Urban Renewable Energy Project
Gasification: Can Trash Power a House?

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Note: all uncited photos were taken by the author/related parties and all uncited text was derived from personal experience/thoughts.

Researcher's note

The purpose of my project is to explore the possibility of using trash to power a house. My overall goal is to create a sustainable energy solution by converting waste materials into energy. This project aims to improve waste management and energy production, contributing to sustainable energy and environmental conservation, as the average American produces over 1,600 pounds of trash per year. This equates to 268 million tons of waste per year with 140 million tons going into landfills.[1]

Initially, I demonstrated the feasibility of this concept. The next phase is to focus on improving and scaling the system to handle more trash efficiently and autonomously. By using a wood gasifier, which historically powered cars with wood fumes, I aim to substitute wood with waste products, showing that trash can be a viable future energy source for homes. In the future, ideally, we can find ways to cleanly burn inorganic materials in addition to organic materials.

1 https://www.dumpsters.com/blog/us-trash-production

Table of Contents

Researcher's note 2

Introduction and Goals 4

How does a gasifier work? 5

- Key components: 5
  - Reactor or Barrel: 6
  - Radiator: 9
  - Filter Bucket and fan assembly: 10
- Important notes: 12

The chemistry behind a gasifier 13

- Key Chemical Reactions: 13
- Syngas: After all the reactions occur, this is the chemical makeup 14

The "aha"—why the gasifier would be beneficial 15

Building process and troubleshooting 16

- Phase 1: materials and planning 16
- Phase 2: building and tinkering 16
  - Phase 2a: preparing materials for assembly 16
  - Phase 2b: assembly 20
- Phase 3: testing and troubleshooting 22
  - Problem 1: leakage 22
  - Problem 2: not knowing the problem 22
  - Problem 3: trying to figure out the problem 22
  - Problem 4: was it the fan? 23
  - Problem 5: tar 25
  - Solution 1: new process 28
  - Solution 2: fuel realization 29
  - Timeline 30

Testing other fuels 32

Thoughts on the design and other possibilities 33

Conclusion: 36

Introduction and Goals

Is it possible to use trash to power a house? This is the intriguing and challenging question that this project aims to explore and answer. By diving into the potential of utilizing waste materials as a source of energy directly for the home, this project's goal is to open new avenues in the realm of sustainable living and renewable energy solutions. Initially, this project will serve as a proof of concept, designed to demonstrate the fundamental feasibility of the idea of converting trash into viable energy.

The proof of concept has been successfully established, so the next phase will involve modifying and scaling the initial model to improve its efficiency and practicality. This means refining the processes, enhancing the technology, and optimizing the system to handle larger quantities of trash more effectively and with lessening amounts of human input as the goal will be to make the system almost completely autonomous. The goal is to develop a scalable solution that can be adapted for different sizes and types of households.

This project is not just about proving that trash can be used to power a house; it is about pioneering a new approach to waste management and energy production. By demonstrating the feasibility, scaling the solution, and continuously improving the system, this project aspires to make a significant contribution to the field of sustainable energy and to the broader goal of environmental conservation.

This goal will be accomplished by using a wood gasifier. Originally, wood gasifiers were used as a substitute for gasoline—able to power cars with just the fumes from burning wood—as risks of gasoline shortages were imminent during the World Wars.[2] However, what if it were possible to not use wood or biomass but to instead use some waste products instead? The goal of this project is to substitute the fuel and use the gasifier to demonstrate that using trash to power a house is a viable option in the future of home energy and more sustainable electricity generation.

[2] https://www.mdpi.com/2076-3298/9/7/92

How does a gasifier work?

A wood gasifier works by converting wood or other biomass into combustible gases, primarily carbon monoxide (CO), hydrogen (H_2), and methane (CH_4), which can be used as fuel for engines, generators, or other applications. The process involves several stages: drying, pyrolysis, oxidation, and reduction (see the next section for a more detailed breakdown).

These reactions convert the carbon dioxide and water vapor into carbon monoxide, hydrogen, and methane, forming the producer gas or syngas.

The resulting syngas, composed mainly of carbon monoxide, hydrogen, methane, and nitrogen, can be filtered and cooled before being used as a fuel in internal combustion engines, generators, or for heating purposes.[3]

Key components:

- **Fuel Hopper**: Where the biomass is stored before gasification.
- **Gasification Reactor**: The main chamber where the biomass undergoes drying, pyrolysis, oxidation, and reduction.
- **Air Inlet**: Controls the amount of air entering the gasifier to ensure partial combustion.
- **Grate**: Supports the biomass and allows ash to fall through.
- **Filter**: Removes particulates from the syngas.
- **Cooling and Cleaning System**: Cools the syngas and removes tar and other impurities.
- **Output Hose**: Provides a way to connect the gas from the gasifier to an engine
- **Fan**: Provides necessary suction force to allow gasifier to start up

[3] https://ankurscientific.com/blog/2018/09/23/how-does-a-gasifier-work/

The above components fit into the three main sections of the gasifier:

1) **Reactor or Barrel**
   a. Fuel hopper, gasification reactor, grate, and air inlet

2) **Radiator**
   a. 1st cooling and cleaning system

3) **Filter Bucket and fan assembly**
   a. 2nd cooling and cleaning system, fan, and output hose

See the labeled diagram.

