



*Production of Quality Feedstock From  
Forest Residues for Emerging Biomass  
Conversion Technologies*

U.S. DEPARTMENT OF  
**ENERGY**

 **HUMBOLDT  
STATE UNIVERSITY**

*For more information please visit [WasteToWisdom.com](http://WasteToWisdom.com)*

# The Economics of Waste to Wisdom

**E.M. (Ted) Bilek**

Economist

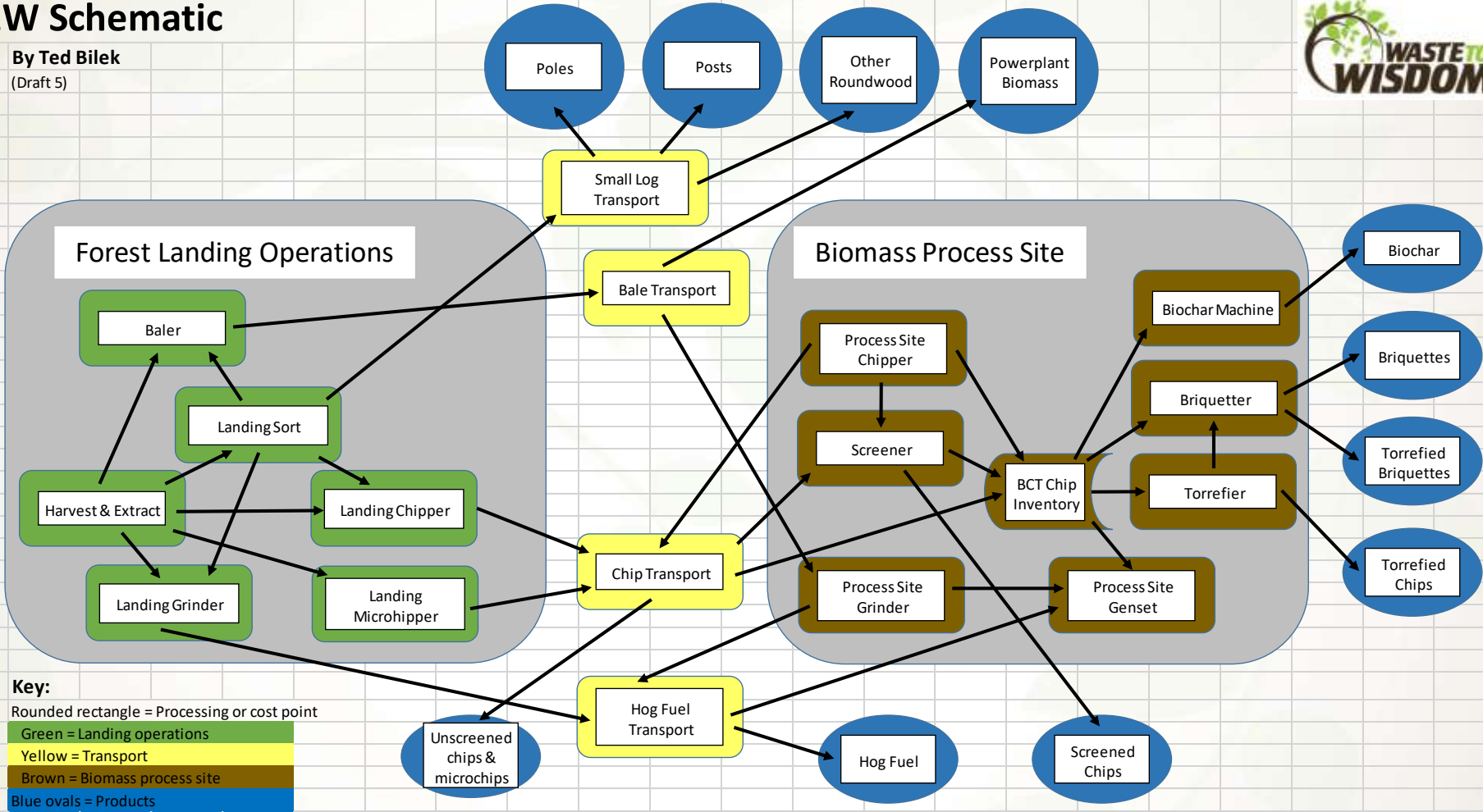
USDA Forest Service, Forest Products Laboratory  
Madison, Wisconsin

# Economics Questions

- Does it make economic sense?
- If it does make economic sense, what are the critical factors that one has to monitor?
- If it does not make economic sense, what conditions have to change that would make it economic?

