Welcome to Aprovecho Research Center's Spring Webinar Series!

Carbon Financing

Prof. Nordica MacCarty

Executive Director of Aprovecho and Assoc. Prof. at Oregon State University

April 30th, 2026

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OSPREY FOUNDATION

Agenda

- Overview of carbon accounting
- Discussion of options for methodologies and measurements
- Details of CLEAR methodology
- Questions & Answers

- Some slides by Elisa Derby from CCA/CLEAR for ETHOS 2026

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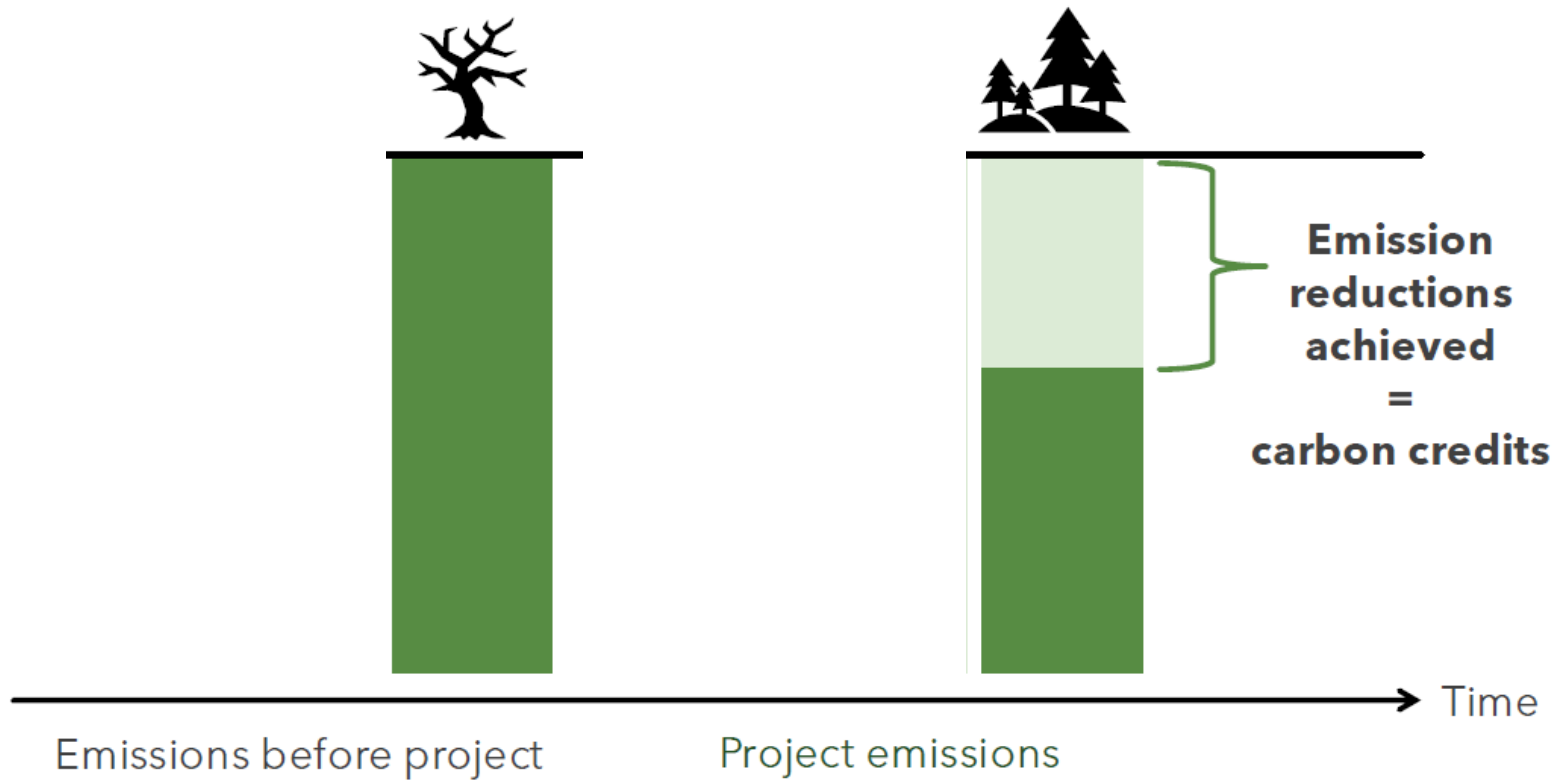
What are carbon credits?

