# Specifying Stove Performance in Climate Terms

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# Caveats

This is a work in progress – motivated by climate interests more than the usual stove interests

This is a trial for possible presentation at the March GACC Meeting in Phnom Penh -

Feedback needed.

# Objective -To analyze the efficiencies

of three stoves

in three ways –

and interpret the differences

Three stoves – char production (%)

1. 0%
2. 3%
3. 25%

Three ways to analyze:

A. Present - action as **stove energy** - (in denominator)
B. New added **char energy** efficiency (numerator)
C. New added **char carbon** efficiency (numerator)

Case A1 (present method, no char)

**Assumptions:**

Weights (kg)

| | |
|---|---|
| Input wood: | 1 |
| Output char: | 0 |

Energies (MJ)

| | |
|---|---|
| Wood/fuel input: | 18 |
| Useful measured energy: | 3.6 |

**Energy Efficiency:**

Eta_A1 = useful energy/input energy
= 3.6 MJ/ 18 MJ
= 20%

| >%char> | **1. (0%)** | 2 (3%) | 3 (25%) |
|---|---|---|---|
| **A (usual)** | **20 %** | | |
| B | | | |

Case A2 (present method, 3% char – by weight of carbon)

**Additional assumptions:**

Weights (kg)

| | |
|---|---|
| Output char: | .03 |

Energies (MJ)

| | |
|---|---|
| Stove energy(almost same stove) | 3.6 |
| Char energy: 0.03 * 30 MJ/kg: | 0.9 |

**Energy Efficiency:**

Eta_A2 = useful energy/input energy

= 3.6 / (18 - 0.9)

= 0.2 / (1-.05)

= (approx) 0.2 * (1+.05)

= **0.21**

| >%char> | 1. (0%) | **2 (3%)** | 3 (25%) |
|---|---|---|---|
| **A (usual)** | 20 % | **21%** | |
| B | | | |
| C | | | |

Case A3 (present method, 25% char – by weight)

**Additional assumptions (some same as for A1 and A2):**

Weights (kg)

Output char carbon: 0.25

Energies (MJ)

Stove (2.4/3.6 = 2/3 as large) 2.4

Char energy: 0.25 * 30 MJ/kg: 7.5

**Energy Efficiency:**

Eta_A3 = useful energy/input energy

= 2.4 / (18 - 7.5)

= 0.133 / (1-.42)

= **0.23**

| >%char> | 1. (0%) | 2 (3%) | **3 (25 %)** |
|---|---|---|---|
| **A (usual)** | 20 % | 21% | **23%** |
| B | | | |
| C | | | |

Case B1 (“numerator” method, no char)

**Assumptions:**

same as for A1

**Energy Efficiency:**

Eta_B1 = useful energy/input energy
+ char energy)/input energy

= 3.6/18 + 0/18
= **0.20**

| >%char> | **1. (0%)** | 2 (3%) | 3 (30%) |
|---|---|---|---|
| A (usual) | 20 % | 21% | 27% |
| **B Energy; numerator)** | **20%** | | |
| C | | | |

Case B2 (“numerator” method, small char)

**Assumptions:** same as for A2

**Energy Efficiency:**

Eta_B2 = useful energy/input energy
+ char energy)/input energy

= 3.6/18 + 0.9/18
= 0.20 + 0.05
**= 0.25**

| >%char> | 1. (0%) | **2 (3%)** | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21% | 27% |
| **B Energy; numerator)** | 20 % | 25% | |
| C | | | |

Case B3 (“numerator” method, large char)

**Assumptions:** same as for A3 (25% char)

**Energy Efficiency (all energy terms in MJ):**

Eta_B3 = useful energy/input energy

+ char energy)/input energy

= 2.4/18 + 7.5/18

= 0.13 + 0.42

**= 0.55**

| >%char> | 1. (0%) | 2 (3%) | **3 (25%)** |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| **B Energy; numerator)** | 20 % | 25 % | **55 %** |
| C | | | |

## Case C1 (“denominator carbon” method, no char)

**Assumptions:**

Carbon content = half of input wood weight = 0.5 kg

Useful carbon = 3.6 MJ / 18 MJ/kg = 0.2 kg

**Carbon Efficiency:**

Eta_C1 = useful carbon/input carbon

= 0.2 / 0.5 **= 0.4**

**Caution**: Maybe the useful Carbon should be 3.6/30 = .12 kg ?? (leads to 24%)

| >%char> | **1. (0%)** | 2 (3%) | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **C. Carbon; numerator** | **40 %** **24 %** | | |

Case C2 (“denominator carbon” method, small char)

