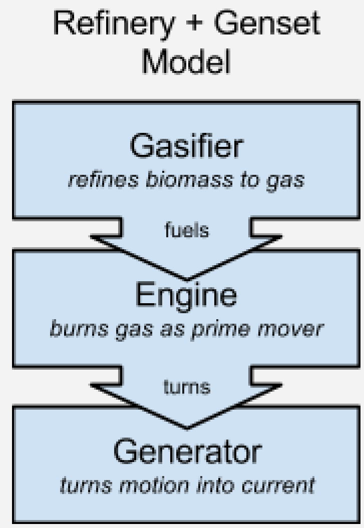
Chapter 2
Biomass Feedstock Requirements

Table of Contents

- Feedstock related terms
  - Feedstock, Fuel
  - Oversized, Undersized, and Fines
  - Fuel Jams: Bridging, Rat-holing, Binding
- Feedstock Qualifications
  - Physical compatibility
      - Upper size limit
      - Lower size limit
      - Correct shape
      - Correct surface texture
      - Friability
      - Resistance to Steamed Disintegration
      - Flow Characteristics
      - Angle of repose
    - Blending feedstocks to compensate for shape and texture
    - Void spaces and physical compatibility
    - Feedstock particle size and char-ash byproduct percentage
  - Chemical compatibility
      - Fixed carbon content
      - Volatile content
      - Fixed carbon to volatile ratio
      - Ash content
      - Alkali Index, slagging, and clinker formation
- Feedstock Preparation
  - Chipping
  - Chunking
  - Pelletizing and Briquetting
  - Sorting
  - Blending undersized pieces and used filter media with feedstock
  - Recovery of tars from condensate
  - Drying feedstock to correct moisture levels
  - Moisture Testing
    - Moisture Meter
    - Microwave Method
- Table of Feedstocks
- Biomass Consumption Table

Feedstock related terms

Feedstock, Fuel



The GEK TOTTI Gasifier onboard the Power Pallet is a refinery that takes crude biomass in the hopper and refines it into a clean-burning gaseous fuel for the engine, while producing char-ash as a waste product. In engineering parlance, material fed into a refinery to drive a chemical process would be called *feedstock*, and the refined product going into the engine would be called *fuel*. However, from the perspective of the user of the Power Pallet, the machine is fueled by biomass. Because of this, you may find the terms *feedstock* and *fuel* used interchangeably. For example, the paddle switch on top of the PyroReactor that regulates the feeding of biomass into the PyroReactor is called the *fuel level switch* (see Annotated Figure A in Chapter 3), but in most of our literature, the biomass is referred to as feedstock.

Oversized, Undersized, and Fines

In the course of feedstock pre-processing, the operator may need to chip and sift material into various size grades—*oversized*, *undersized*, and *fines*. Each Power Pallet comes with hardware cloth screens for the user to sift their feedstocks with. (See the graphics on p. 14.)

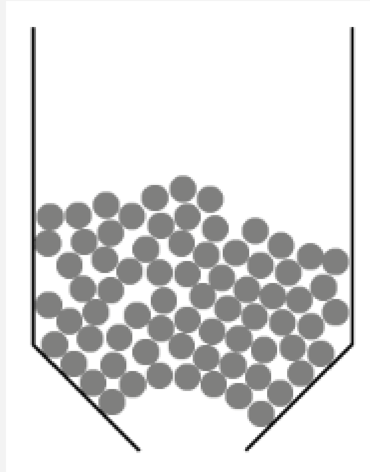
- Oversized feedstock ("*overs*" for short) is material that fails to fall through the 1" mesh
- Undersized feedstock ("*unders*" for short) is material that falls through the ½" mesh, but remains above the ⅛" mesh.
- Fines are all of the remaining material small enough to pass through the ⅛" mesh but too coarse to pass through the window screen mesh.

All material that passes through the window screen mesh is effectively sawdust, and is neither suitable as feedstock nor as gas filter media.

Fuel Jams: Bridging, Rat-holing, Binding

Many of the difficulties that arise when working with solid feedstocks come from difficulties with bulk material handling. Three of the most common forms of fuel jams are *bridging*, *rat-holing*, and *binding*.

