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Results of Testing the Mimi Moto
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Figure 1 The Mimi Moto Stove with its two combustion chambers.

The Mimi Moto was tested by Aprovecho staff at the Aprovecho laboratory in March of 2017. Aprovecho conducted standard laboratory testing [WBT 4.2.3, LEMS, Safety] to determine performance metrics related to the stove's fuel use, emissions, and user safety.

Methods

The pot dimensions were 27 cm in diameter, and 16 cm in height. It was filled with 5 L of water. After the hot start phase the pot was placed on an electric hot plate to keep the water near the boiling temperature. A lid was placed on the pot to prevent water from evaporating.

The stove was batch fed with pellets of Douglas fir. The fuel had a moisture content of 3% (wet basis). The large combustion chamber was filled with 400 g for both the cold and hot starts, and the small combustion chamber was filled with a fresh batch of 300 g for the simmer phase. Switching combustion chambers between the hot start and the simmer necessitated that a fresh batch of pellets be used for the simmer.

To start the stove the top layer of pellets was removed from the combustion chamber and 10 g of alcohol gel was stirred into the pellets until they were coated. For the 400 g load the top layer weighed 50 g, and for the 300 g load the top layer weighed 30 g. The alcohol gel remained in contact with the pellets for only a few minutes before ignition.

The stove features a speed controlled electric fan. It has the settings of off, the range of 0 to 4, and maximum. For the high power phases the fan was ramped up to setting 3 over the period of 1 minute and remained there for the duration of the phase. For the simmer phase the fan was turned to 1 after about 10 seconds.

At the end of each test phase the fuel load was dumped out and the carbonized and unburned pellets were separated by hand. A pellet was considered carbonized if it could be ground into the tray by hand with a few pounds of pressure.

The starting water temperature for all of the high power tests was 20 C.

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Test Results

The IWA test results for each test are shown in Figure 2. A statistical analysis of the IWA metrics is presented in Figure 3. In Figure 4 the following metrics are provided for each phase: temperature corrected time to boil, firepower, thermal efficiency, and turn down ratio (simmer only). The calculation of each of the metrics is provided in the WBT protocol. The IWA results are also shown in Figure 5 in the GACC format. The individual safety scores are shown in Figure 6.

The stove achieved Tier 4 performance in the IWA metrics for all but the low power specific fuel consumption rate. The time to boil was fast, about 15 minutes.

Stove type/model		mimimotojohn8	mimimotojohn9	mimimotojohn10	mimimotojohn 12	mimimotojohn13	Mimi Moto
Location		apro	apro	apro	apro	apro	Average
Wood species		df pel	df pel	df pel	df pel	df pel	**df pel**
Date		3.7.17	3.9.17	3.9.17	3.24.17	3.28.17	**3.7.17**
IWA Performance Metrics	**units**	**Value**	**Value**	**Value**	**Value**	**Value**	
High Power Thermal Efficiency	%	49.3%	50.6%	50.8%	49.0%	50.1%	50.0%
Low Power Specific Consumption	MJ/min/L	0.017	0.021	0.017	0.022	0.020	0.019
High Power CO	g/MJd	0.93	0.96	0.75	0.69	1.14	0.90
Low Power CO	g/min/L	0.04	0.03	0.02	0.03	0.03	0.03
High Power PM	mg/MJd	5.6	9.2	8.3	9.3	15.4	9.6
Low Power PM	mg/min/L	0.25	0.06	0.19	0.17	0.44	0.22
Indoor Emissions CO	g/min	0.16	0.14	0.10	0.11	0.16	0.14
Indoor Emissions PM	mg/min	1.0	1.3	1.1	1.2	2.2	1.4
Safety	Index	97					97
		Tier	**Tier**	**Tier**	**Tier**	**Tier**	
High Power Thermal Efficiency		4.0	4.1	4.1	4.0	4.0	4.0
Low Power Specific Consumption		4.0	3.6	3.9	3.5	3.7	3.7
High Power CO		4.8	4.8	4.9	4.9	4.8	4.8
Low Power CO		4.5	4.7	4.7	4.6	4.7	4.6
High Power PM		4.8	4.7	4.7	4.7	4.6	4.7
Low Power PM		4.7	4.9	4.8	4.8	4.5	4.7
Indoor Emissions CO		4.6	4.6	4.7	4.7	4.6	4.6
Indoor Emissions PM		4.4	4.3	4.4	4.3	3.9	4.3
Safety							4.3

Figure 2 IWA metrics for each of the test iterations

Stove type/model		**Mimi Moto**			**N =**	**5**				
Location		Average	Estimate	Estimate	Stdev	Interval	COV	Tier	Estimate	Estimate
Wood species		**df pel**								
Date		**3.7.17**								
IWA Performance Metrics	**units**									
High Power Thermal Efficiency	%	50.0%	51.0%	49.0%	0.8%	1.0%	2%	4	4.1	4.0
Low Power Specific Consumption	MJ/min/L	0.019	0.017	0.022	0.002	0.003	11%	3	4.0	3.5
High Power CO	g/MJd	0.90	0.67	1.12	0.18	0.22	20%	4	4.9	4.8
Low Power CO	g/min/L	0.03	0.02	0.04	0.01	0.01	27%	4	4.7	4.5
High Power PM	mg/MJd	9.6	5.1	14.0	3.6	4.5	38%	4	4.8	4.6
Low Power PM	mg/min/L	0.22	0.05	0.40	0.14	0.17	62%	4	4.9	4.6
Indoor Emissions CO	g/min	0.14	0.10	0.17	0.03	0.04	21%	4	4.7	4.5
Indoor Emissions PM	mg/min	1.4	0.8	2.0	0.5	0.6	34%	4	4.6	4.0
Safety	Index	97						4		

Figure 3 Statistical analysis of the IWA metrics.