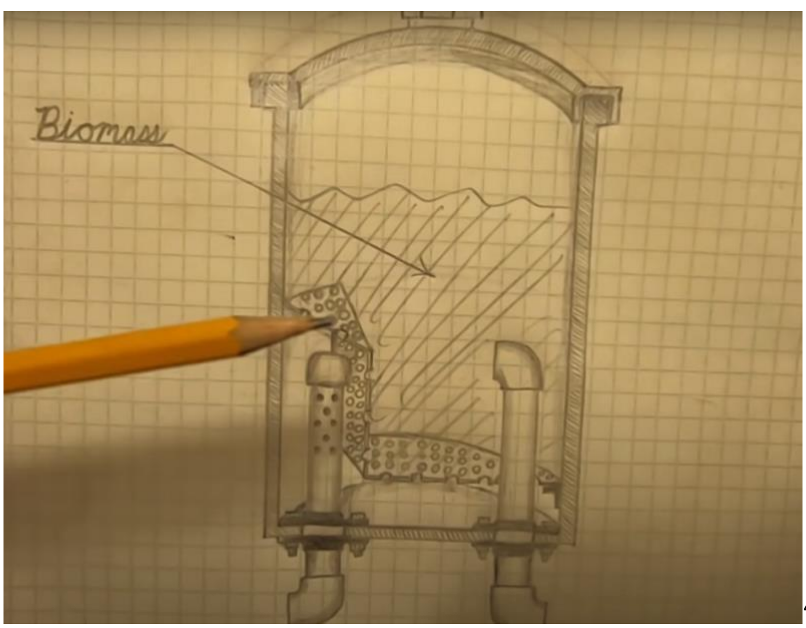
Reactor or Barrel:

The barrel or reactor is the place where the magic happens or where the entire gasification process occurs.

The barrel houses not only the fuel hopper but also the gasification reactor. The fuel is sealed into the hopper (an old paint mixer) where it is allowed to burn and undergo the gasification process.

Since this gasifier is a cross-draft design—meaning that the air/gas flows horizontally within the reactor—inside of the barrel, there are two vertical pipes 1.25" in diameter and 6" in height.

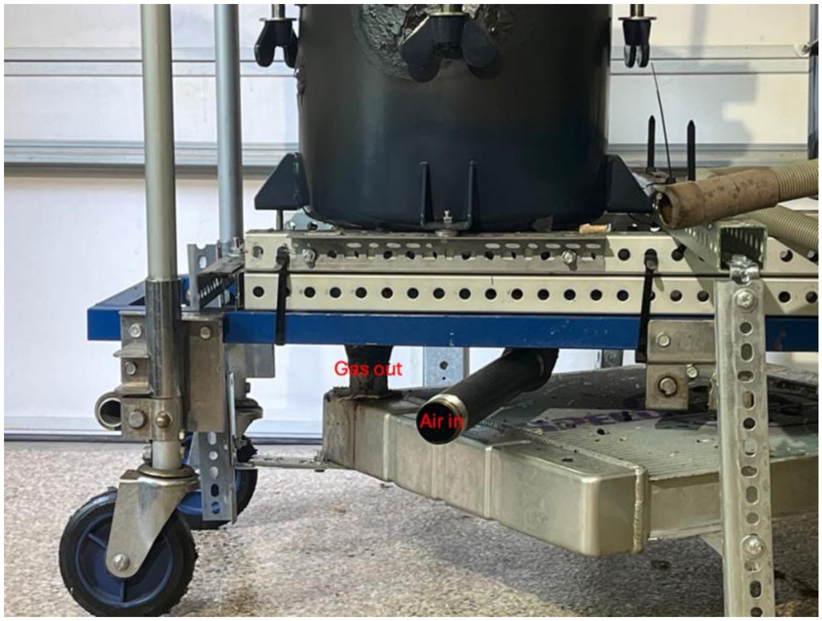
- One of the pipes is attached to the air inlet, letting in air to keep the gasification process going.
- The other pipe is where the gas leaves the barrel. The gas is sucked through that pipe by a fan on top of the filter bucket.
- The pipe on the left of the below diagram with numerous small holes (under the basket grate) is the "gas out" pipe, or where the gas is sucked out of the barrel and towards the radiator.
- The pipe on the right of the below diagram is the "air in" pipe, or where air is allowed to enter the barrel from the outside world.



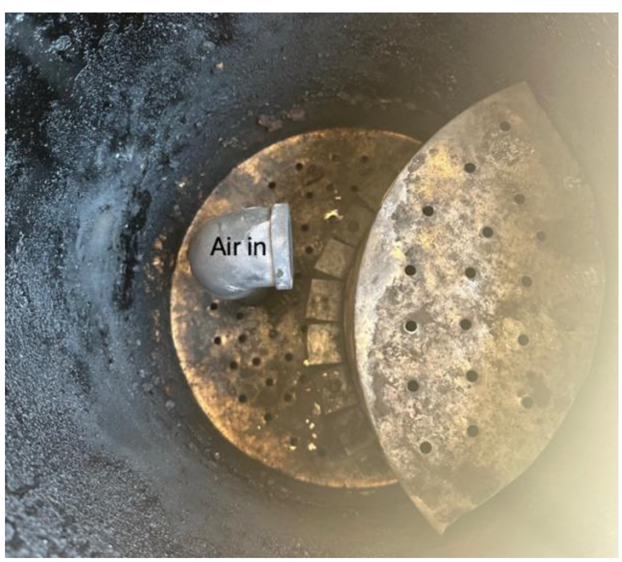
[4]

[4] https://www.youtube.com/watch?v=Bvl5XxVVjDM

It is possible to see this design aspect inputted into the actual gasifier. See below, the long pipe is the “air in” while the small pipe connected to the large radiator on the bottom is the “gas out.”



