# Biomass Fuel for Export to EU Countries

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## ABSTRACT

The US and Canada now ship more than 4.7 million tons (4.3 million tonnes) of wood pellets to Europe, valued at some $650 million/year. Total worldwide pellet consumption is in the range of 30 million tons per year. Conservative projections predict an increase in European wood pellet use from 10.8 million tons to 23.8 million tons between 2010 and 2020.

There is an old saying in fuel preparation – do only as much as the application requires, *and no more*. So why take all the effort to make a wood pellet just to burn it? The reasons are that they are a standard commodity, are low in moisture, have good flow properties, and are higher in bulk density than raw wood. However, they are costly, are prone to dusting and crushing, and generate CO (carbon monoxide) while in storage.

Are pellets the only way to slake the European thirst for biomass, or are there superior, lower cost, greener fuels available with smaller carbon footprints? One that has potential is dry micro chip fuel. This is created by a new generation of in-forest chippers which produce a nominal ¼" long by 1/16" (6 mm x 1.5 mm) thick chip. When dried, micro chip fuel has all of the positive properties desired for combustion: low moisture, good handling, near zero dust and little breakage when handling, and based on preliminary tests, no detectable CO generation in storage.

This paper covers differences in technology, capital cost and power use when comparing these two competing fuels, and the implications for export wood fuel carbon footprint analysis.

## INTRODUCTION

North America now ships $650 million USD[1] worth of fuel wood pellets to Europe, England and Scandinavia. This paper explores use of an alternate path to making a lower cost, greener export wood fuel.

The EU (European Union) has set a goal of 20% renewable energy by the year 2020, a major market driver. Worldwide pellet production is estimated at close to 30 million tons per year[2]. Conservative projections[3] predict an increase in EU wood pellet consumption from 10.8

million tons to 23.8 million tons between 2010 and 2020. Projections show that the southeastern US alone has the potential to produce over 6 million tons per year by 2020.

An old saying in fuel preparation is "*do only as much as the application requires, and no more*." So why take all the effort to make a wood pellet? The reasons are that they are a standard commodity, are low in moisture, have good flow properties, and are higher in bulk density than raw wood. But they are costly, prone to dusting and crushing, and generate carbon monoxide (CO) while in storage.

Lower cost, *greener fuels* are available with smaller carbon footprints. One that has potential is dry micro chip fuel. This is created by a new generation of in-forest chippers which produce a nominal ¼" long by 1/16" (6 mm x 1.5 mm) thick chip. Production of this fuel, in place of wood pellets, can half the capital cost of the plant, and the energy used in wood fuel preparation, and reduce the export fuel cost by $100 million USD per year.

## NEW GENERATION OF CHIPPERS

Historically, in-field disk and drum chippers produced a 2x2x1/4" (50 mm x 50 mm x 6 mm) chip for pulp wood or hog fuel use. The new generation of micro chippers is finding use for both the pulp and paper market and wood fuel market. An example is shown in Figure 1, a diesel powered drum chipper. Examples of these machines can be found on manufacturer's websites.[4, 5] For fuel and pulp markets, the chips are blown into a 20 - 23 ton chip van, which then goes direct to the end user or to a rail head if rail transport is employed for longer hauls.

Figure 1, Diesel Powered Whole Tree Drum Type Micro Chipper (Courtesy Peterson)


## COMPARING PELLETS AND DRY MICRO CHIP FUEL

"Engineered Fuels"[6] are those that undergo one or more beneficiation steps prior to being burned. For biomass, this would start with the base fuel of stem wood, whole tree chips or hog fuel. Beneficiation steps include size reduction, drying, pelleting, briquetting and torrefaction. Each step has its own costs and benefits. This paper focuses on dry micro chip fuel and its comparison to pellets.

Micro chip fuel is a new biomass product aimed primarily at the industrial export market, and secondarily at the national market for residential and commercial wood heating. The term DMC Fuel™ has been trademarked by TMTS Associates, Inc, an engineering consulting firm focusing on biomass projects. TMTS has also tested DMC Fuel ™ properties, developed flowsheets and quantified cost reductions to help promote its move into the marketplace.

Figure 2 shows the traditional "hog fuel" produced by whole tree chippers and also by coarse-grind hammermills. As shown in the photo of weathered hog fuel, it is relatively course, with top size of about 2" (5 cm).