Bridging refers to when the feedstock forms an arch or a dome held together by friction, compression, or entanglement, and does not flow as the material below it is emptied away; surface friction and bad feedstock geometry are the primary culprits behind this phenomenon. Bridging is most likely to happen where the hopper narrows down as the material is wedged together by the walls of the hopper.



An illustrated cross-section example of feedstock bridging.

Rat-holing refers to the problem of feedstock flowing only along a narrow column or tunnel while the material around the tunnel resists flowing due to friction, compression, or entanglement. Rat-holing can sometimes enable flame to back-propagate from the combustion zone through the tunnel in the feedstock all the way into the volume of combustible gases that have mixed with air in the hopper, causing a *puff event.*, Puff events are relieved by the pressure relief valve on the hopper.

An exampe of rat-holing in feedstock.

Binding refers to the problem of feedstocks forming compression resistant piles or stacks rather than freely flowing or falling when pushed by the auger or by the weight of material above it. When such a formation occurs, transport of the feedstock from the hopper to the reactor halts.

Any of the above problems may require operator intervention to resolve; if severe, these may even disqualify a feedstock as impractical for gasification.

Feedstock Qualifications

The GEK TOTTI gasifier system is a fuel refinery that takes cellulosic biomass as its crude fuel input and refines it into clean burning producer gas for an internal combustion engine. In order to facilitate this process, the feedstock must be both **physically compatible** with the auger and the gasifier to minimize the risk of fuel jams and bridging, as well as **chemically compatible**, to facilitate the necessary chemical reactions and to minimize the risk of fouling by clinkers and mineral deposits from the ash.

At the present time, the GEK TOTTI gasifier system is only known to be compatible with feedstocks composed of pieces of *lignocellulosic biomass*—in layman's terms, dry woody biomass such as wood chips, nut shells, and canes and prunings of similar composition.

Physical compatibility

The physical compatibility of a feedstock is determined by the following qualifications:

Upper size limit
The feedstock should not have pieces with a maximum dimension larger than 1.5 inches (about 4 cm). Feedstock with sizes exceeding these limits are at risk of jamming the auger or may fail to engage the auger at all, since the flights of the auger are about 1.5 inches apart. Long pieces also tend to have difficulty flowing and are prone to bridging.

Lower size limit
The lower size limit that the operator should use during sifting is ½" (about 1.25 cm). No more than 10% of the feedstock should be smaller than ½"; Feedstock with an excess of small particles is at risk of imparting too much gas flow resistance to support the rate of reaction needed to sustain an engine. Undersized and fine pieces also increase the risk of bridging in the hopper.

Correct shape
Due to the great diversity of feedstocks available, and the limited control most users have over processing methods, there is not so much a correct shape as there are incorrect shapes that should be avoided. Good shapes have sufficient surface area to support reduction reactions as well as enough voidspace in the bulk material to support a high rate of gas percolation. (Void spaces are discussed in detail later on.) The feedstock must ***not*** have shapes that are conducive to stacking or tangling. For example, cubic and domino shaped pieces are not compatible even if they are of the right size because these shapes tend to cause binding and cause severe jams in the drying bucket and at the interface of the auger and the PyroReactor. Also, long stringy particles must be separated from the feedstock; materials such as corn stover, vines, grain stalks, or leaf matter will entangle the feedstock or even the auger and cause constant fuel jams.

Correct surface texture

The ideal surface texture for feedstock is smooth, such as found on some nut shells and wood chips produced by a chipper with sharp blades. Extremely rough feedstocks are at risk of fuel jams simply because the pieces tend to lock together to form bridges rather than flowing. For example, pinecone pieces and coarse chunks of bark tend to interlock and jam in the hopper. Wood chips are also at risk if they are excessively rough and exhibit a lot of internal friction as a bulk material. It has been observed that wood chips tends to have smoother surfaces if they are chipped while moist rather than chipped when very dry; dry wood tends to splinter and shatter rather than be cut by the blades of a chipper, and the resulting surfaces tend to be rough.

Friability

Friability is the ease with which a solid material breaks into smaller pieces by physical contact. In layman's terms, friability means the ability to crumble. Friable feedstocks are not compatible with the GEK TOTTI gasifier system on the Power Pallet. The physical transportation of the feedstock by the auger may crush friable feedstocks into crumbs, which would likely be smaller than the lower size limit and choke the flow of gases.