# W2W Schematic

By Ted Bilek  
(Draft 5)



## Comminution Equipment Owning & Operating Costs (1 of 2)

<b>Cost per Scheduled Machine Hour</b>	Modified Dump Truck (300 HP)	Loader in unit and with grinder or chipper (250 HP)	Peterson Pacific 2700C Horizontal Chipper (475 HP)	Peterson Pacific Horizontal Grinder (1050 HP) (e.g. 5700C)	Morbark Beaver M20R (400 HP)	Morbark Chipper (875 HP)
Fixed or ownership costs	\$ 10.48	\$ 45.94	\$ 44.04	\$ 74.35	\$ 41.91	\$ 69.84
Variable or operating costs	23.10	41.96	58.69	118.58	34.65	61.91
Subtotal: Machine owning & operating costs	\$ 33.57	\$ 87.90	\$ 102.73	\$ 192.93	\$ 76.56	\$ 131.75
Labor costs	\$ 42.00	\$ 42.00	\$ -	\$ -	\$ -	\$ -
<b>TOTAL HOURLY COSTS (\$/SMH)</b>	<b>\$ 76</b>	<b>\$ 130</b>	<b>\$ 103</b>	<b>\$ 193</b>	<b>\$ 77</b>	<b>\$ 132</b>
<b>MACHINE THROUGHPUT (BDT/SMH)</b>	<b>23.54</b>	<b>34.24</b>	<b>14.53</b>	<b>32.33</b>	<b>17.11</b>	<b>37.43</b>
<b>MACHINE COST PER BDT OF OUTPUT</b>	<b>\$ 3.21</b>	<b>\$ 3.79</b>	<b>\$ 7.07</b>	<b>\$ 5.97</b>	<b>\$ 4.47</b>	<b>\$ 3.52</b>

## Comminution Equipment Owning & Operating Costs (2 of 2)

Cost per Scheduled Machine Hour	AWD Tractor (HP)	Chip Trailer (trailer only)	Highway tractor	Self-loading truck for tops with trailer to haul additional logs	Bin truck	Bins (for bin truck)
Fixed or ownership costs	\$ 7.53	\$ 2.82	\$ 7.86	\$ 18.89	\$ 7.86	\$ 1.81
Variable or operating costs	8.57	0.77	38.53	44.61	36.67	0.50
Subtotal: Machine owning & operating costs	\$ 16.10	\$ 3.60	\$ 46.39	\$ 63.50	\$ 44.53	\$ 2.31
Labor costs	\$ 28.00	\$ -	\$ 28.00	\$ 28.00	\$ 28.00	\$ -
<b>TOTAL HOURLY COSTS (\$/SMH)</b>	<b>\$ 44.10</b>	<b>\$ 3.60</b>	<b>\$ 74.39</b>	<b>\$ 91.50</b>	<b>\$ 72.53</b>	<b>\$ 2.31</b>
<b>MACHINE THROUGHPUT (BDT/SMH)</b>	<b>13.24</b>	<b>9.26</b>	<b>10.12</b>	<b>7.59</b>	<b>10.12</b>	<b>22.50</b>
<b>MACHINE COST PER BDT OF OUTPUT</b>	<b>\$ 3.33</b>	<b>\$ 0.39</b>	<b>\$ 7.35</b>	<b>\$ 12.05</b>	<b>\$ 7.16</b>	<b>\$ 0.10</b>

# Biomass Feedstock Costs

\$/BDT

Ground hog feedstock to market	\$	24.50
Chips to market w/small chipper	\$	23.01
Chips to market w/large chipper	\$	22.05
Chips to BCT site	\$	22.51
S.D. logs to BCT site	\$	3.72