Figure 2, Hog Fuel

Figure 3 shows both micro chip fuel (at left) and wood pellets (at right). Fuel wood pellets are about 3/8" (10 mm) diameter x 5/8" (16 mm) long. Dry micro chip fuel's smaller size makes drying much easier and faster (as compared with the old standard 2"x2"x1/4" whole tree chips, or 2" hog fuel), getting the job done with shorter dryer residence time and smaller dryer shells. Combustion (including drying, devolatilization, carbonization, and carbon burnout steps) is much more rapid for dry micro chip fuel, due to the thinner 1/16" vs. 3/8" ((1.5 mm x 16 mm) (one sixth the thickness) minimum dimensional difference between the fuels, and for some combustors, a final grind before the fuel entering the furnace may not be required for dry micro chip fuel.

Figure 3, Dry Micro Chip Fuel and Conventional Wood Pellets

Table 1 lists the pros and cons of wood pellets and dry micro chip fuels. Figure 3 shows comparative flow sheets.

Table 1, Pellet and Dry Micro Chip Pros and Cons

| **Pellet Pros** | **Dry Micro Chip Fuel Pros** |
|---|---|
| Well-established commodity | Lower capital costs |
| High bulk density | Lower power, labor and maintenance cost |
| Low moisture content | Low moisture content |
| -- | Lower cost per ton |
| -- | Greener fuel: Less power per ton used in manufacture |
| -- | No grinder/hammermill |
| -- | No pellet mill |
| -- | No pellet cooler |
| | Smaller dryer shell |
| **Pellet Cons** | **Dry Micro Chip Fuel Cons** |
| Dusting and crushing in transport and handling | New product |
| Loss of integrity upon wetting; protection from weather required | Lower bulk density |
| Need for hammermilling/grinding to less than 1/16" (1.5 mm) particle size before pelletizing | Higher ocean transport cost and fuel use |
| High energy and maintenance pelletizing step | Change in storage design to open roofed building |
| High cost and power consumption in manufacture; high cost per ton | |
| Need for pellet coolers | |
| Requires silo type storage | |
| Carbon monoxide generated in storage[7] CO levels have been found that are many times the NIOSH IDLH (Immediately Dangerous to Life and Health) level of 1,200 ppm, with CO concentrations of 1,460 to 14,600 ppm in cargo holds for ocean shipped pellets | |

The properties of micro chip fuel vary little with type of wood, with the exception of slightly higher heat content and volatile fraction for softwoods as compared to hardwoods, as would also be the case with pellets.

Micro chip fuel ash content will vary with feed stock, and, if sand and fines are excessive, screening to remove sand and fines can be done as part of the production process after drying. Any resultant fines can be used as dryer fuel.

Pellet bulk density is in the range of 45 lb/cu ft (720 kg/m3), while micro chip fuel is about 15 lb/cu ft (240 kg/m3). Cost for truck shipping differs little in practice between the two fuels, as both can make a full truckload weight, and a standard 48' (15 m) chip van can transport a full truckload (20 short tons plus) of micro chip fuel.

Overseas shipment is by major carriers (e.g., NYK Bulk, MOL and K line) with chips shipped in 3.6 million cu ft (100000 $m^3$) capacity ships, and pellets in dry bulk 1.8 million cu ft (50000 $m^3$) capacity ships. Typical receiving ports are Rotterdam, Antwerp, Liverpool, and Stockholm. Two major US east coast export ports are Savannah and Brunswick, GA.

An additional advantage of micro chip fuel is the potential outsourcing of the drying step to existing tolling facilities to enable low risk, fast startup of production and bypass the need to expend capital and time on equipment procurement, permitting and construction.

**MAJOR POWER AND FUEL USE IN PELLET PRODUCTION**

The production of dry micro chips eliminates the grinding step to ~1/16$^{th}$ of an inch top size (1.5 mm), and of the pelletization process. Figure 4A is a cross-section of a hammermill, where swinging hammers grind and break material up until it can pass through chosen size holes in an abrasion resistant grate. The pellet mills traditionally (as shown in Figure 4B) use internal rollers that force the ground and dried wood through thick rotating dies. Both the grinding and the pelletization processes use considerable power (about 125 hp or 93 kW) per ton per hour pellet production) for their motors. The coal-equivalent fuel used by an electric utility to produce power for such hammermills and pelletizers is equal to about 7% of the heat available in the pellet product. Both inlet moisture content and temperature control of the process is critical to making strong pellets. In terms of CO2 emissions, the 125 hp per ton per hour to grind and pelletize would generate 216 lb (98 kg) of CO2 per ton of pellets using coal-based electric power.