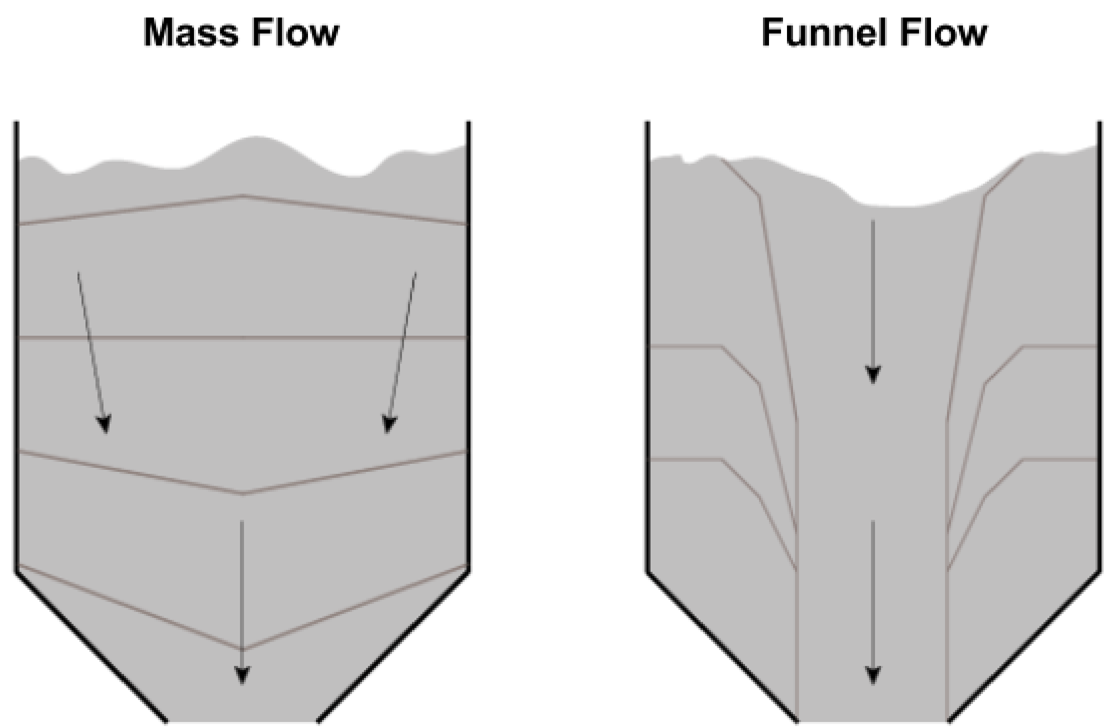
Resistance to Steamed Disintegration

Densified lignocellulosic feedstocks such as pellets and briquettes have a tendency to swell and disintegrate when exposed to high humidity. For this reason, even correctly sized pellets and briquettes can be impractical feedstocks; moisture driven off of the feedstock in the drying stage steams the feedstock in the hopper, and steaming causes pellets and briquettes to disintegrate into sawdust and to swell and compress into a single mass. Pellets or briquettes that disintegrate and swell from humidity in the reactor after shut-down can form a large packed plug of material that is very hard to clean out of the reactor.

With sufficient expertise in managing steam exposure, densified fuels can be used, particularly if the operator manually manages the shut-down process to prevent the build-up of steam in the reactor and hopper. Torrefaction (low temperature pyrolysis in the range of 200˚-350˚C, akin to toasting) of pellets and briquettes may potentially be usable because torrefaction stabilizes densified fuels against steamed disintegration.

Flow Characteristics

The flow characteristics of a feedstock are a function of their shape, size, and texture, and have a major impact on how practical a feedstock will be. The two characterizations of how solid materials flow are *funnel flow* and *mass flow*. Most feedstocks will have flow characteristics somewhere between these two.



Mass flow is preferable to funnel flow; feedstocks that strongly exhibit funnel flow are prone to rat-holing and bridging. ***Both of these forms of fuel jams leave feedstock deceptively visible through the viewport on the hopper***; if the low fuel alarm is sounding, but the hopper viewport shows feedstock, there is probably a fuel jam of some sort in the hopper.