Another crucial part of the barrel is the grate basket, or where all the fuel sits during gasification. There are small, 3/8” holes drilled all throughout the basket to allow air/gas to flow through, but to not let the wooden pellets (the fuel) to fall through. The pipe on the left with the elbow attachment is the “air in” pipe. The “gas out” pipe sits under the shelf created by the basket as it helps keep any fuel from obstructing the flow of gas leaving the barrel.



While the gasifier is running, the lid is tightly sealed—important not only for the gasification process but also important because it helps force the gas through the rest of the system (the radiator and filter bucket) and eventually to the output hose.

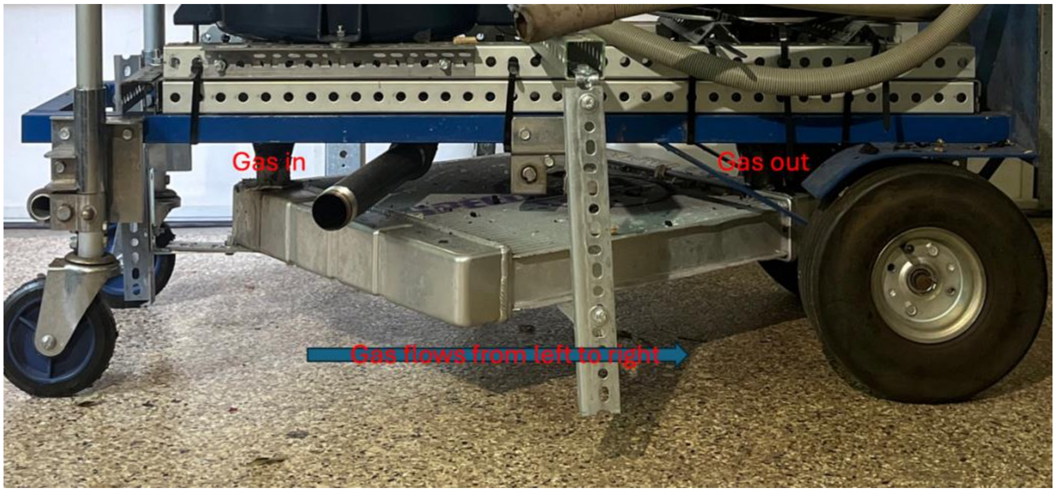
The reactor, one of the vital pieces of the gasifier, works to provide a place for fuel storage, a place for gasification to occur, and a place to allow a limited amount of air to reach the reaction. The output from the reactor is dirty syngas, a combination of Hydrogen, Methane, Carbon Monoxide, and tar. The gas, before entering any type of engine or generator, must be filtered and cooled.

Radiator:

The radiator is one of the simpler parts of the gasifier system in terms of building and assembly. It is just an old car radiator. On one side of the radiator enters the hot gas, fresh from the reactor. The gas is then sent into many small tubes where cool ambient air is allowed to pass over the tubes and cool the gas within those tubes to more manageable temperatures before it is sucked out the other end through to the filter bucket.

Since gasification occurs at extremely high temperature of around 750 degrees Fahrenheit, it is extremely important to have a good cooling system before using the gas as fuel. The radiator does such a good job of cooling the gas that it can be touched without discomfort at the outlet pipe.

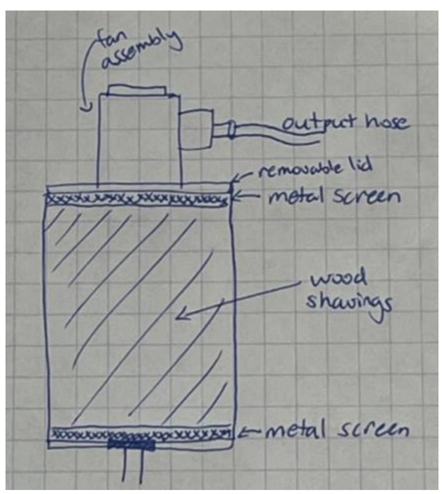
Beyond just cooling the gas to manageable temperatures, the radiator helps take tar out from the gas. As the gas cools within the radiator, tar is deposited on the inside of the radiator, helping to clean the gas before it enters the filter. Its twofold function helps the functionality of the gasifier, serving as a much-needed curator of gas.



Filter Bucket and fan assembly:

The filter bucket and fan assembly is the final stage of the gasifier before the gas is ready to enter an engine.

The filter bucket is connected to the radiator via a pipe at the bottom of the bucket. The air is free to flow from the radiator into the filter bucket where a metal screen on the bottom of the bucket holds wood shavings that act as the filter material. On top of the wood shavings is another metal screen to hold the shavings in the bucket. It creates a metal screen and wood shaving sandwich. The bucket is sealed with a removable lid that has the fan assembly attached. See diagram.

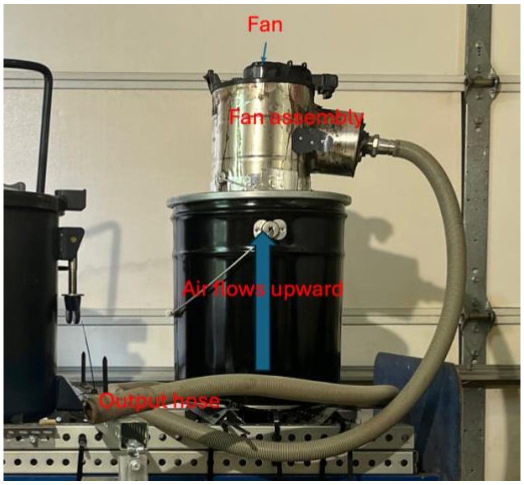


Tar is deposited around the center of the bucket more so than other areas as the center of the bucket is where most of the airflow is concentrated.