1 carbon credit

=

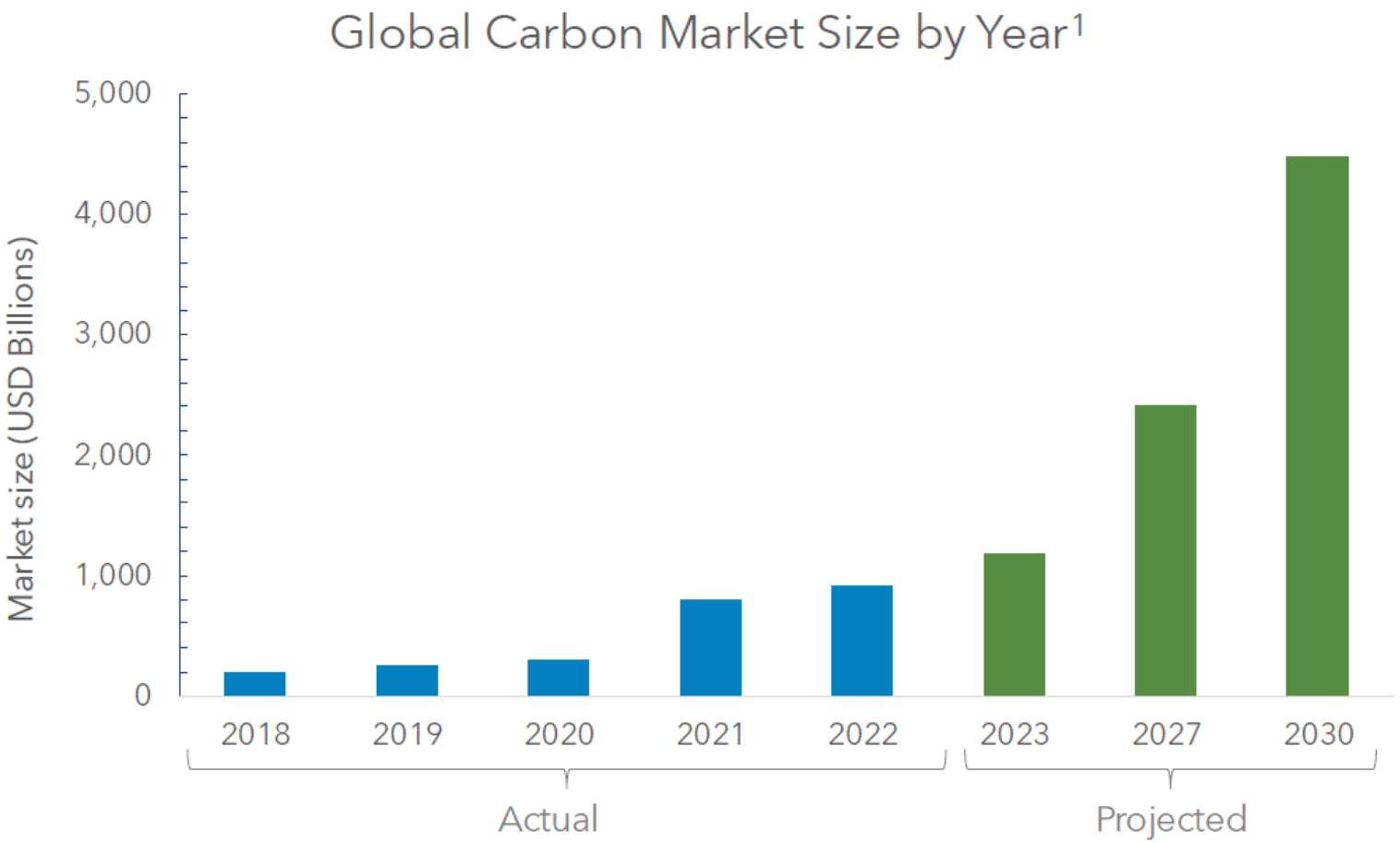
1 tonne of CO_2e reduced, removed or avoided.