Diesel is used to fuel the in-forest chippers. While it varies with species, a rough estimate is 2.25 wet tons of micro chips produced per gallon (3.8 liters) of diesel fuel burned[4, Morbark] in the chipper engine. The diesel use represents 0.7% of the product wood's heat value.

Figure 4 Hammermill and Pellet Mill
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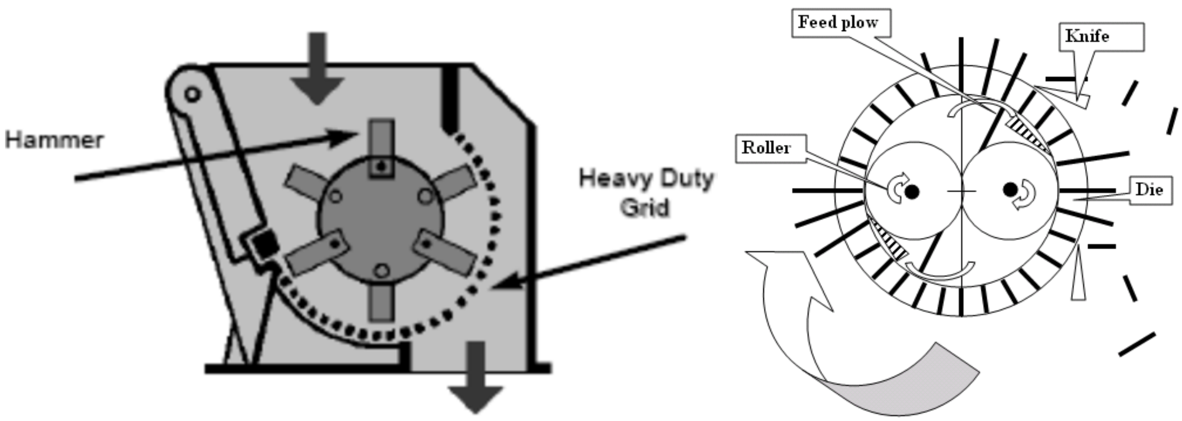
| 4A Hammermill Cross-Sectional End View | 4B Rotary Pellet Mill Cross Sectional End View |
| --- | --- |




## COMPARATIVE FUEL COST

Fuel Costs

A range of fuel costs are presented in Table 2, based on prevailing US prices. The coal, gas and oil costs are those paid by utilities for use in power generation. Hog fuel is burned directly at pulp and paper plants for steam and power. European prices for natural gas and fuel oil are higher than in the US and vary by country. Note that political decisions (e.g., the EU 2020 goals for renewable fuel) ultimately trump normal market pricing. Also keep in mind that burning coal entails extensive APC (air pollution control) systems, with significant cost for sulfur, particulate and mercury removal. One must take care in adding up delivered fuel cost as well as other operating and maintenance costs at point of use to make appropriate economic comparisons.  Based on US pricing, pellet costs are more than all fuels in Table 2 except fuel oil.

Capital and Operating Cost

There are significant power savings in production when shifting to dry micro chips from pellets due to reduced grinding power and elimination of pellet presses (see Figure 5). This also reduces the carbon footprint for dry micro chips, and the ratio of energy used in producing a fuel vs. energy in the fuel product.

How much more fuel does it take to transport the lower density fuel in larger volume/lower bulk density ships? A study done by the University of Iowa[8] for export grain shipments shows net ton-miles per gallon of fuel for various sized ships, with fuel efficiency going up as dwt (deadweight tonnage) goes up. Wood pellets in a dry bulk carrier at 1.8 million cu ft (50,000 m3) capacity would load 31,500 short tons (28,600 dwt) at 35 lb/cu (560 kg/m3) foot density. Dry micro chips in a chip carrier with 3.6 million cu ft capacity ships would load 27,000 short tons (24,500 dwt) at 15 lb/cu foot (240 kg/m3) density. Pellets would require 9.0 gallons (34 liters) of fuel oil for the ship per ton transported[8] vs. 9.6 gallons (36 liters) (7% more fuel for ocean transport) for dry micro chip fuel for the 4500 mile (7200 km) trip. This transport fuel use is equivalent to about 9% of the energy contained in a ton of either wood fuel.