Angle of repose

The *angle of repose* of the feedstock correlates with the flow characteristic of the feedstock. The angle repose is the angle at which the a large heap of the feedstock will settle to when pulled by nothing but gravity. Even small samples will give you a pretty good sense of the angle of repose of your feedstock. In the following illustration, cylinders of feedstock were inverted onto a flat surface, and gently lifted off, permitting the feedstock to settle into a heap. As you can see, wood chips, which are rough, exhibit a greater angle of repose compared to smooth round macadamia nut shells. The larger the angle of repose, the greater the risk of bridging and rat-holing.

A comparison of the angle of repose of wood chips and of macadamia nut shells. The greater angle of repose of the wood chips correlates a greater risk of bridging and rat-holing.

Blending feedstocks to compensate for shape and texture

The texture of a feedstock may be compensated for by blending a rough feedstock with a smooth and easily flowing feedstock. For example, wood chips that are prone to jamming due to texture or shape may benefit from being blended with smoother feedstocks, such as hazelnut or macadamia nut shells. Because there is so much variation in feedstock availability, the optimal blend must be determined by experimentation on a case by case basis.

Void spaces and physical compatibility

The aspect that the size and shape qualifications are trying to control is the *average void-space size* in the feedstock—the average size of the spaces between the pieces of feedstock. Gasification is critically dependent on the following processes which depend on a balance between adequate void space and surface area:

- **Combustion and tar cracking**— combustion of tars happens in the gaseous phase, and can only occur when there are large enough spaces between the pieces of charred feedstock to support the mixing of oxygen and tar gases for combustion, and to prevent the endothermic reduction reactions at the surface of the char from suppressing the high combustion temperatures. With correctly sized feedstock, a portion of the tar gases is combusted, and the remaining tar gases are cracked into H_2 and CO gases by the high temperatures.
- **Gas flow through solids**— the void spaces in the charred feedstock also support gas flow through the char bed. As the combustion products flow through the char bed, reduction reactions convert H_2O and CO_2 into H_2 and CO gases while consuming the char. The feedstock must have enough void space to support a rate of flow through the char bed that matches the gas consumption rate of the engine.

Feedstock that is too fine or that has too large a proportion of fine pieces will inhibit combustion and choke the flow of gas; feedstock that is too coarse may not have enough surface area in contact with the percolating gases to support the surface reactions that yield high energy gas.

Feedstock particle size and char-ash byproduct percentage

Fine feedstocks and feedstocks with a higher proportion of fines will produce more char ash per amount of feedstock compared to coarser feedstocks. As the pieces of charcoal shrink, they eventually inhibit gas flow and are eventually purged by the grate shaker to restore the rate of gas flow. Finer feedstocks reach this condition more quickly and more often than coarser feedstocks, and result in a larger proportion of their volume purged.

Chemical compatibility

Chemical compatibility refers to how well the chemical composition of a feedstock supports the chemical reactions in the gasifier. Poor chemical compatibility will result in weak gas, dirty gas, or excessive clinkers fouling the grate basket of the reactor. The four major aspects of chemical compatibility are:

Fixed carbon content

The fixed carbon content describes how much of the carbon in the feedstock remains as charcoal after pyrolysis. If the feedstock does not have sufficient fixed carbon (generally around 20% or more by weight), it will not form a good charcoal, without which the feedstock will not be able to support the reduction reactions that produce most of the combustible gas.

Volatile content

The rest of the carbon content of lignocellulosic biomass is contained in the volatile chemicals that contain hydrogen, oxygen, and other elements; these volatiles come off of the feedstock during pyrolysis as tar gases (wood smoke) during pyrolysis. The reactor combusts a portion of these gases to provide heat to drive the rest of the reactions, and cracks the rest of these tar gases into CO and H_2 gas by exposing them to temperatures in excess of 800˚C.

Fixed carbon to volatile ratio

Typical biomass volatile to fixed carbon ratios are in the range of 75/25 to 80/20; try to pick feedstocks with comparable ratios for best results. The fixed to volatile carbon ratio influences the temperature at which the reactor operates. The volatile content of biomass contributes to two endothermic processes: pyrolysis, and tar cracking. Feedstocks that are too high in fixed carbon while having insufficient volatile matter tend to burn too hot. For this reason, feedstocks such as coal and pure charcoal are not suitable. Feedstocks that have too large a proportion of volatiles compared to fixed carbon tend to burn too cool to support efficient tar cracking.