Source: UNDP (2025). High Integrity Carbon Markets Toolkit, Module 1, Part 1. Available at: https://climatepromise.undp.org/sites/default/files/2025-11/UNDP%20HICM%20Toolkit_Module%201-%20Part%201_Nov%202025.pdf

CLEAN COOKING ALLIANCE

Global carbon market valued $900+ billion in 2022; expected to grow ~5x by 2030



Drivers of Carbon Market Growth

- Increase in carbon price
- Greater number of and increased commitment from outcome buyers
- Rise in market maturity and standardization

[1]Carbon Market Year in Review 2020, Refinitiv.
Global Carbon Credit Market (Value, Volume) - Analysis By Market Type (Voluntary, Compliance), End User, By Region, By Country: Market Size, Insights, Competition, Covid-19 Impact and Forecast (2023-2028), Azoth Analytics.
Global Carbon Credit Market Analysis, Coherent Market Insights.

Pervasive over-crediting from cookstove offset methodologies

Annelise Gill-Wiehl ✉, Daniel M. Kammen & Barbara K. Hava

Nature Sustainability **7**, 191–202 (2024)

Abstract

Cookstove carbon offset projects can progress multiple Sustainable Development Goals (SDGs), including climate, energy, health, gender, poverty and deforestation. However, project emission reductions must be accurately or conservatively estimated to avoid undermining climate action and long-term SDG financing. Here we conduct a comprehensive, quantitative, quality assessment of offsets by comparing five cookstove methodologies with published literature and our own analysis. We find misalignment, in order of importance, with fraction of non-renewable biomass, firewood–charcoal conversion, stove adoption, stove usage, fuel consumption, stacking (using multiple stoves), rebound and emission factors. Additionality, leakage, permanence and overlapping claims require more research. We estimate that our project sample is over-credited 9.2 times. Gold Standard's metered methodology, which directly monitors fuel use, is most aligned with our estimates (1.5 times over-credited) and has the largest potential for emission abatement and health benefit. We provide recommendations to align methodologies with current science and SDG progress.

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What is a methodology?

A carbon standard methodology defines the technical requirements and procedures for quantifying, monitoring, and verifying emission reductions or avoided emissions under an approved carbon standard.

Examples of cookstove carbon methodologies

UNFCCC
- AMS-II.G
- AMS-I.E

Gold Standard:
- Reduced Emissions from Cooking and Heating TPDDTEC
- Methodology for Metered & Measured Energy Devices
- Simplified Methodology for Clean & Efficient Cookstoves

Verra
- VM0050 Energy Efficiency and Fuel-Switch Measures in Cookstoves

4C has developed the Comprehensive Lowered Emissions Assessment and Reporting (**CLEAR**) **Methodology** for Cooking Energy Transitions **(currently under review for approval).**

Overview of GHG Emission Reductions (ERs) quantification

Baseline emissions

–

Project emissions

Emission reductions

Determining Emission Reductions (ER)

- Emissions = Energy Consumption * Emission Factor
  = EC * EF

- Energy Consumption
  - Old/bad method
    - Project EC $= BaselineEC\,\frac{\eta_b}{\eta_p}$
  - New/better method
    - Project energy consumption must be measured with KPT or continuous tracking

