Blowing Smoke:

The curious case of the mangled metric

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26 September 2014

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The Results Based Financing Model Drives Us

Results Based Financing requires an updated approach to testing

The test methods must use representative burning and cooking cycles in each region

The protocol should specify task which are appropriate and representative of actual use in that region.

The metrics used for each section of a cycle must be valid scientifically and culturally for that cycle.

The definitions of each important term should conform to standard scientific usage. Undefined terms like ‘simmering’ should not be used.

Is char produced during a fire ‘burned fuel’ or not?

Char remaining is obviously not burned, though it is consumed. Well, maybe it is not consumed, because it has not been burned. Now what?

Perhaps we can say it is ‘consumed fuel’ in that it was produced from fuel ‘used’ by the stove. If the ‘fuel remaining’ can be used by the same stove in the next fire, then it *is* ‘fuel remaining’ and has not been ‘consumed’.

Thus the definition of ‘fuel consumption’ carries great importance. If fuel is placed in a stove and ‘burned’ and new fuel is required for the next test, the first batch has been ‘consumed’ from a foresters perspective.

Fuel Consumed (F_C): The fuel consumption of a biomass burning stove is defined as the mass [kilograms] of new fuel drawn from a supply that is sourced outside the cooking system needed to conduct any one of a series of identical replications of a burn cycle, save the first[1].

Differences in Concepts, Metrics and Computations

WBT 4.1.2

WBT Version used to create IWA Tiers

		COLD STA
Calculations/Results	Units	data
Wood consumed (moist)	g	655
Net change in char during test	g	154
Equivalent dry wood consumed	g	234.1
Water vaporized from all pots	g	162
Effective mass of water boiled	g	4,838
Time to boil Pot # 1	min	22
Temp-corr time to boil Pot # 1	min	23
Thermal efficiency	%	53.4%
Burning rate	g/min	11
Specific fuel consumption	g/liter	48