Below is a photo of the filter bucket without the screen sitting on top. After 3-4 runs, the wood shavings turn black—evidence that they are doing their job of cleaning the gas before it heads to a generator. At this point, the wood shavings should be exchanged for fresh ones.

The gas is sucked up through the filter material, depositing the final bits of tar and impurities in the wood shavings before leaving the gasifier system.

The fan assembly is attached to the top of the filter bucket lid and sucks air throughout the entire gasifier providing not only suction to allow gas to flow through the system but also suction to allow air to enter the reactor. The fan is extremely important as it provides the suction required to run the gasifier before it is attached to a generator or an engine. When the gasifier is connected to an engine, the fan can be turned off as the suction from the pistons in the engine is enough to run the gasifier.



Attached to the fan is an output hose, allowing the gasifier to be connected to an engine or to just provide a singular output spot for the gas.

Important notes:

The gasifier must be completely airtight (excluding the air inlet and output hose) to limit leakage of gas and entrance of air. Any leakage or entrance of air will compromise the effectiveness of the system and prevent proper gasification, leading to the output gas failing to burn.

When testing the gasifier, the telltale sign that the gasifier is ready and up and running is if the output gas can burn. If so, the gas can safely be put into a generator, if not, the gas will not combust in a combustion chamber.

The gasifier will get extremely hot, so when touching any part, especially the reactor, while the gasifier is running is extremely dangerous. Even the dolly, which is used as the base apparatus for the gasifier, got extremely hot.

The chemistry behind a gasifier

Within gasification, there are four main processes:[5]

1. **Drying**: The biomass (wood) is heated to evaporate moisture content, usually at temperatures below 200°C (392°F). This step is crucial as the efficiency of the gasification process depends on the dryness of the biomass.

2. **Pyrolysis**: Once dried, the biomass undergoes pyrolysis (also known as thermal decomposition) at temperatures between 200°C and 700°C (392°F to 1,292°F) in the absence of oxygen. This step breaks down the biomass into solid char (biochar), volatile gases, and tar.

3. **Combustion:** The volatile gases and tar are then exposed to a controlled amount of oxygen (air) in the oxidation zone, typically at temperatures between 700°C and 1,300°C (1,292°F to 2,372°F). This limited combustion generates heat and produces carbon dioxide (CO_2) and water vapor (H_2O).

4. **Gasification**: The hot gases from the oxidation zone pass through the char layer, where a series of reduction reactions occur. The high temperature and the presence of char cause various reactions to occur.

Key Chemical Reactions:[6]

- **Combustion Reactions**. Partial combustion occurs due to the limited supply of oxygen.
    - Carbon Combustion
        - $2C + O_2 >> 2CO$
    - Carbon Monoxide Combustion
        - $2CO + O_2 >> 2CO_2$
    - Hydrogen Combustion
        - $2H_2 + O_2 >> 2H_2O$

[5] http://biofuelsacademy.org/index.html%3Fp=396.html
[6] https://netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/gasification-chemistry

- **Gasification reactions**. These reactions convert the remaining carbon and other compounds into syngas. Note that the “<>” means the reaction can happen both ways.
  - Water Gas Reaction
    - $C + H_2O <> CO + H_2$
  - Boudouard Reaction
    - $C + CO_2 <> 2CO$
  - Methanation Reaction
    - $C + 2H_2 <> CH_4$
- **Secondary reactions**. These reactions further refine the syngas composition.
  - Water-Gas shift reaction
    - $CO + H_2O <> CO_2 + H_2$
  - Steam-Methane reforming
    - $CH_4 + H_2O <> CO_2 + 3H_2$

Syngas: After all the reactions occur, this is the chemical makeup[7]

- Nitrogen (N_2): ~ 50.9%
- Carbon Monoxide (CO): ~27.0%
- Hydrogen (H_2): ~14.0%
- Carbon Dioxide (CO_2): ~4.5%
- Methane (CH_4): 3.0%
- Oxygen (O_2): 0.6%

The syngas can function as a fuel for internal combustion engines.[8]

[7] https://science.howstuffworks.com/environmental/green-tech/energy-production/gasification.htm
[8] https://midwestpermaculture.com/downdraft-wood-gasification/

The "aha"—why the gasifier would be beneficial

The overall goal of this project is to demonstrate that it is possible to power a home using the waste produced by that home. But why would this be beneficial?

This gasifier would not burn things like plastics or other inorganic material. The gasifier would burn all things organic, including paper, wood, cardboard, food waste, and other naturally occurring substances and convert it into power. Though some of these substances can be recycled, only around 20-30% of all recyclable materials are recycled.[9] This means that 70-80% of recyclable materials still end up in landfill.

By using the gasifier to power a home, it limits the amount of waste that goes to landfills, preserving the dwindling space left in them for a longer period of time. Not only does it preserve landfill space, but it also decreases the need for landfills, meaning land originally planned to become a landfill could be used for other activities including for homes, recreation, or other uses. It is safe to say that landfills are not ideal.[10]

Landfills also emit dangerous odors including hydrogen sulfide and ammonia as the waste breaks down. Landfills also emit methane, which is extremely flammable, posing a hazard to those working in the landfills as well as those living near them. Not only do these odors pollute the area around landfills, but they can also seep through the soil and enter buildings through their ventilation systems, polluting the nearby city as well. Exposure to these fumes can cause respiratory and eye irritation, headaches, nausea, and other symptoms.[11]

By using the waste produced in homes to power that same home, a more circular way of living is created meaning that in the long run, less waste will be generated. By using waste to power a home, it is possible to not only have a completely independent or almost completely independent electricity generator for each home but in doing so, it would limit the amount of fumes emitted into the air by burning coal and petroleum to generate power at power plants.