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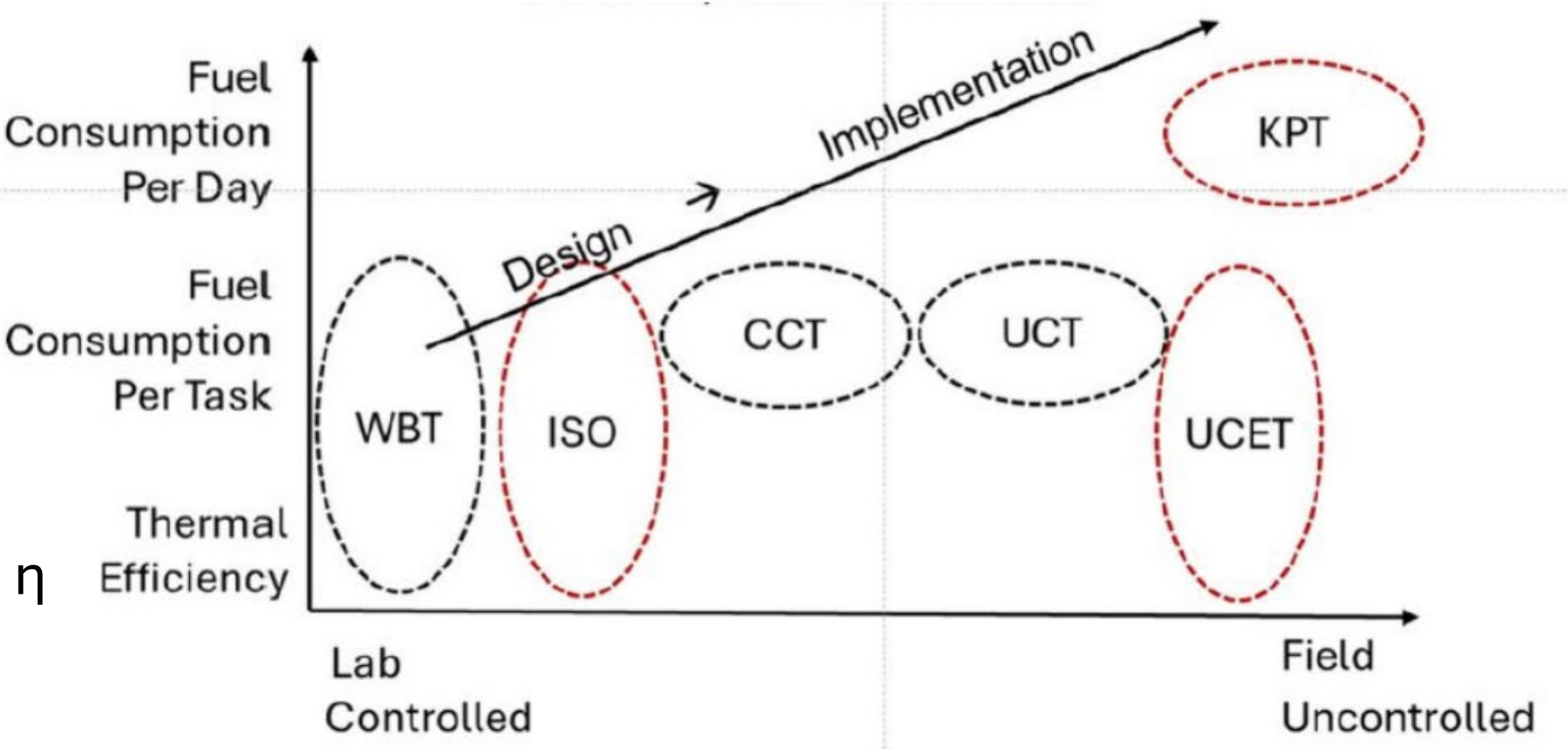

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Thermal Efficiency

$$\eta = \frac{Q_{pot}}{Q_{fire}}$$

Where Q is a measure of heat in Joules:

$$Q_{pot} = c_{p,water} m_{water} \left(T_{end} - T_{start}\right) + m_{water,evaporated} h_{fg,water}$$

where $c_{p,water} = 4.186 \frac{J}{g°C}$ $h_{fg,water} = 2,264 \frac{J}{g}$

$$Q_{fuel} = m_{fuel} LHV_{fuel}$$

where $LHV_{wood} = 20,580 \frac{J}{g}$ $LHV_{LPG} = 46,400 \frac{J}{g}$

Results are specific to the pot, fuel, firepower, tending practice, etc.

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Why is using thermal efficiency bad for carbon credits?

- Lab does not predict field
- Thermal efficiency can be optimized with a wide pot, careful tending, etc.
- Measured from as few as 5 tests
- Thermal efficiency is related to fuel consumption but it is not the best metric

Why is KPT better?

- Requires large sample of households to achieve 95% confidence
  - Minimum 100 households for CLEAR
- Randomly sampled households
- 4 days per household
- Can be paired with sensors and surveys to track technology usage and number of people eating

What is the Digital KPT (dKPT)?

