Aprovecho Research Center

Advanced Studies in Appropriate Technology

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The following results are from 30 minute water boiling tests performed at the TLUD Summit, end of January 2019, at the Aprovecho Research Center laboratory. The data are not statistically significant. Therefore, conclusions drawn from the numbers are likely to be invalid. When performed carefully, a minimum of five repetitions are needed to create confidence.

Stove type/model		Championdummit1	Champion 4 inch	Championstick wood	ChampionPrimeAirControl	championforce dair2	championforce dair3	Marco	Marco4
Fuel species		Doug Fir Pellets	Doug Fir Pellets	Doug Fir Sticks	df pel	df pel	df pel	Doug Fir Sticks	Doug Fir Sticks
Date		1/29/18	1/29/18	1/29/18	1.30.19	1.31.19	1.31.19	1/29/18	1/30/18
ISO Performance Metrics	**units**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Thermal Efficiency Without Char	%	22.7%	25.5%	21.0%	25.0%	25.4%	30.1%	10.7%	10.2%
CO per Energy Delivered to Cooking Pot	g/MJd	4.01	1.43	7.06	6.29	2.54	1.53	13.82	23.44
PM per Energy Delivered to Cooking Pot	mg/MJd	284.2	189.8	473.6	301.5	142.6	140.5	1203.4	1601.4
ISO Tiers		**Tier**	**Tier**	**Tier**	**Tier**	**Tier**	**Tier**	**Tier**	**Tier**
Thermal Efficiency Without Char		2.2	2.5	2.0	2.5	2.5	3.0	1.0	1.0
CO per Energy Delivered to Cooking Pot		4.2	5.0	3.0	3.3	5.0	5.0	1.6	0.7
PM per Energy Delivered to Cooking Pot		2.7	3.1	2.0	2.6	3.4	3.4	0.8	0.6
Basic Operation	units								
COLD START- HIGH POWER									
Time to boil Pot # 1	min	No Boil	No Boil	29	24	12	14	No Boil	No Boil
Temp-Corrected Time to Boil	min			25.8	23.2	10.2	11.8		
Test duration	min	30	30	30	30	30	30	30	31
Firepower	watts	4,669	2,893	5,833	5,906	11,333	7,781	8,435	14,981
Average Cooking Power	kW	1,054	735	1,206	1,473	2,871	2,335	892	1,511
Char mass productivity	%	23%	28%	24%	28%	22%	27%	9%	8%
Energy Consumption									
Net Calorific Value (dry)	kJ/kg	18,512	18,512	19,314	18,512	18,512	18,512	19,314	19,314
Moisture Content	%	3%	3%	10%	3%	3%	3%	10%	10%
Effective Calorific Value (as received)	kJ/kg	17,883	17,883	17,138	17,883	17,883	17,883	17,138	17,138
COLD START- HIGH POWER									
Energy Consumed w/o char		8,369	5,186	10,352	10,587	20,315	13,949	14,970	27,473
Energy Consumption Rate	kJ/min	279	173	345	353	677	465	499	886
Energy Delivered to the Cooking Pot	kJ	1,897	1,323	2,170	2,651	5,167	4,204	1,606	2,811
Char energy productivity	%	41%	50%	43%	50%	40%	47%	17%	14%
Emissions Rate									
COLD START- HIGH POWER		(cold start)	(cold start)	(cold start)	(cold start)	(cold start)	(cold start)	(cold start)	(cold start)
CO	gr/min	0.3	0.1	0.5	0.6	0.4	0.2	0.7	2.1
CO2	gr/min	15	17	26	31	78	47	37	66
PM2.5	mg/min	18.0	8.4	34.3	26.6	24.6	19.7	64.4	145.2
appx BC mg	mg/min								
PM2.5 Quality Control									
COLD START- HIGH POWER									
Mass Scattering Cross Section	m2/g	1.32	1.63	1.38	1.24	2.95	1.80	7.21	11.47
Net Filter Weight	g	0.00111	0.00051	0.00211	0.00162	0.00149	0.00244	0.00421	0.00936

Not statistically significant.

Stove type/model		Kirk	kirksummit4	kirksummit5	kirksummit6	FAB	fabturndown	FABsuperpot	normsummit1
Fuel species		Doug Fir Pellets	df pel	df pel	df pel	Doug Fir Pellets	Doug Fir pel	df pel	df chips
Date		1/29/18	1.30.19	1.30.19	1.31.19	1/29/18	1.31.19	1.31.19	1.30.19
ISO Performance Metrics	**units**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**	**Value**
Thermal Efficiency Without Char	%	22.4%	37.0%	34.7%	34.4%	42.1%	46.5%	54.2%	20.6%
CO per Energy Delivered to Cooking Pot	g/MJd	0.51	1.03	0.98	0.79	0.21	0.25	0.04	21.82
PM per Energy Delivered to Cooking Pot	mg/MJd	75.3	94.6	62.2	79.4	23.3	95.3	6.8	1539.4
ISO Tiers		**Tier**	**Tier**	**Tier**	**Tier**	**Tier**	**Tier**	**Tier**	**Tier**
Thermal Efficiency Without Char		2.2	3.6	3.4	3.4	4.2	4.6	5.0	2.0
CO per Energy Delivered to Cooking Pot		5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.8
PM per Energy Delivered to Cooking Pot		3.9	3.7	3.9	3.8	4.6	3.7	4.9	0.6
Basic Operation	units								
COLD START- HIGH POWER									
Time to boil Pot # 1	min	29	19	24	21	18	19	17	14
Temp-Corrected Time to Boil	min	24.2	15.8	20.1	17.7	14.9	16.8	14.2	12.0
Test duration	min	30	30	30	30	30	30	30	48
Firepower	watts	6,744	5,946	3,846	5,227	4,749	3,392	3,841	14,399
Average Cooking Power	kW	1,504	2,189	1,333	1,790	1,991	1,571	2,072	2,894
Char mass productivity	%	20%	24%	29%	27%	22%	26%	25%	
Energy Consumption									
Net Calorific Value (dry)	kJ/kg	18,512	18,512	18,512	18,512	18,512	18,512	18,512	19,314
Moisture Content	%	3%	3%		3%	3%	3%	3%	15%
Effective Calorific Value (as received)	kJ/kg	17,883	17,883	18,512	17,883	17,883	17,883	17,883	16,050
COLD START- HIGH POWER									
Energy Consumed w/o char		12,089	10,658	6,923	9,371	8,512	6,080	6,885	40,543
Energy Consumption Rate	kJ/min	403	355	231	312	284	203	230	845
Energy Delivered to the Cooking Pot	kJ	2,706	3,940	2,399	3,223	3,583	2,827	3,730	8,336
Char energy productivity	%	36%	43%	50%	48%	40%	47%	44%	
Emissions Rate									
COLD START- HIGH POWER		(cold start)	(cold start)	(cold start)	(cold start)	(cold start)	(cold start)	(cold start)	(cold start)
CO	gr/min	0.0	0.1	0.1	0.1	0.0	0.0	0.0	3.8
CO2	gr/min	31	35	21	29	30	18	26	80
PM2.5	mg/min	6.8	12.4	5.0	8.5	2.8	9.0	0.8	267.3
appx BC mg	mg/min								
PM2.5 Quality Control									
COLD START- HIGH POWER									
Mass Scattering Cross Section	m2/g	1.04	1.20	-0.12	0.58	0.90	0.90	11.81	8.63
Net Filter Weight	g	0.00042	0.00076	0.00030	0.00053	0.00017		0.00008	0.02631

Not statistically significant.