**Assumptions:**

“Useful stove” carbon = 3.6 MJ / 18 MJ/kg (unchanged) = 0.2 kg

Char carbon (ignoring ash) = 0.03 kg

**Carbon Efficiency:**

<u>Eta_C2</u> = useful carbon/input carbon + char carbon/ input carbon

= 0.2 / 0.5 +.03/0.5

**= <u>0.46</u>**

**<u>Caution</u>** Maybe better

24 +6 = 30% ??

| >%char> | 1. (0%) | **<u>2 (3%)</u>** | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **<u>C. Carbon; numerator</u>** | 40 % (24 %) | **<u>46 % (30%)</u>** | |

Case C3 (“denominator carbon” method, large char)

**Assumptions:**

“Useful stove” carbon = (unchanged) = 0.133 kg

Char carbon (ignoring ash) = 0.25 kg

**Carbon Efficiency:**

<u>Eta_C3</u> = useful carbon/input carbon
+ char carbon/ input carbon

= 0.13 / 0.5 + 0.25 /

**= <u>0.77</u>**

**<u>Caution</u>**: Maybe better [(2.4/30) kg +.25 kg]/ .5 kg = 66%

| >%char> | 1. (0%) | 2 (3%) | **<u>3 (25%)</u>** |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **<u>C. Carbon; numerator</u>** | 40 % (24%) | 46 % (30%) | **<u>77 % (66 %)</u>** |

Comments on Row A of the final 9-element matrix

**1. This row is here to compare today's standard approach with the following two rows. <u>Nothing</u> surprising here.**

**2. The impact of the % char variable is <u>small</u>:**

**Col. 2: 3% char adds 1% to efficiency**
**Col. 3: 25% " " 13% " " (doubles)**

| >%char> | 1. (0%) | 2 (3%) | 3 (25%) |
|---|---|---|---|
| **<u>A (usual formula)</u>** | **<u>20 %</u>** | **<u>21 %</u>** | **<u>27 %</u>** |
| B Energy; (numerator) | 20 % | 25 % | 55 % |
| C. Carbon; (numerator) | 40 % (24%) | 46 % (30%) | 77 % (66%) |

Comments on Row B of the final 9-element matrix

**1. This row is here to compare something different from today's standard approach. <u>Something</u> surprising here.**

**2. The impact of the % char variable is large:**
**Col. 2: 3% char adds 4 % to efficiency**
**Col. 3: 25% " " 28% " " (doubles)**

**3. The "why" is not yet clear to me. But Row A (standard) looks suspicious.**

| >%char> | 1. (0%) | 2 (3%) | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| **<u>B Energy; numerator)</u>** | **<u>20 %</u>** | **<u>25 %</u>** | **<u>55 %</u>** |
| C. Carbon; numerator | 40 % (24 %) | 46 % (30 %) | 77 % (66 %) |

Comments on Row C of the 9-element matrix

**1. This row is here to compare something very different from today's standard approach. <u>Something very</u> surprising here.**

**2. The impact of the % char variable is large:**
**Col. 1: 0% char <u>doubles</u> the C-efficiency**
**Col. 2: 3% char adds 21 % to E-efficiency**
**Col. 3: 25% " " 22 % " "**

**3. The full"why" is also not yet clear to me. But "C" is clearly different from "E". Important for carbon credits**

| >%char> | 1. (0%) | 2 (3%) | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **C. Carbon; numerator** | **40 % (24 %)** | **46 % (30 %)** | **77 % (66 %)** |

# Conclusions

1. **The present standard approach is downplaying much about charcoal-production – especially from a climate perspective.**

2. **Char-making stoves are effective in atmospheric carbon removal – and it is possible to show that.**

3. **The present equations will lead to less future removal of carbon from the atmosphere (less carbon-negativity).**

| >%char> | 1. (0%) | 2 (3%) | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **C. Carbon; numerator** | **40 % (24 %)** | **46 % (30 %)** | **77 % (66 %)** |

# Recommendations

**1. The present standard approach is OK to keep unchanged. But dropping all mention of char will give an even less accurate portrayal of stove performance**

**2. Either add the methods of the second and third rows (preferred), or describe how to calculate these rows from the data needed to calculate the first row results.**

**3. GACC should ask a task force remove the Conflict in Row C.**

| >%char> | 1. (0%) | 2 (3%) | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **C. Carbon; numerator** | **40 % (24 %)** | **46 % (30 %)** | **77 % (66 %)** |

# Questions to Audience

1. **Are you surprised at the differences?**

2. **Is it important to add the new rows?**

3. **What more information is needed to make a "sale" of the method?**

| >%char> | 1. (0%) | 2 (3%) | 3 (25%) |
|---|---|---|---|
| A (usual formula) | 20 % | 21 % | 27 % |
| B Energy; numerator) | 20 % | 25 % | 55 % |
| **C. Carbon; numerator** | **40 % (24 %)** | **46 % (30 %)** | **77 % (66 %)** |