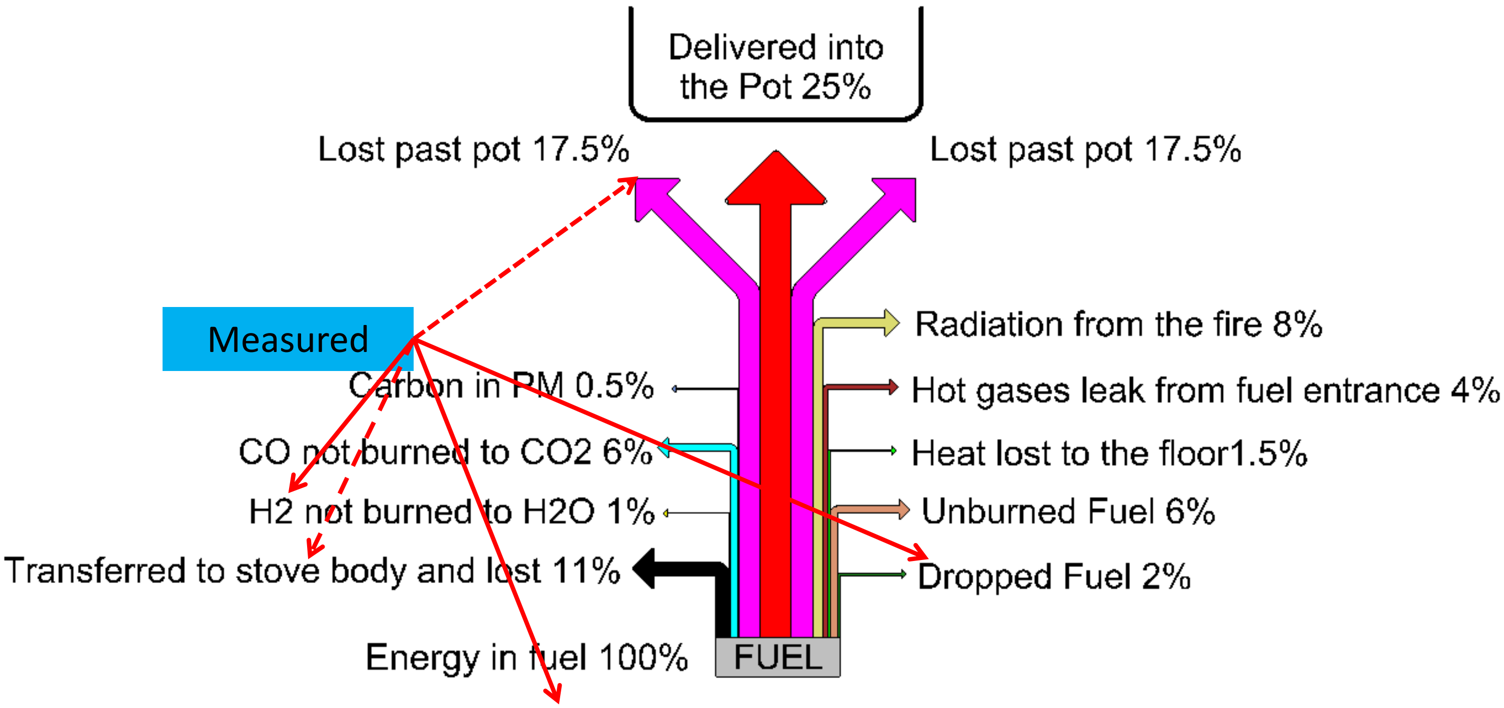
First Principles View

Concept correction for char remaining which it cannot burn. Drops to Tier 0.

		COLD STA
Calculations/Results	Units	data
Wood consumed (moist)	g	655
Net change in char during test	g	-
Equivalent dry wood consumed	g	535.6
Water vaporized from all pots	g	162
Effective mass of water boiled	g	5,000
Time to boil Pot # 1	min	22
Temp-corr time to boil Pot # 1	min	23
Thermal efficiency	%	19.1%
Burning rate	g/min	24
Specific fuel consumption	g/liter	107

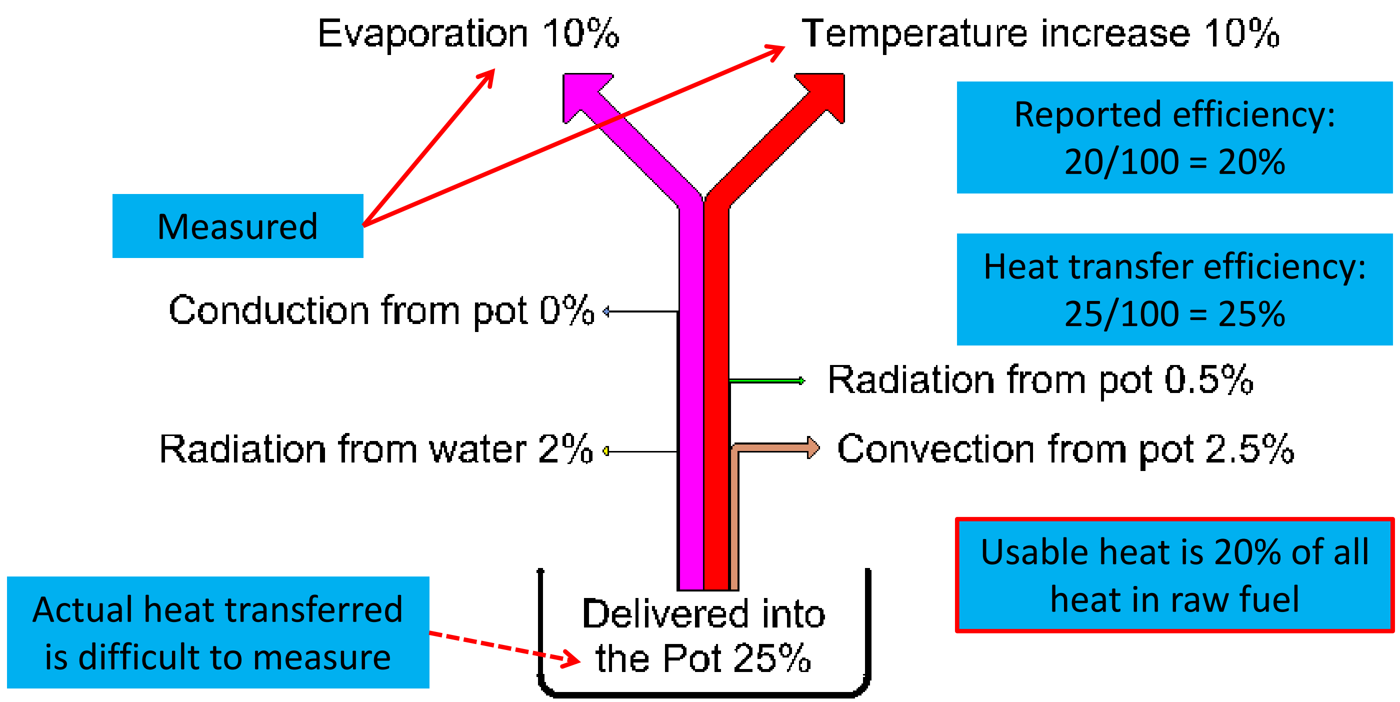
The format is copied from the WBT4.x with the IWA version on the left, with the formulas and concepts corrected on the right. The Thermal efficiency was over-reported by 280% of value. The UNFCCC uses this metric to calculate CDM credits.

