Industrial heat	0.2%	80%	0.2%	Industrial solar	30%	188
					60%	375
Combined heat and power (heat used for residential heating)	0.2%	57%	0.1%	PV for electricity; PV + heat pump for heat	26%	225
Combined heat and power (heat used for industry)	0.2%	74%	0.1%	PV for electricity; industrial solar for heat	24% 44%	160 295