Ash content

The ash content of a feedstock consists of minerals that form solid oxides. These mineral oxides do not contribute to the gas production of the feedstock; they are purged along with small pieces of char in the form of black *char-ash* by the shaking of the grate basket, and secondarily through the cyclone, which captures any char dust and ash material that become entrained in the gas stream. If the ash content of a feedstock is in excess of 5%, the feedstock is at risk of forming slag and clinkers, and may fouling the ash handling system. Such feedstocks are not suitable for gasification.

Alkali Index, slagging, and clinker formation

The temperature at which a feedstock's ash fuses into slag and clinkers (ash rocks) is an important factor in determining whether the feedstock is suitable for gasification. The temperatures in front of the air nozzles, where the combustion is most intense, can be as high as 1200˚C; the temperatures in the reduction zone can be in the range of 800˚-1000˚C. If the feedstock ash is at risk of fusing in these temperature ranges, the feedstock may not be suitable.

The *alkali index* has been proposed as another method to help determine how prone biomass is to slagging. Alkali indices above 0.17 kg/GJ clinker and ash fouling is probable, and above 0.34 kg/GJ fouling is virtually certain to occur.[1] This is because sodium and potassium are fluxing agents that decrease the fusion temperatures of other mineral oxides.

Alkali Index is calculated as follows

$$\frac{1{,}000{,}000}{HHV} \times \frac{Ash}{100} \times \frac{K_2O + Na_2O}{100}$$

where:

HHV is fuel High Heating Value [GJ/kg]
Ash is fuel ash [% dry weight]
K_2O is potassium oxide [% ash weight]
Na_2O is sodium oxide [% ash weight]

[1] see Alkali Report, Miles, et al, 1995.

Feedstock	HHV [MJ/kg]	Alkali Index [kg/GJ]
Hybrid Poplar wood	18.95	0.29
Switchgrass	18.08	0.60
Rice Straw	18.91	1.31
Rice Husks	15.84	0.50
Almond Hulls	18.90	1.74
Sugarcane Bagasse	18.99	0.01
Sunflower Shells	18.64	0.80

Alkali index of example feedstocks

Alkali index is only one of several factors that determine the likelihood of slagging and clinker formation. Silica content is another major indicator of slagging risk. Feedstocks rich in silica, such as rice husks, are too prone to fouling to be usable as feedstocks, even when they are physically compatible.

An example of one of the clinkers that fouled a reactor running a test on almond husks.

The ECN Phyllis2 biomass database is a great resource for finding data on fixed carbon, volatiles, and ash content. Using data from this database, you can usually pre-qualify or disqualify a prospective feedstock based on chemical compatibility.

ECN Phyllis2
https://www.ecn.nl/phyllis2/

Feedstock Preparation

Chipping

When processing feedstock such as tree limbs, logs, and canes, it will be necessary to chip the material. There are three major styles of chippers, two of which operate on the same principle:

- **Disc and drum chippers**— these chippers have a heavy disc or drum with a bladed slot as the cutting device. The cutting device is spun at a high speed, and wood is struck with a great deal of momentum by the blade, which removes a thin layer of chips with each revolution. In models with adjustable blade offsets, the size of the chips can be regulated by adding or removing shims under the blade.
- **Screw auger chippers**— these chippers have a conical bladed auger that rotates with a great deal of torque. The auger pulls the wood against a bearing surface and cuts it into layers it while pulling each layer apart. This kind of chipper does not have an adjustable chip size; the only way to change the chip size is to swap out the bladed auger for another auger designed to produce a different sized chip.

An example of the chipping mechanisms of a disc chipper compared to a screw auger chipper.

Disc and drum chippers are more common and more affordable, but produce a much larger distribution of chip sizes which require sorting, whereas bladed auger chippers produce a very consistent chip size, but are expensive and are only available from a few brands. When determining chip size, adjust blade offsets and auger sizes according to the size recommendations described under the physical compatibility section above.

Chunking

Feedstocks such as vine canes, thin tree limbs, and saplings may be better processed by chunking rather than chipping. Chunkers have a highly leveraged blade and a depth stop that will cut long canes into chunks. If properly calibrated, chunkers will process raw feedstock into very consistently sized and shaped pieces.