Heat Flow Diagramme - Fire



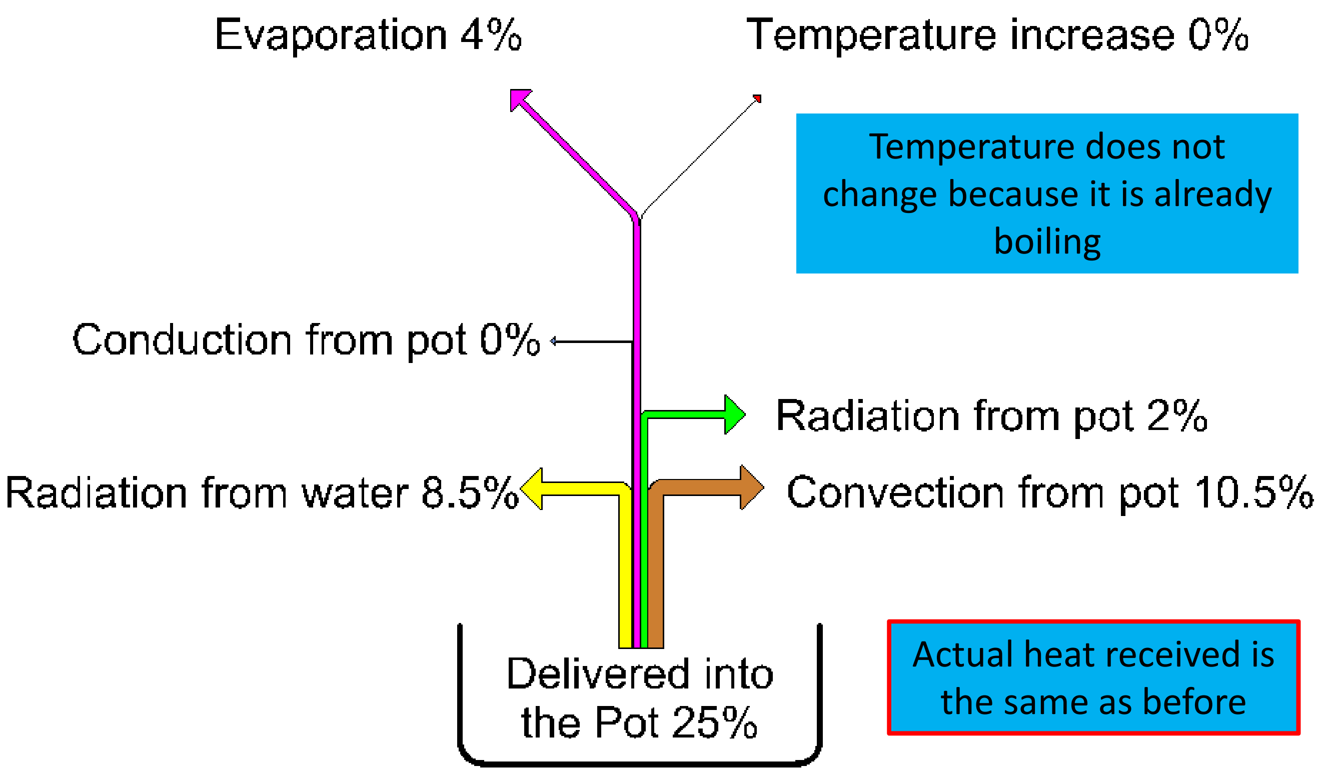
Some fuel energy paths can be measured easily (solid red lines). Heat flow is easier to evaluate than heat in unburned fuel. Losses are chemical, mechanical or wasted heat in gases. “Heat Transfer Efficiency” to the pot is 25% of the heat available in the raw fuel.