Table 2, Comparative Fuel Costs

| **Waste or Fuel** | **Gross Heating Value Btu/lb** | **Approx-imate Cost, $/MM Btu*** | **Comment (Source, Date)** |
|---|---|---|---|
| Natural gas | 23,896 | $7.19 | Utility supply (EIA 7/14, first 3 mo. 2014) |
| No. 6 fuel oil | 18,266 | $20.00 | At ~$3/gal sale to end user; price varies with sulfur content (EIA, 7/14, first 3 mo. 2014) |
| Coal | 9,000 – 15,000 | $2.08 | $45.77/ton; cost based on 11,000 Btu/lb (EIA, 2012 US Utility avg.) |
| Wood waste | ~4,250 at 50% mc | $2.20 | $18.74/ton delivered (Georgia Forestry Commission, 7/3/14). Local availability (not suitable for coal fired utility boiler firing) |
| Wood, whole tree chips | ~4,250 at 50% mc | $2.55 | $21.75 per ton delivered (Georgia Forestry Commission, 7/3/14) |
| Wood pellets | ~7650 at 10% mc | $9.15 | Average price for export 2013 ~ $140 USD/ton |
| Dry micro chip fuel | ~7650 at 10% mc | $7.84 | Assuming $20/ton lower cost than pellets ~ $120 USD/ton |

Note: To convert from $/MM Btu to $/gigajoule, divide by 1.06

More detail on carbon footprint estimates can be found in reference 9.

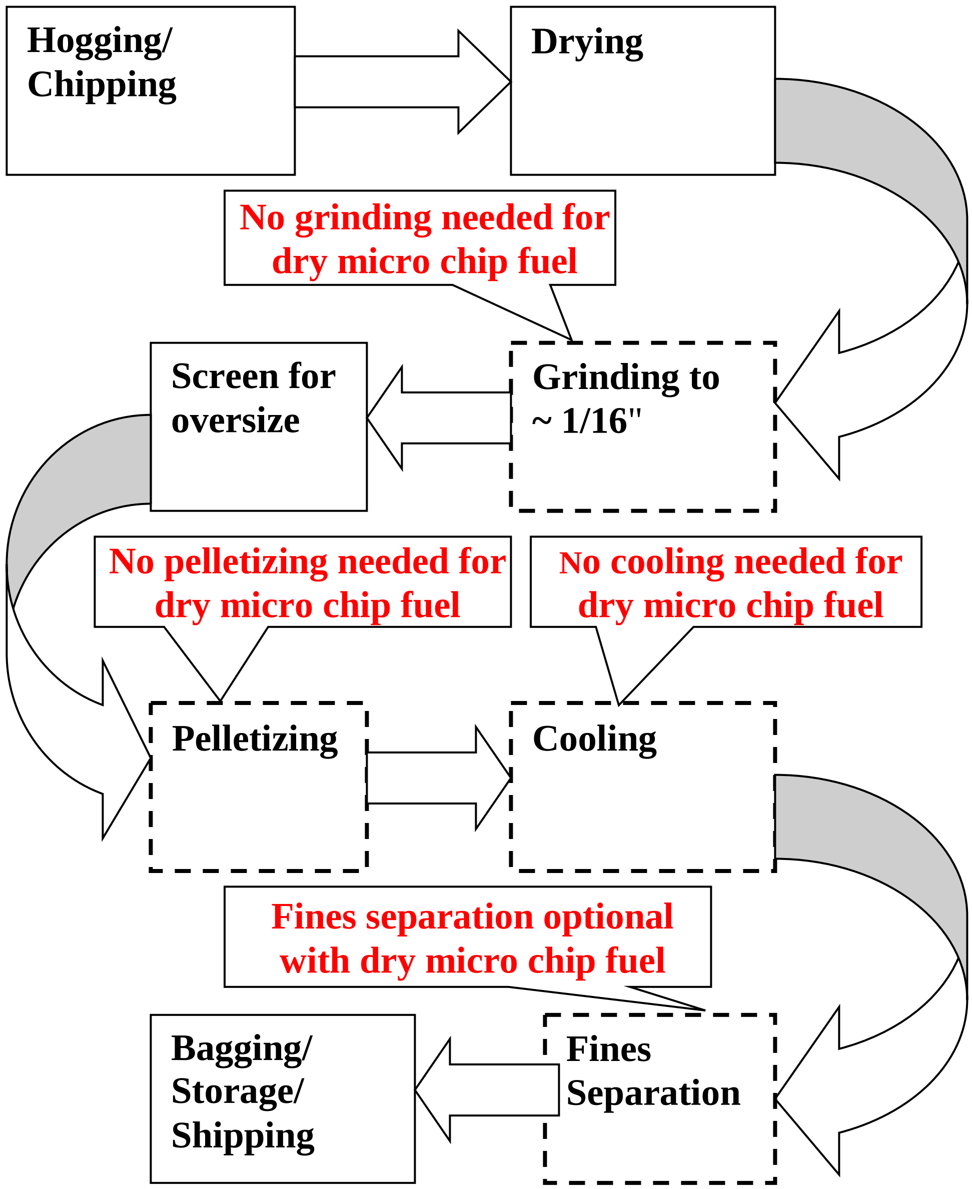
Elimination of equipment from the flowsheet (the hammermill, multiple pellet mills, pellet cooler, interconnecting conveyors, etc.) cuts purchased equipment cost by 57%. Total savings for power, maintenance, labor, reduced amortized cost of capital is in the range of $30-$35/ton of dry product. Estimates of the premium for transatlantic shipping of lower bulk density product via chip carriers suggest an added cost of $15/ton, resulting in a net savings on dry micro chip fuel delivered to the EU of about $20/ton when compared to wood pellets.