- Sensors can make KPT easier, require less staff time, and provide a verifiable data log
  - SUMS – Stove Use Monitor – records when stove is used based on temperature
  - FUEL – from OSU and Climate Solutions Consulting – FUEL sensor measures fuel use over time and allows for multi-day KPT without visiting location. EXACT sensor verifies stove usage when fuel consumed.
  - IOT – Power sensors installed in electric stoves to track energy consumption

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CLEAR Methodology

- Intended to replace the many current methodologies
  - To reduce overcrediting – “more conservative”
  - To cover all types of projects
    - Continuously tracked (ethanol, electricity, LPG, pellets) = CTEC (metered) at the household level
      - Requires project stove tracking with either KPT in project and baseline, or CCTs to calculate displacement
    - Non-CTEC (wood and charcoal stoves)
      - Requires KPT for Non-CTEC
      - ISO is only used to meet minimum qualifications for thermal efficiency
- Monitoring is conducted by projects, RTKCs can help
- Not yet adopted, but hopefully soon

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CLEAR emission reductions calculation: Inputs & sources/ methods: Fuel consumption

Inputs needed to estimate ERs	How to determine it		
Inputs/adjustments	**Non-CTEC projects**	**CTEC projects**	
Baseline fuel consumption	Global default or KPT	Baseline KPT	Back-calculated from project data, using CCT-derived fuel consumption ratios and usage surveys
Project fuel consumption	KPT	Project KPT (incl. metered data)	Metered project data alone
Hawthorne Effect (HE)	Measured with SUMs	Not required	
	25% discount to ERs if not measured through SUMs.		

Non-CTEC

Wood and Charcoal stoves

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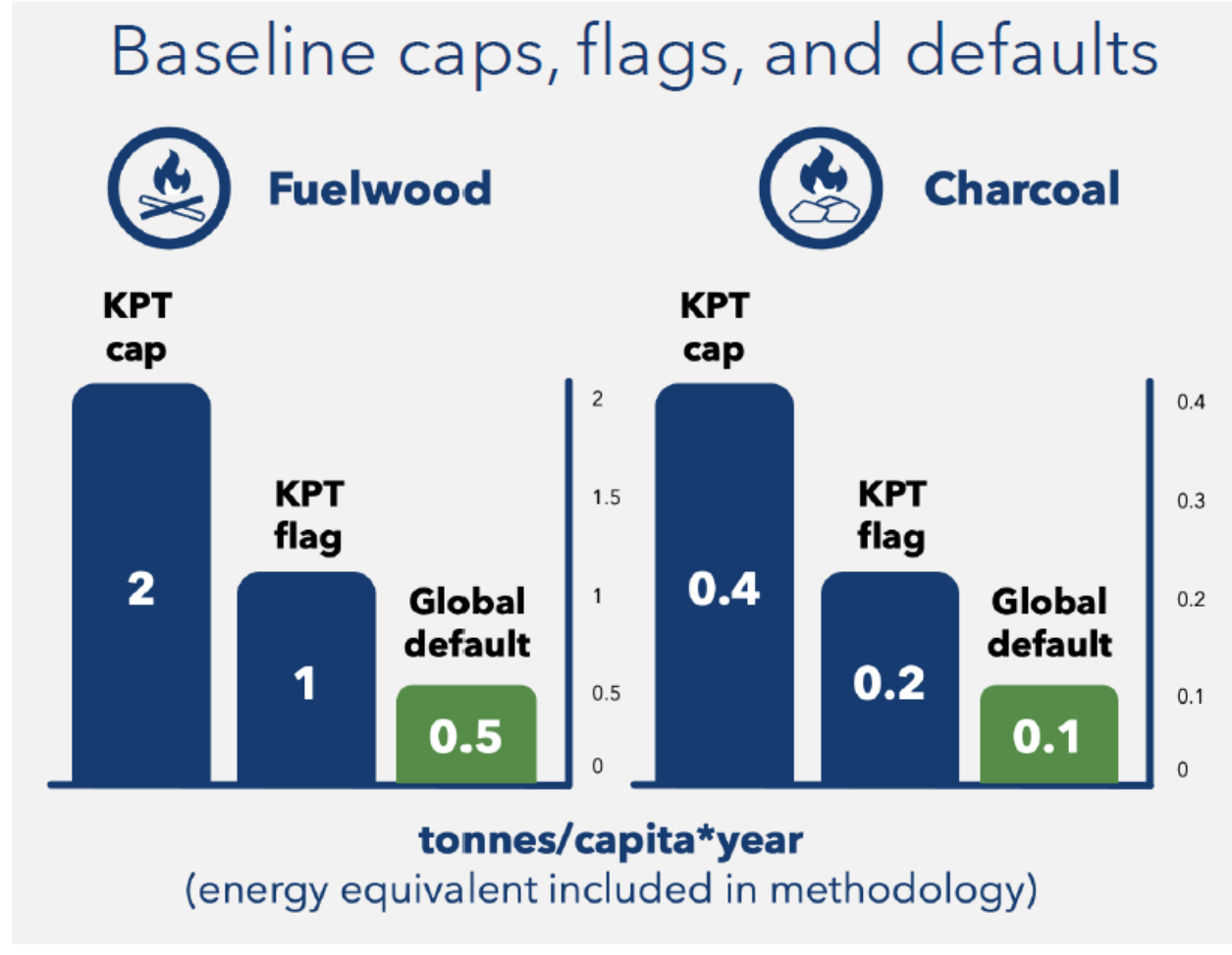
Fuel consumption: Non-CTEC options