The gasifier would be a one-time cost (except occasional maintenance) and it would not only reduce the costs of electricity to the home, but it would also reduce costs of weekly trash pickup meaning that the gasifier could be a more economically efficient option.

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[9] https://recyclingpartnership.org/residential-recycling-report/
[10] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9399006/
[11] https://www.health.ny.gov/environmental/outdoors/air/landfill_gas.htm#:~:text=Summary,dioxide%20are%20of%20most%20concern.

Building process and troubleshooting

The building process, including planning and gathering materials, in total took about 3-4 months and can be split into 3 phases.

Phase 1: materials and planning

The materials and planning phase was the first step in getting the gasifier up and running. By looking at various gasifier designs online, it was fairly easy to pick one to use as inspiration.[12] After getting a design in mind, the next step was to create a list of parts needed and to find them either around the house, online, or at a hardware store.

Following the purchase of parts was the creation of a timeline, which included the “finish build date”, “up and running date”, and “working properly date.” The dates were estimates as this project is new and there was no easy way to tell how long it would take. While working on this project at night, after school, and on the weekends, it took about 50 total man hours to get it up and running properly.

Phase 2: building and tinkering

Phase 2 was the longest of the three phases and can even be divided into 2 smaller phases.

Phase 2a: preparing materials for assembly

The first step in phase 2a was to prepare all the materials, for example, the barrel (reactor) and the lid for the barrel had a paint finish on the inside that needed to come off, so a few hours were spent sanding the paint off.

See the inside of the barrel—all exposed metal used to have a blue paint finish. All of it was sanded off before continuing with the build. The outside and inside used to have the same color. See how the inside is a little streaky in terms of its colors—evidence of the sanding process.

[12] https://www.youtube.com/watch?v=AyTqo4mCUUY&t=967s

Since the barrel was an old paint mixer, there were various mixers, holes, and other devices bolted to the lid, so getting those out so they would not obstruct the fuel/basket was paramount. Since taking these devices out left holes in the lid, sealing the holes up with bolts and muffler sealer would create an airtight lid—essential for the functionality of the gasifier.

See the original barrel—all accessories had to be removed.

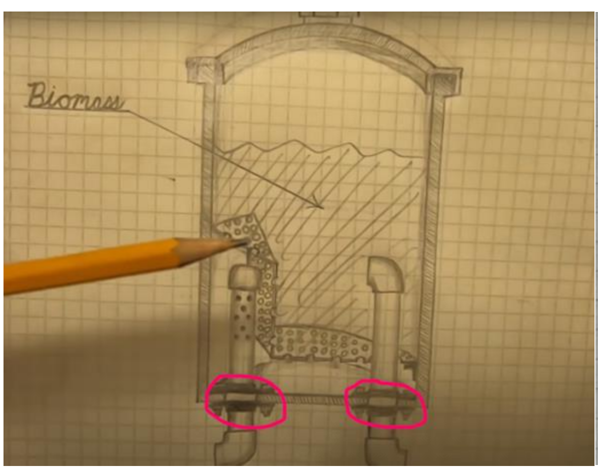

[13]

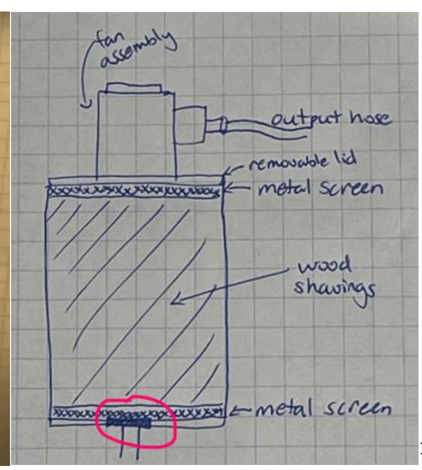
Eventually, the lid looked like this from the outside (left), and like this from the inside after the machine had run many times (right). The gray material on the outside lid (left) is muffler sealer—used to make the lid airtight after removing the accessories.

[13] Image: https://www.amazon.com/gp/product/B00IK4B5UC/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1

Another part of creating an airtight lid was to replace the rubber gasket with a fiberglass rope as the rubber could not resist the high temperatures as well as the fiberglass rope. The fiberglass rope was sealed with simple silicone cement. In the bottom left of the picture on the right (see above), it is possible to see the fiberglass rope, coated in tar, that serves to create a seal between the lid and the barrel that can resist the high temperatures required for gasification. See the area circled in pink.

The next part of the preparation phase was to drill 1.5” holes in the bottom of the barrel as well as the bottom of the filter bucket to allow the pipes to fit to the bottom of both parts. Holes were drilled in the areas circled in pink.