Pelletizing and Briquetting

Feedstocks that have incompatibly small particle sizes (such as saw dust) can potentially be made usable by being pressed into briquettes or pellets, especially if they are subsequently torrefied. Pellet mills compress the raw feedstock through a plate under extremely high pressure, often resulting in enough heat to fuse the lignin content of wood. Briquetting systems compress the raw feedstock or a feedstock slurry into a mold, often with a binder mixed in; the feedstock material then binds together to form larger pieces.

The biggest risk of pelletizing and briquetting are friability and steam disintegration, which torrefaction may mitigate. These are discussed in the prior section on physical compatibility.

Sorting

Each Power Pallet ships with several hardware cloth mesh screens on the crate: 1 inch, ½ inch ⅛ inch, and window screen. These meshes are intended for sorting feedstock and filter media. The recommended method for sorting the feedstock using the mesh screens is as follows:

Sifting with the 1" screen to remove over-sized pieces.
Over-sized pieces remain above the screen.

Lean the screen against a wall, and use a large shovel such as a snow shovel, and toss some feedstock on the top of the screen. As the feedstock tumbles down the incline, pieces which are too large to pass through the mesh will remain above, and pieces which are small enough will pass through. The material may need several passes for thorough sorting. If the material needs some agitation to help it along, spread it around with the shovel.

Sifting with the ½" screen to remove undersized pieces and fines. These fall through the screen.

For feedstock, you want to isolate the pieces which are smaller than 1” and larger than ½” for the bulk of your feedstock, and then blend in fines as needed.

Blending undersized pieces and used filter media with feedstock

The current generation of the GEK TOTTI gasifier (V5) can tolerate up to 10% of its feedstock as undersized pieces and fines. To maximize the utilization of your biomass, you may blend some of the fines back into your feedstock.

The gas filter uses biomass as its filter media in layers, starting with fuel grade biomass at the bottom, medium sized fines smaller than ½” (about 1cm) in the middle, and very small pieces smaller than ⅛” (about 3mm) at the top. (See the filtration section in Chapter 3.) In the course of filtration, the filter media acts as a condensation surface to remove residual tar from the producer gas. The tar content is still energy rich, and the used filter media should be dried and mixed with the feedstock to recover this energy content.

When blending fines and used filter media into freshly sorted feedstock, please limit these to 10% or less by volume, and make sure the used filter media is adequately dried and evenly blended into the feedstock.

Recovery of tars from condensate

The condensate liquid that collects in the condensate vessel and in the bottom of the gas filter is rich in tars; this liquid is smelly, and not generally safe to dispose of into streams or soil because of its toxicity, which is akin to the toxicity of cigarette tars. This energy content of these tars can be recovered by disposing of the condensate by pouring or spraying the condensate evenly over feedstock and letting it dry to appropriate levels; the tars will eventually be consumed in the gasifier.

Drying feedstock to correct moisture levels

The GEK TOTTI gasifier system onboard the Power Pallet operates best with feedstocks that have a moisture content no higher than 30%, and no lower than 10%, as measured on a dry weight basis. The gasifier will tolerate increasing levels of moisture (up to 30%) with increasing load, since higher loads afford the gasifier more waste heat with which to dry feedstock, and higher temperatures in the combustion zone with which to drive reduction reactions which consume water vapor. At moisture levels above 30%, the water vapor within the system interferes with the gasifier’s ability to maintain the temperatures required for producing clean gas. Moisture levels under 10% risk excessively high temperatures at the hearth and the formation of clinkers from the fusion of ash.

To ensure a quick start up of the GEK systems, use feedstock with <15% moisture content in the pyrolysis column and the drying bucket at first, since during the first start the drying bucket and pyrolysis column are cold. When the flare is sustained, the system will be able to take up 25% moisture content. Moisture levels above this will make it difficult to light the gasifier and will burden the system with a higher amount of tar.

The recommended method of drying wood for feedstocks is to chip your wood first, and then dry it by spreading it out on a tarp or on hardware cloth and leave it exposed to the sun. This is because dried wood tends to splinter and form rough pieces when chipped, and rough feedstock tends to cause bridging and fuel jams. Also, drying chipped wood is much faster and more efficient than drying whole wood due to the increased surface area exposed to the air.