## PRODUCT REGULATION AND SPECIFICATIONS

In addition to grading by industry standards for industrial (higher ash) and residential (lower ash) markets, multiple parameters are tested on wood pellets:

- fines content, bulk density, diameter, length
- heating value, chloride, moisture content,
- pellet durability index
- ash content

Figure 5, Flow Sheet for Pellets and Differences for Micro Chip Fuel



Comparatively, micro chip fuel requires only moisture content, particle size range, ash content and heating value tests. Table 3 shows general specifications for micro chip fuel:

Table 3, Generic Dry Micro Chip Fuel Specifications

| **Parameter** | **Value** | **Comment** |
|---|---|---|
| Size | Nominal top size 1/4"x1/16" (5 mm x 1.5 mm) | This can be fine-tuned for end use |
| Moisture content | +/-10% | 8-12% typical, wet basis |
| Heating value | +/-7650 Btu/lb (18 kJ/kg) | Varies with hardwood (less), softwood (more) |
| Bulk density | +/-15 lb/ft$^3$ (240 kg/m$^3$) | Approximate |
| Ash | 0.5% to 2% | Varies with source; can be reduced by screening |

A major issue for export is moisture content. Wet wood is generally banned from shipment due to the potential for transporting parasites, such as PWN (pine wood nematode). PWN treatment per the "56/30" rule requires a core temperature of at least 56°C for 30 minutes for wood chips. Hence, the drying step is mandated for overseas shipment.

While wet wood chips tend to pack leading to arching and bridging in storage and handling systems, dry wood is freer flowing, and is stronger and less prone to jams and hang-ups.

In-house testing was done on bulk density and poured angle of repose (see Figure 6 and 7) The bulk density is as reported in the above table, and angle of repose is approximately 35 degrees for the dry micro chips tested.

Figure 6, Angle of Repose Testing Tools

Figure 7, Poured Conical Pile of Dry Micro Chips

SUMMARY

While wood pellets are the current logical choice for export of biomass for industrial/utility use in the EU and Scandinavia, dry micro chip fuel has potential for lowering costs and reducing the carbon footprint associated with biomass fuel, and making it yet a greener and less costly fuel source. The reduced capital cost and electrical use result from elimination of the grinding and pelletization steps. When dried, micro chip fuel has all of the positive properties desired for combustion: low moisture, good handling, near zero dust, little breakage when handling, and based on preliminary small scale TMTS tests, no detectable CO generation in storage. In addition, fuel can be stored in simple, lower-cost, roofed buildings instead of traditional pellet silos.

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## KEYWORDS

Biomass, carbon footprint, DMC Fuel™, dry microchip fuel, dry micro chip fuel, wood pellets