Stove type/model		mimimotojohn8	mimimotojohn9	mimimotojohn10	mimimotojohn 12	mimimotojohn13	Mimi Moto
Location		apro	apro	apro	apro	apro	Average
Basic Operation							
COLD START							
Temp-Corrected Time to Boil	min	13.8	20.0	14.1	15.9	12.8	15.3
Thermal efficiency	--	48%	52%	50%	49%	49%	50%
Firepower	watts	4,727	4,468	4,382	4,525	4,820	4,585
HOT START							
Temp-Corrected Time to Boil	min	12.9	13.1	13.8	14.8	13.8	13.7
Thermal efficiency	--	51%	49%	52%	49%	51%	50%
Firepower	watts	4,740	4,785	4,396	4,536	4,746	4,640
SIMMER							
Thermal efficiency	--	44%	50%	52%	52%	53%	50%
Firepower	watts	1,184	1,387	1,188	1,401	1,320	1,296
Turn down ratio	--	4.00	3.34	3.69	3.23	3.63	3.58

Figure 4 Fuel related metrics

GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

IWA Tiers of Performance Report

Cookstove Manufacturer	
Model	Mimi Moto
Testing Center	Aprovecho Research Center
Protocol	WBT4.2.3, LEMS
Fuel Used	Douglas Fir Pellets
Pot Used	Stainless Steel Flat Bottom, 27 cm diameter, 16 cm height
Test Dates	Mar-17

These results were obtained in accordance with the IWA and the Global Alliance for Clean Cookstoves' reporting requirements. [1] This data and additional supporting data are shared publically through the Stove Performance Inventory.

Signature	
Name	

[1] Interim Stove Performance Reporting Requirements: http://community.cleancookstoves.org/files/318

Original document.

		Metric	Value	Unit	Sub-Tier
Efficiency/Fuel Use					
Tier	**3**	High power Thermal Efficiency	50%	%	4
		Low power Specific Consumption	0.019	MJ/min/l	3
Emissions					
Tier	**4**	High power CO	0.90	g/MJ_d	4
		Low power CO	0.03	g/min/l	4
		High power PM 2.5	9.58	mg/MJ_d	4
		Low power PM 2.5	0.22	mg/min/l	4
Indoor emissions					
Tier	**4**	High power Indoor emissions CO	0.12	g/min	4
		Low power Indoor emissions CO	0.11	g/min	4
		High power Indoor emissions PM 2.5	1.33	mg/min	4
		Low power Indoor emissions PM 2.5	0.90	mg/min	4
Safety					
Tier	**4**	Points from 10 weighted safety parameters	97	points	

Tier 0 → Improving Importance → Tier 4

Figure 5 Test results in GACC format.

Individual Scores for Safety Assessment Criteria

Assessment Criteria	Score (1 – 4)	Multiplier
Sharp Edges and Points	4	1.5
Cookstove Tipping	4	3
Containment of Fuel	4	2.5
Obstructions Near Cooking Surface	4	2
Surface Temperature	4	2
Heat Transmission to Surroundings	4	2.5
Temperature of Operational Construction	4	2
Chimney Shielding	4	2.5
Flames Surrounding the Cookpot	3	3
Flames/Fuel Exiting Fuel Chamber, Canister, or Pipes	4	4

Figure 6 Individual safety scores

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Discussion

During the testing of pellet stoves there are typically some woody pellets that can be categorized as charcoal, but small errors are practically unavoidable. A more accurate method is available that consists of grinding the remaining wood and charcoal together, forming a hand full of test pellets, and measuring the heat content of the test pellets using a bomb calorimeter. The client opted to not use the more expensive grinding method for this test series.

Although the WBT does not specify a fixed starting water temperature it was deemed necessary because several tests were performed with a starting temperature of 10 C (the temperature of the well water), but the thermal efficiency was found to be lower. The change in thermal efficiency may have been due to the change in the proportion of carbonized to unburned fuel and the associated error in determining that proportion.

It was difficult to apply the WBT 4.2.3 to this stove because the protocol is primarily designed for continuous fed stoves. Recent revisions have given guidance for testing batch fed stoves, but they assume that one batch of fuel will be used to do a high and low power cooking task. ARC deemed it reasonable to assume that the batch fed guidelines could be applied to this stove and still give comparable results to other batch fed stoves because the only difference between it and other batch fed stoves is that for optimum performance the stove seems to require that the user gauges how much fuel is needed for a portion of the cooking task instead of the whole cooking task. Users or other testers of the stove should expect the Mimi Moto to perform differently if only one combustion chamber is used with the stove.

Loading new pellets for the simmer phase necessitated slightly different calculations for fuel use during the simmer phase. The char remaining is normally calculated as the difference between what was left at the end of the simmer phase and what was left at the end of the cold start phase (which is assumed equal to what was left after the hot start phase). For this method that calculation was ignored and the charcoal remaining at the end of the simmer was directly measured.

References

LEMS
http://aprovecho.org/software/

Safety
https://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/407-1.pdf

WBT 4.2.3
http://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/399-1.pdf

Original document.