Moisture Testing

To determine the moisture content of your feedstocks, we recommend the following two methods:

Moisture Meter

The Power Pallet user kit comes with a battery powered moisture meter that can detect moisture levels up to 40%. To obtain an estimate of the moisture content of the wood:

1. Pick out a few random samples of feedstock. Be sure to sample from within your pile of feedstock; samples from the surface may be drier than average and may give you misleading test results.
2. Test each piece of feedstock: turn on the moisture meter and stab the two prongs into a single piece of feedstock. The display will give a fairly reliable estimate of the moisture content.
3. Average the moisture levels of each of the pieces you tested.

Microwave Method

This method is recommended for materials that cannot be tested using the moisture meter, such as nut shells.

1. Select a random sample of your biomass.
2. Weigh the sample (m_{wet}) and record.
3. Place the sample in a microwave and microwave for 15-60 seconds.
4. Record the new weight of the sample.
5. Repeat steps 3-4 until measured weights stabilize.
6. Average the last three (stabilized) measurements (m_{dry}).
7. Report the percentage moisture content on a dry basis:
   $100 \cdot (m_{wet} - m_{dry}) / m_{dry}$

Note: you can also use an oven, but be sure not to burn the sample.

Table of Feedstocks

The following table of feedstocks shows the most common feedstocks that are known to work, and what feedstocks are known to be problematic.

Suitability Key

Dark Green	Known to work with minimal operations and maintenance effort
Green	Known to work with increased operations and maintenance effort
Yellow	Maintenance intensive. Will work with increased operations and maintenance effort, may have increased slagging and other downtime impacts.
Red	Not tested or known to not work.
Dark Red	Known fundamental incompatibilities.

General Requirements For All Feedstocks

- Effective particle size: 0.5”–1.5” (1 cm–4 cm)
- Moisture content (% by dry weight): <30%
- Ash content <5%

Feedstock	Notes	Processing
Walnut Shells	Shell halves and large pieces work; finely crushed shells do not.	Sifting, drying.
Coconut Shells	See general requirements. Caution: Large pieces may cause auger binding or bridging.	Crushing, sifting, drying.
Hardwood Chips - Oak, Beech	See general requirements. Caution: Thick chips may cause auger binding.	Chipping, sifting, drying.
Softwood Chips - Douglas Fir, Pine	See general requirements.	Chipping, sifting, drying.
Corn Cobs	Must not contain husks. Caution: Increased chance of slagging.	Needs to be chopped to correct size.
Palm Kernel Shells	Caution: Risk of high temperatures	May work if blended with feedstocks that burn at lower temperatures

Wood Pellets	Larger pellets have better void spaces Caution: Pellets crumble due to humidity on shutdown.	
Saw Dust	Caution: Too fine, not physically compatible.	
Manure - Cow, Pig, Chicken, etc	Caution: High slag, low energy density.	
Coffee Grounds	Pellets of grounds prone to disintegration.	
Macadamia Nut Shells	Not enough testing to validate performance; excellent physical compatibility when sifted.	
Bamboo	Processing into chips difficult.	
Grassses - Switchgrass, Miscanthus, etc.	High silica and low bulk density.	
Paper Waste	Not physically compatible in paper form; same risks as pellets when pelletized. High ash content.	
Sugarcane Bagasse	Stringy material - not physically compatible; certain fuel jams.	
Corn stover	High ash content; silica content leads to slag.	
Oil Palm Pressings		
Rice Husk	High silica content leads to slagging.	
Coconut Husk	Not physically compatible	
Municipal Solid Waste / Trash	Slag risk; heavy metals; plastic content not suitable, especially PVC.	
Coal	Burns too hot; processes not designed to handle sulfur and other contaminants.	
Plastics	Melts and fouls auger/reactor; does not have good fixed carbon content. May contain or create toxic compounds	
Tires	Not chemically compatible.	

Biomass Consumption Table

The biomass consumption rate of the Power Pallet is approximately 1.2 kg of feedstock per 1 kWh of electrical energy. The actual consumption rate varies with load, moisture and quality of the feedstock.

Power [kW]	Estimated feedstock consumption rate [kg/hr]
2	2.4
4	4.8
6	7.2
8	9.6
10	12.0
12	14.4
14	16.8
16	19.2
18	21.6
20	24.0