Heat Flow Diagramme – Cold Pot, High Power



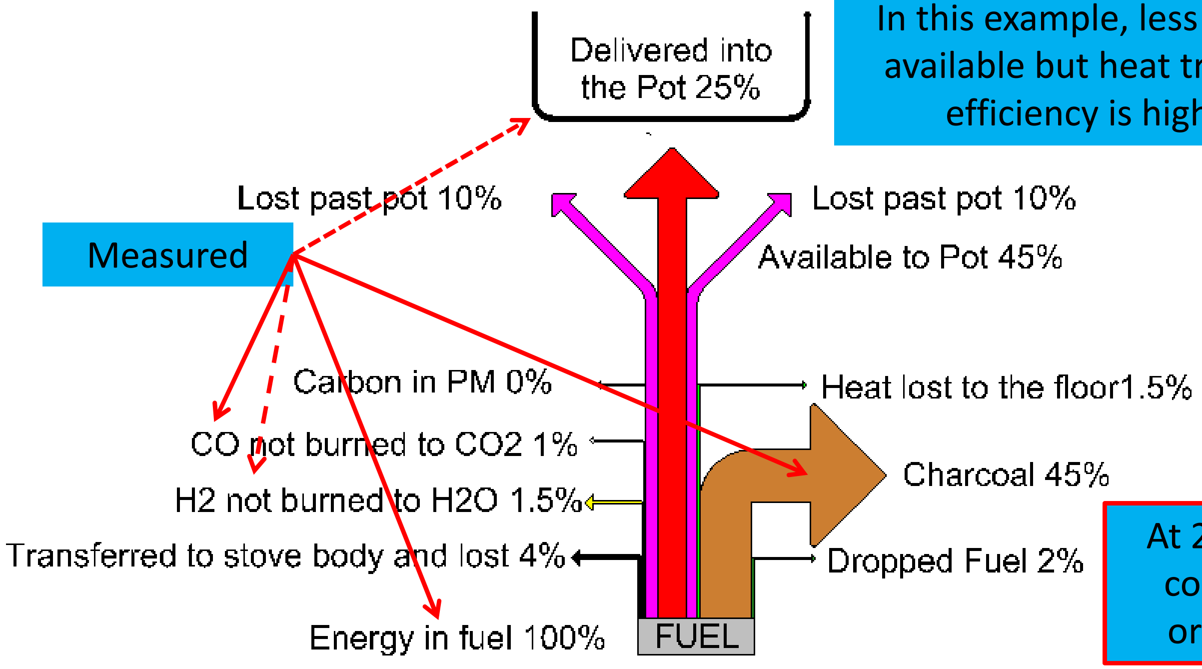
During a heating cycle, the losses from the pot are provided and the net heat gained by the water can be determined observing the change in temperature and evaporated water mass. The measured heat transfer efficiency is lower than the actual efficiency as not all heat losses can be measured. Heat getting into the pot is 25% of the heat in the fuel, but only 20% is useful.