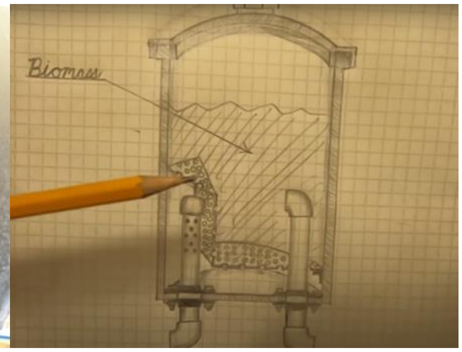


[14]

The barrel came with an inner bucket, and with a little bit of cutting with an angle grinder and drilling of holes, that inner bucket became the grate basket that goes

[14] https://www.youtube.com/watch?v=Bvl5XxVVjDM (left)

inside of the barrel and that holds the fuel up from the bottom of the barrel. Another, larger hole was drilled to allow the “air in” pipe to fit through. This is a top-down view of the basket inside of the barrel. The “air in” pipe has an elbow connection to allow air to get in the barrel but to limit fuel from going inside that pipe while the machine is running as wood pellets get piled up high (see region shaded “biomass”). The grate sits like a “L” shape with an extension on the top (see right) and shields the “gas out” pipe.



Building the fan assembly was another integral part of the build. By using aluminum tape, sealer, and an old car fan, the fan was attached to the lid of the filter bucket at one end and attached to a hose at the other end using a flange that screwed into a ½ barb ½ screw device (circled in pink) that connected it to a hose. The fan runs off a battery, connected via yellow + and – wires that run directly to the fan.

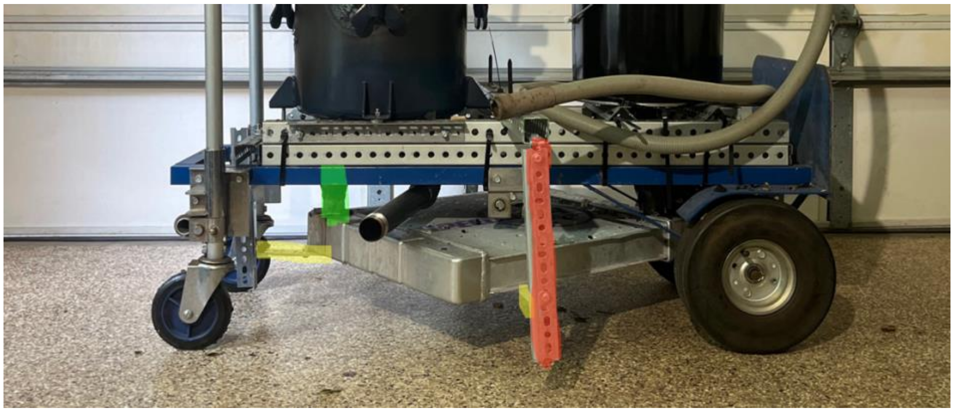
Phase 2b: assembly

The first part of the assembly phase was to find a base that could hold the gasifier. Using an old dolly seemed to work well. Not only was it stable enough to support the heavy parts but it also provided good mobility to be able to move the gasifier inside and outside with ease.

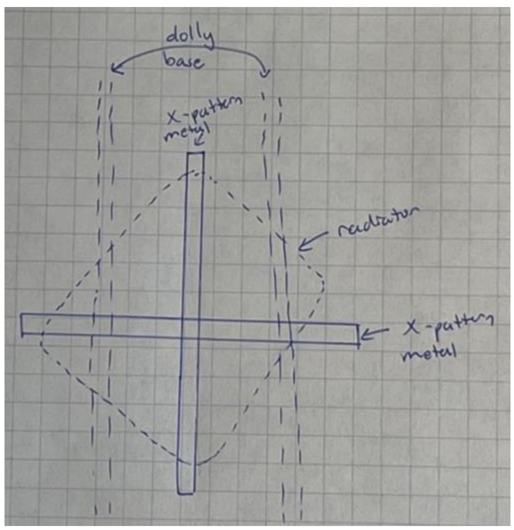
See the dolly with the empty barrel sitting on top. Nothing is connected yet, but just knowing that the barrel was able to sit on top of the dolly was instrumental in the progression of the base.

The second part of the assembly was to figure out how to configure the three main components—reactor, radiator, and filter bucket—so that they could fit together properly. The radiator sits below the dolly but above the ground, so an X-pattern of flat pieces of metal as well as angle irons and other metal parts were used to attach the radiator to the dolly. Square steel pieces were used to prop up the filter bucket and the barrel so that there was enough distance to allow the pipes to connect those two parts to the radiator. This process took considerable time—upwards of a few hours—to situate everything properly.

It is possible to see parts of the X-patterned metal (yellow) that run underneath the radiator to support it. 90-degree metal pieces connect the X-patterned metal to vertical pieces to support it from above (red). The height of the radiator changed a lot to make sure that the distance between the radiator and the barrel (green) was long enough to allow the pipe to fit.



See the top-view diagram below to better visualize how the X-pattern of metal supported the radiator from below.



After everything was situated properly, pipes were sealed with muffler sealer to the radiator to create an airtight seal (green) as the radiator did not allow the pipes to screw in—unlike the flanges that were used to connect the pipes to the barrel and filter bucket. After sealing the barrel to the radiator and the filter bucket to the radiator, it was time to bolt/zip tie everything to the dolly to make sure nothing would move and the seals would not break.

After filling the filter bucket with wood shaving, the fan assembly was attached and the gasifier was ready to be tested. The final product is as shown:

Phase 3: testing and troubleshooting

Problem 1: leakage

The first problem following the first few burns of the gasifier involved improper seals. Tar was leaking out of the connections between components—particularly between the radiator and the barrel as well as the radiator and the filter bucket. The liquid tar would leak out and drip onto the ground—not ideal.

Problem 2: not knowing the problem

After numerous burns and tests with the gasifier, the output gas still would not burn. What could be the problem? The fuel, the fan, the seals, the process, what was wrong?

This is the part of the testing and troubleshooting process that was not only tedious but also mildly frustrating as now knowing how to proceed made it hard to make progress.