## Biomass Conversion Technology Equipment Owning & Operating Costs (1 of 2)

	Gasifier genset (All Power Labs)	Diesel genset (Multiquip)	Small wood baler (Forest Concepts)	Large wood baler (Forest Concepts)	Peterson Microchipper	Deck Screen (Peterson Pacific)	Star Screen (Peterson Pacific)
<b>Cost per Scheduled Machine Hour</b>	PP20GT with dried microchips	DCA25SSIU4F	Woodstraw Baler I	Woodstraw "New Age" Baler	Model 4300	Deck Screen	Star Screen
Fixed or ownership costs	\$ 1.66	\$ 1.17	\$ 18.49	\$ 49.77	\$ 54.40	\$ 57.59	\$ 74.53
Variable or operating costs	1.81	1.93	17.47	58.35	83.49	39.00	36.89
Subtotal: Machine fixed and variable costs	\$ 3.47	\$ 3.10	\$ 35.96	\$ 108.12	\$ 137.88	\$ 96.59	\$ 111.42
Labor costs	4.16	2.22	42.00	-	-	-	-
Subtotal: Machine operation costs	\$ 7.63	\$ 5.32	\$ 77.96	\$ 108.12	\$ 137.88	\$ 96.59	\$ 111.42
Feedstock costs	\$ 0.28	\$ -	\$ -	\$ 22.58	\$ 106	\$ 405.02	\$ 220.68
<b>TOTAL HOURLY COSTS</b>	<b>\$ 7.91</b>	<b>\$ 5.32</b>	<b>\$ 78</b>	<b>\$ 131</b>	<b>\$ 244</b>	<b>\$ 502</b>	<b>\$ 332</b>
<b>MACHINE THROUGHPUT (BDT/SMH)</b>	<b>11.63kW/SMH</b>	<b>11.63kW/SMH</b>	<b>1.19</b>	<b>5.95</b>	<b>26.51</b>	<b>11.40</b>	<b>22.80</b>
<b>COST PER UNIT OF OUTPUT</b>	<b>\$ 1.064/kWh</b>	<b>\$ 0.715/kWh</b>	<b>\$ 66/BDT</b>	<b>\$ 22/BDT</b>	<b>\$ 9/BDT</b>	<b>\$ 44/BDT</b>	<b>\$ 15/BDT</b>



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- Diesel fuel would have to increase to \$5.86/gallon to equate the electricity costs from the diesel and gasifier gensets.
- There are large economies of size associated with both the larger wood baler and with the star screen.
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## Biomass Conversion Technology Equipment Owning & Operating Costs (2 of 2)

	Biochar machine (Biochar Solutions)	Biochar machine (Biochar Solutions)	Biomass dryer (Norris Thermal Technologies)	Torrefaction machine (Norris Thermal Technologies)	Briquette Press (RUF-400)	Briquette Press (RUF- 400)	Beaver Korea Sawdust Machine
<b>Cost per Scheduled Machine Hour</b>	unique	unique (scaled- up version)	Belt-o-matic 123B	CM 600 with dried microchips	RUF 400 with dried microchips	RUF 400 with torrefied chips	400 HP
Fixed or ownership costs	\$ 16.94	\$ 27.10	\$ 2.28	\$ 40.66	\$ 5.32	\$ 5.32	\$ 33.88
Variable or operating costs	9.14	8.48	0.20	39.47	4.16	4.16	30.65
Subtotal: Machine fixed and variable costs	\$ 26.08	\$ 35.58	\$ 2.48	\$ 80.13	\$ 9.47	\$ 9.47	\$ 64.53
Labor costs	24.94	24.94	2.08	4.16	4.16	4.16	-
Subtotal: Machine operation costs	\$ 51.02	\$ 60.52	\$ 4.56	\$ 84.28	\$ 13.63	\$ 13.63	\$ 64.53
Feedstock costs	\$ 9.57	\$ 13.56	\$ 2.91	\$ 20.97	\$ 11.84	\$ 76.98	\$ 14.23
<b>TOTAL HOURLY COSTS</b>	<b>\$ 61</b>	<b>\$ 74</b>	<b>\$ 7</b>	<b>\$ 105</b>	<b>\$ 25</b>	<b>\$ 91</b>	<b>\$ 79</b>
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- There are economies of size associated with the biochar machine and also with the briquette press (not shown).
- Biochar is a relatively costly product, suitable for only higher-valued markets, although it is effective at reducing biomass waste.
- Torrefaction is expensive using the Norris CM600, but briquetting adds only about \$40/ton additional cost to the product, enabling farther shipping.

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# Economics Questions (review)

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# Additional Factors

- Markets
- Carbon credits
- The cost and feasibility of the alternative
- The value of sound sleep

# Economics Conclusions

- It depends...

# BOGOR

by BURTON SILVER

WOODSMEN'S ANNUAL EXAMINATION  
ECOLOGY: QUESTION 1:  
DESCRIBE THE PROCESS OF ROTTING  
WHICH OCCURS ON THE FOREST FLOOR.



© BURTON SILVER

Rotting is very hard  
to see. However by  
pressing your ear to  
some rot you can  
actually hear it  
happening.



It sounds like  
faint music being  
played very slowly  
backwards.



(This is why  
it is called  
decomposition)





# Questions?