Heat Flow Diagramme – Hot Pot, Low Power



Heat Flow Diagramme – 20% Charcoal maker

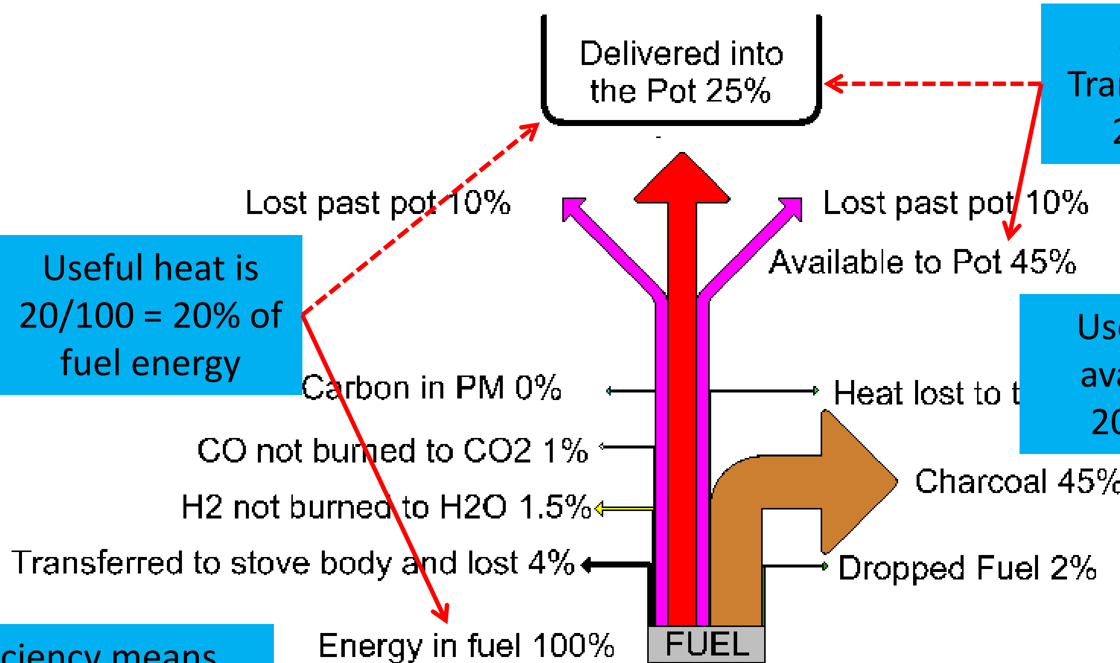
In this example, less heat is available but heat transfer efficiency is higher



At 20% yield, charcoal contains 45% of the original fuel energy

Charcoal Making pyrolyser

Heat Flow Diagramme – Thermal efficiency



Charcoal Making pyrolyser

Actual Heat Transfer Efficiency 25/45 = 56%

Useful heat is 20/100 = 20% of fuel energy

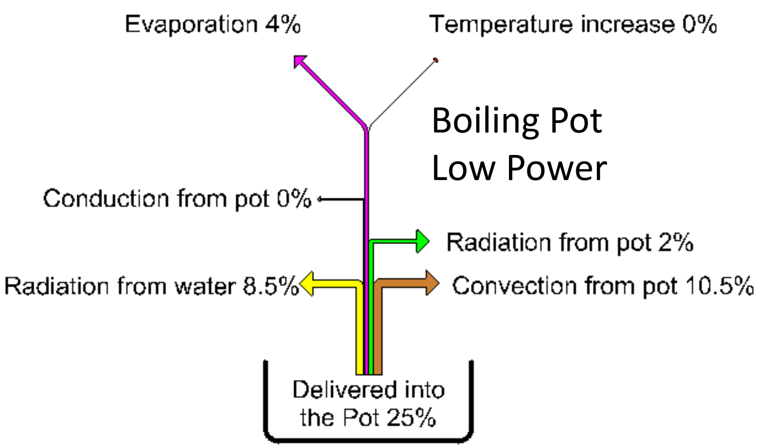
Useful Heat to available heat 20/45 = 44%