Problem 3: trying to figure out the problem

After re-doing the seals on the gasifier and tinkering with the fuel as well as the process of starting the machine, the gasifier was still not working properly. Maybe it could be the amount of oxygen content within the reactor that was causing issues? Too much, too little? Was the radiator not working properly?

At this point, the new fan was not on the machine, it was a weaker, wall-plug fan that had much lower RPM than the car fan. See next section under “first iteration”.

This original fan did the job of sucking the air through the system and out of the hose, but it did not provide enough suction to really get the machine running. However, it was not 100% clear whether there was too much air or too little air. Testing continued.

Problem 4: was it the fan?

The only feasible solution was to get a new fan—that would be to change the original fan to something more powerful. There were a total of 4 iterations before the final design (as seen in the above sections).

The first iteration was the very first version—using a wall-plug fan to pull air through the system. Though the fan successfully sucked air through the system in sufficient quantity, the output gas did not light on fire, so the fan did not work. See the design below.

The second iteration was to use a new fan—something a little bigger and more powerful. The issue with this fan was that it sucked air through such a big area that it was hard to funnel the air to a hole the size of a hose. The fan did not suck air through the system properly. Even though it was set up to suck air out, the setup actually pushed air in the opposite direction than intended. So instead of pushing air up through the green tube, it pushed air down into the filter, even though the fan was spinning in the proper direction.

The third iteration was to connect a hose to the lid without a fan (left) and to have a fan push air through the system from the air inlet (right). This system worked initially as it pushed a higher volume of gas through the system than ever before, however, the gasifier did not work properly—the output gas did not burn.

The final iteration was to use a car air conditioning fan from an old Toyota. By putting the fan into a can and having an output hole on the side, the air would suck through the top of the lid and go out through the side into a hose. This system not only worked exceptionally well to pull air through the system in a sufficient quantity, but it also led to the first successful run of the machine. That is to say that the output gas finally set on fire!

The fan seemed to solve the system’s issues, but the burn was still not sustained. On to figure out how to sustain the burn indefinitely.

Problem 5: tar

A continuing issue beyond the leakage was the accumulation of tar within the system. Tar would accumulate within the reactor, radiator, pipes, filter, and other areas. See the inside of the lid below. This accumulation would not be an issue as it is just a thin coating on the inside of the machine—not hampering its functionality.

However, a larger issue is when large amounts of tar would accumulate in the moving parts, namely the fan. In the second iteration of the fan, this is what the inside of the fan looked like after a few runs:

Tar accumulation to that level rendered the fan useless. A fan should not look like that—evidence that the fan or the filter was faulty. Replacing the fan for iteration 3 and 4 seemed to solve the problem as tar accumulation did not occur to the same extent as in the picture above.

It is possible to see a small amount of black coating on the inside of the final iteration of the fan below, but nothing as significant as earlier.

The fan was working properly, even after numerous runs of the machine—evidence that the fan was not getting caked with tar like before. However, the accumulation of tar at the beginning led to a fault in the structural strength of the fan apparatus. Originally, the fan was just attached with aluminum tape, which did not hold under the accumulation of liquid tar. The side part fell off the fan. See below.

The accumulation of tar had compromised the structural integrity of the attachment, so rivets along with bent metal pieces were used to provide structural integrity to the machine and muffler sealer was used to create a strong seal. Since, the machine has held up nicely and the limited accumulation of tar has not affected the structure of the machine.

Solution 1: new process

After solving the issues with the gasifier, it was time to fine-tune the start-up process to help sustain a longer burn (of output gas). The first step was to put some wooden pellets into a charcoal chimney (like the ones used to start up a grill) and get those lit on fire. After pouring those pellets into the gasifier, put a metal screen in an arch shape to create an air pocket around the “air in” pipe to make sure the fuel does not snuff out the fire. See below.

After the screen was placed, it was time to fill the machine to almost the top with new fuel (wood pellets or biomass) and let it burn until the fire became very large like so (the fire didn't need to get that large in subsequent burns):

It was time to seal up the machine and turn on the fan to start running it. In a couple of minutes, the output gas would start to be able to be lit on fire and the gasifier would be working properly. In these photos, the blowtorch is off (it was used to start the fire) and the output gas burned almost indefinitely.

Solution 2: fuel realization

After starting to fine-tune the process, there were some issues regarding the sustained burn of output gas. The output gas would light on fire for a bit, then it would diminish, and eventually go out. After bringing a blow-torch to the output gas again, the gas would seem like it wanted to light on fire, but then it would go out and not sustain a burn.

On around the 20th burn and after pouring new fuel on top of the existing flame, the output gas burned for the longest it ever had, and this is when the fuel realization hit: it took new, unburned fuel for the output gas to be able to be lit on fire—the charcoal (already burned wood pellets from previous burns of the machine) that had been used to start up the fire and made up the majority of the fuel, did not contribute to an output gas that could be lit on fire. In other words, a substance can only be combusted twice, not three times. And in this example, using new fuel means that the output gas can light on fire.

It is kind of dark, but the fuel in the bottom of the reactor (left) is old fuel or charcoal. Burning this fuel will help get the fire started but will not yield an output gas that can combust (or light on fire). The new fuel (right) solves this issue and allows for a combustible output gas.


[15]

Timeline

In total, the project has taken (so far) a total of five months, so here is a timeline of the testing phase (starting in mid-May 2024 and still continues). Each time the machine is run is called a "burn" so the "10th burn" is the 10th time the machine has been fired up and run.

