The short- and long-run environmental value of waste conversion

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Wastes can be leveraged for decarbonization, provided we know how to think about them, argues Corinne Scown

Main

Deep decarbonization of the global economy requires that we reduce our reliance on fossil carbon resources and increase reliance on other resources: land for renewable power generation, critical materials for energy storage and grid infrastructure, and organic feedstocks for use in carbon removal and production of renewable fuels/products. When faced with the enormity of this challenge, it is alluring to seek opportunities to get something for nothing; in other words, make use of our waste. What follows are a set of fundamental questions that have yet to be fully grappled with in the scientific literature: 1) what truly is a waste? and 2) how do we quantify the near- and long-term economic and environmental implications of redirecting these resources?

Life-cycle assessment (LCA) methods rely on a clear delineation between what is and is not a waste. A co-product can be assigned a portion of the production system's overall environmental burdens. For example, each product from a petroleum refinery can be allocated a portion of its total emissions based on its energy content or mass output. A waste, however, does not carry that burden. In fact, a process that takes in waste may be assigned an offset credit for the avoided impacts of disposal. Food waste diverted from landfills or manure diverted from storage lagoons can reduce fugitive methane emissions. The implications for research, policy, and carbon markets are enormous and controversial. However, the distinction between a waste and a product is ambiguous and requires a more nuanced approach.

The concepts of additionality (in carbon markets) and incrementality (in hydrogen) both refer to the need for investments to yield new environmental benefits rather than shifting limited resources from one useful application to another. A common pitfall among existing studies is the failure to recognize acknowledge current uses of materials deemed wastes or residues. Some crop residues are used for animal bedding or animal feed supplements. Fats, oils, and greases are attractive feedstocks in anaerobic digesters. Biosolids from wastewater treatment plants may be applied as alternative daily cover at landfills to control odors and pests. This is where incorporating technoeconomic analysis (TEA) with LCA can be valuable. One can reasonably ask whether an output generates revenue or if the producer must bear some nonzero financial burden to destroy or dispose of it. The complex reality is that the same material may be a waste product in one region, but a co-product in another, depending on access to infrastructure and local buyers.

The first step in any waste valorization study is to clearly define the counterfactual: what would have happened to this resource in a business-as-usual scenario and is it truly a waste or is it a co-product? TEA and market data can be valuable in making educated guesses when reliable data is not available. Would the waste product be flared, incinerated, landfilled, diverted to some low-value application, or simply curtailed (in the case of variable renewable electricity)? The counterfactual should reflect the location and configuration of the system(s) being studied. Unfortunately, even this approach misses a longer-term feedback loop. By creating a market for these resources, we cause the counterfactual to change over time. Ideally, a thriving market is created for what used to be a waste and the original counterfactual no longer holds true. To address this transition, researchers and policy analysts should consider establishing short- and long-run counterfactuals.

The distinction between short- and long-run is far from new. Economists discuss short- and long-run marginal costs, while energy modelers distinguish between short- and long-run generators and emission rates on the grid. For waste, many of the same considerations apply. Loads of solid waste can be redirected in a matter of hours or days, but the lead time for utilizing wastes that require new sorting or upgrading equipment is longer. Compressed biomethane, produced by upgrading biogas to remove the contaminants and CO_2, can only be reshuffled across different applications in the short run, but new production can be incentivized. In the mid-term, an existing anaerobic digester or landfill might shift from combusting its biogas to generate electricity (a business-as-usual counterfactual) to upgrading the biogas to sell as compressed biomethane. In the long run, entirely facilities could be built to take in waste that would otherwise be landfilled or sent to septage treatment. In this long-run case, landfilling may be justified as the counterfactual. The concept

extends to plastics as well. Facilities must compete for existing post-consumer plastic bales in the short run but can incentivize new recovery and sorting in the longer term.

The recommendation to differentiate between short- and long-run counterfactuals for waste management and utilization can hopefully improve the transparency and specificity of future LCAs and TEAs that focus on waste utilization. By expanding our thinking to both the immediate next steps and the intended destination, we can equip the scientific, industry, and policy community with the information they need to make better decisions that direct resources to their highest and best use in the context of a future decarbonized economy.

Competing interests

Corinne Scown has a financial interest in Cyklos Materials.