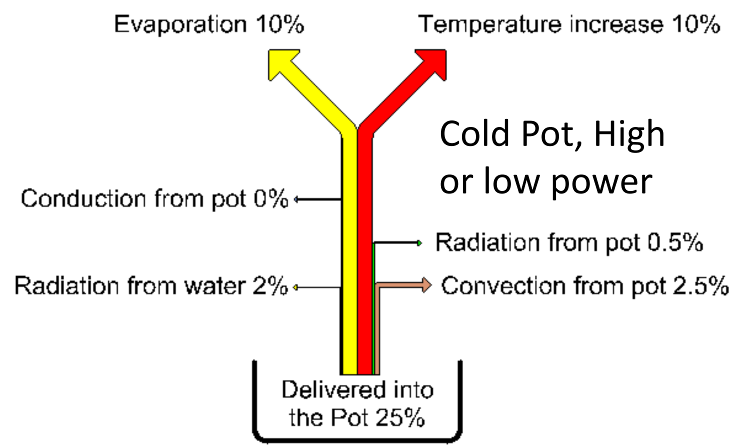
System efficiency means useful heat divided by the energy available from the fuel consumed, whether generated or not

Heat Transfer Efficiency is 280% of System Efficiency and Useful Heat Transfer Efficiency is 222% of System Efficiency.

Heat Flow Diagramme for the charcoal maker – Thermal efficiency determined using a boiling or cold pot, high or low power, produces very different results for the same metric

System Efficiency is still 20% but measurements under different conditions give different answers to the same question. In these examples, 25% of the energy has been transferred but the 'efficiency' number reported varies significantly.





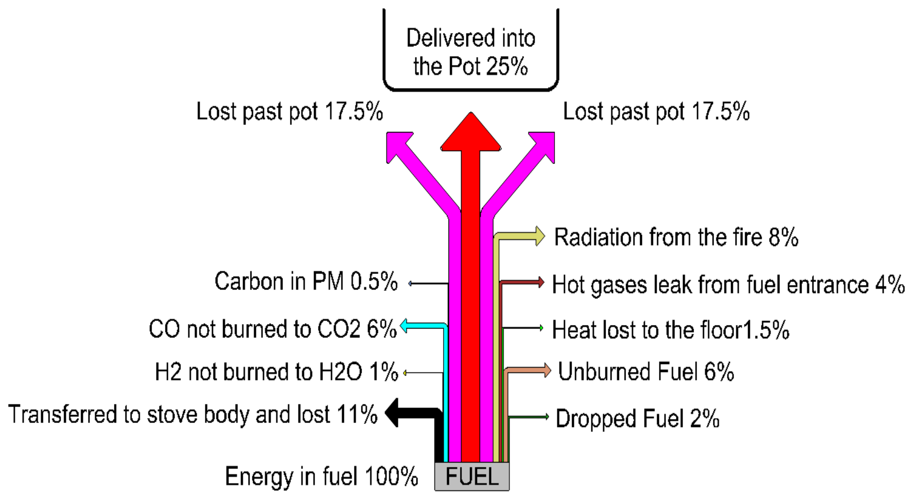
Low power *reported* efficiency = 4%

High power *reported* efficiency = 20%

While heat transfer efficiency *appears to be* 4/45 = 9%

While heat transfer efficiency *appears to be* 20/45 = 44%

The efficiency with which heat is transferred into a pot of hot water is not affected by the water mass.



Conclusion:

The IWA Low Power (simmering) metrics for fuel consumption and emissions ‘per litre’ are invalid. For example: adding more hot water to simmering pot does not require that additional fuel to be burned to keep it hot.

The END (of mangled metrics?)

1 http://www.newdawnengineering.com/website/library/Papers+Articles/ETHOS/20140122%20ETHOS%20Annegarn,%20Pemberton-Pigott%20Definitions.ppt