Option 1	Option 2
Baseline fuel consumption	*Baseline fuel consumption*
Baseline KPT	**Global default**
Project fuel consumption	*Project fuel consumption*
Project KPT	**Project KPT**



CLEAR Accounting – non-CTEC

$$ER_y = (BE_y - PE_y)(1 - LE_y)$$

$$BE_y = \sum_i (EC_{base,i,y} \times (fNRB_i \times EF_{base,i,CO2} + EF_{base,i,nonCO2})) + \sum_i UE_{base,i,y}$$

$$EC_{base,i,y} = H_{sb} \times ntEC_{base,i,y} \times \frac{PTD_{h,\Psi,y}}{CD}$$

$$PTD_{h,\Psi,y} = \Psi_y \times \sum Days_{y,h}$$

$$PE_{unad,j,y} = \sum_j (EC_{proj,j,y} \times (fNRB_i \times EF_{proj,j,CO2} + EF_{proj,j,nonCO2})) + \sum_j UE_{proj,j,y} + PE_{ele}$$

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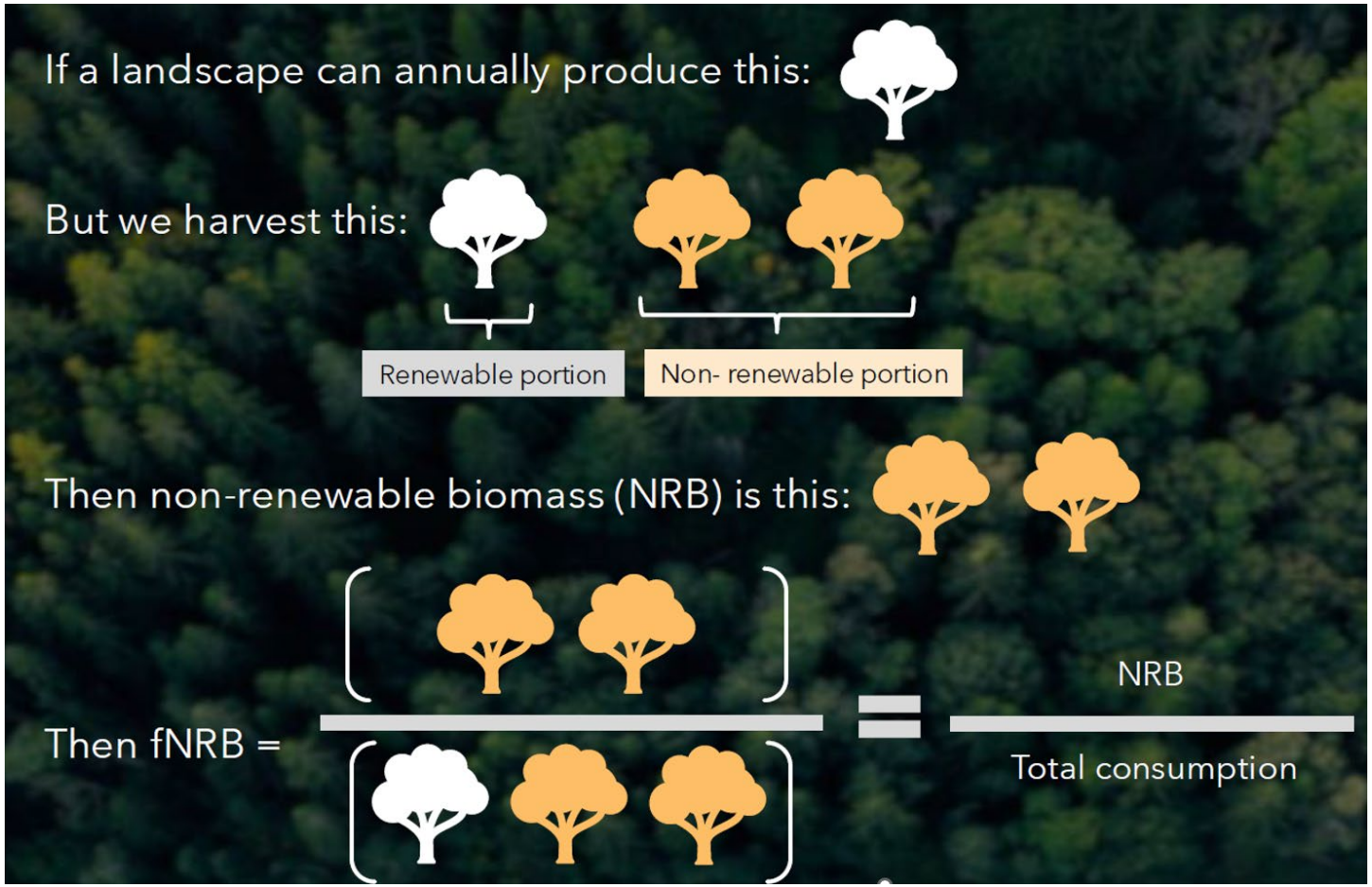
What is fNRB?