[15] https://www.wfae.org/energy-environment/2021-11-13/despite-concerns-over-co2-wood-pellet-maker-courts-new-industries

- 1st burn—nothing notable. However, the machine worked (as in the gas flowed through it properly, yet it did not set on fire)
- 2nd burn-4th burn. Nothing notable.
- 6th burn—nothing notable, but decided to switch from the first fan iteration to the second iteration.
- 10th burn—finally had a pressure reading on the barrel, meaning that the system was sealed properly and there was enough gas production from the fire.
- 12th burn—nothing notable, but switched from the second fan iteration to the third.
- 14th burn—nothing notable, but switched from the third fan iteration to the fourth and final.
- 15th burn—refined the process a little bit: started a giant bonfire in the reactor before closing the lid. The new fan combined with this process meant that the output gas was very close to lighting on fire.
- 18th burn—got a semi-sustained burn of the output gas, but it did not last.
- 20th burn—the output gas burned for a longer period of time and figured out that it takes new fuel to allow the output gas to burn, meaning that substances can only combust twice. It was a great learning and allowed future burns to work properly.

Testing other fuels

The goal of the gasifier project is to be able to use other fuels in the machine and make it work. Gasifiers in general have been tested with and have worked with biomass (wood, leaves, organic material, etc.) so burning in the barrel in the picture below is an amazon box (including cardboard, tape, label, etc.), some leaves, sticks, and a dried orange peel.

The flame looked normal and very similar to when wood pellets were burning, just the fire was not as big as there was not high of a fuel density within the barrel, which could be fixed by shredding the waste into small pieces before putting it into the barrel.

To test to see whether or not the other fuels would work, a device that measures relative quantities of gasses in the air (namely CO and O_2) was used (right). Even though the device measures four different types of gasses, only two are part of the gasifier reactions: CO and O_2.

The reader gave a similar result of CO when wood pellets were burning (60 umol/mol) so it seems like the alternative biomass fuel is burning properly.

Thoughts on the design and other possibilities

The design for a wood gasifier is quite clever—it offers a relatively inexpensive way to turn random biomass around the house (often in off-the-grid areas) into electric power. Though the design is clever, it presents challenges—namely gas emissions into the atmosphere from the generator and from running the machine when the output gas does not burn. However, after the gasification process occurs, the output gas is a cleaner gas than just burning wood as burning wood produces a gas that contains tar among other pollutants.

So, to use this in the home, there must be a resolution for this gas emission issue, so what if there was a way to turn the gas into a solid that does not burn more energy than the gasifier produces meaning that there is still energy left over to power a home. In the best-case scenario, there would be five products of the gasifier: electricity, solid carbon, gaseous oxygen, gaseous hydrogen, and ash.

The project has been very enjoyable—not only the building process but the learning process and the dreaming process. Are there better solutions? Can we make those solutions a reality? What is truly possible in this world?

Some of these questions have already been answered. While on this journey to explore alternative energy options, there are two devices that are very intriguing:

The first device is a personal hydrogen station. In short, the hydrogen station uses distilled water and maltic acid to charge almost any device. It came with three parts: the hydrofill, the hydrostik, and the minpak.

The hydrofill is the station that converts the distilled water into hydrogen and oxygen atoms, storing the hydrogen atoms into a hydrostik. It takes a number of hours to fill a hydrostik.

The hydrostik is like a battery—it stores the hydrogen gas to be used and converted into energy. It screws into the hydrofill in the circular area in the middle and screws into the side of the minipak.

The minipak is what converts the hydrogen stored in the stik into usable electricity. It has a USB port and can power a built-in flashlight as well. The only issue with this setup is that it takes battery power (or in this case, a small amount of power from a wall) to send charged ions through the distilled water and separate the water into its respective gasses. So, the station does not function independently, but the idea could work in some sort of vehicle that uses a battery like the vehicles of today.

Another interesting device is a “heating element.” It is a camping device that uses a small fire to create electricity. It is very good for off-grid power (as well as solar) and is able to charge a phone like the hydrogen station.

[16]

With these new possibilities on the horizon, it is only a matter of time before the whole energy industry is completely changed for the better. With electric cars seemingly being the new wave of energy, it would be cool to see other types of energy (like hydrogen) rival electrics and maybe even take over the next phase of energy production and change society forever.

[16] https://www.amazon.com/gp/product/B00FU8RBPE/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&th=1

Conclusion:

The Urban Renewable Energy Project demonstrated that waste materials can indeed be converted into usable energy through gasification. The feasibility of using a gasifier to power a home has been successfully established, highlighting the potential of this innovative approach to waste management and sustainable energy production. By focusing on improving and scaling the system to handle larger quantities of trash more efficiently, this project paves the way for a more autonomous and practical solution to household energy needs.

The building and testing phases of the gasifier revealed valuable insights into the challenges and potential of this technology. Key issues such as tar accumulation, fan efficiency, and fuel realization were addressed, leading to significant improvements in the system's functionality. The detailed exploration of gasification chemistry and the design considerations for each component of the gasifier underscored the complexity and ingenuity required to transform waste into energy. The iterative process of troubleshooting and refining the gasifier was instrumental in achieving a reliable and effective solution.

Looking ahead, the successful demonstration of the gasifier opens up exciting possibilities for future advancements in renewable energy. By continuing to innovate and optimize the technology, it is conceivable that waste-to-energy systems could become a commonplace feature in homes, contributing to a more sustainable and environmentally friendly future. This project not only showcases the viability of gasification as a renewable energy source but also inspires further research and development in the field of sustainable energy solutions.

To modify an old proverb: One person's trash is another one's treasure. Let's turn all our trash into treasure in the future.