- Fraction of Non-Renewable Biomass
- Determined through complex geospatial models in software called MOFUSS



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KPT Sample Sizes

- Minimum sample size is 100 KPTs and 200 surveys
- For projects of 25,000 or more project households, the minimum required random sample sizes for all monitored parameters, except those shall scale by 0.05% in proportion to the total number of project households above 25,000
  - A project with 250,000 households requires:
    - KPTs: 100 + (0.0005 × [250,000 − 25,000]) = 213
    - Surveys: 200 + (0.0005 × [250,000 − 25,000]) = 313
- Projects must still demonstrate that the final sample achieves the 95/10 precision threshold

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Stove Age Groups

After distribution of project stoves

	Baseline	Year 1	Year 2	Year 3
Batch 1		100	50	33
Batch 2			50	33
Batch 3				33
Total KPTs	**100**	**100**	**100**	**100**

Sampling shall be stratified proportionally across installed cookstove age groups (<1 year, 1–2 years, 2-3, 3-4, and 4> years) to ensure that performance and usage estimates reflect the distribution of cookstove ages in the project.

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Usage (PTD) Measurements

- SUMs or surveys for Project Technology Days (PTDs):
  - To be eligible to claim up to 90% of maximum PTDs, project proponents not estimating PTDs with SUMs must take customer support actions
    - Otherwise 75% is assumed
  - Otherwise SUMs are used to indicate usage
- SUMS used to recalculate Hawthorne effect during 30 continuous days before and/or after the 4-day KPT
  - Otherwise PTDs must be reduced to 75%

CTEC

Electricity, LPG, Ethanol, pellets if energy consumption is tracked at the **household** level

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CTEC - Project

- Cooking events do not need to be measured (no SUMS)
- All project stove project energy consumption is tracked through fuel sales (pellets, ethanol, LPG) or metering (LPG, electricity, biogas) at the household level (used as input to KPT)

$$PE_y = \sum_j (tEC_{proj,j,y} \times (fNRB_i \times EF_{proj,j,CO2} + EF_{proj,j,nonCO2})) + \sum_j UE_{pro}$$

- Or for electricity, depends on source of electricity (grid/off-grid)

$$PE_{elec,y} = 10^{-6} \times [\frac{tEC_{proj,grid,y} \times EF_{proj,grid,y}}{1 - TDL_y} + (tEC_{proj,offgrid,y} \times \sum_k f_{k,y} \times EF_{proj,offgrid,k})]$$

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CTEC - Baseline

- Baseline options
  - Back calculated with specific consumption (SC) from 15 CCTs (5 cooks, 3 repetitions) per stove

$$EC_{d-base,i,y} = tEC_{proj,j,y} \times tPC_{b,i} \times (\frac{SC_{b,i}}{SC_{p,j}})$$

  - Baseline KPT
- Other, non-project cookstoves that may be in use in the project scenario are ignored, and the baseline fuel consumption calculation only includes that which is displaced by the project cookstove

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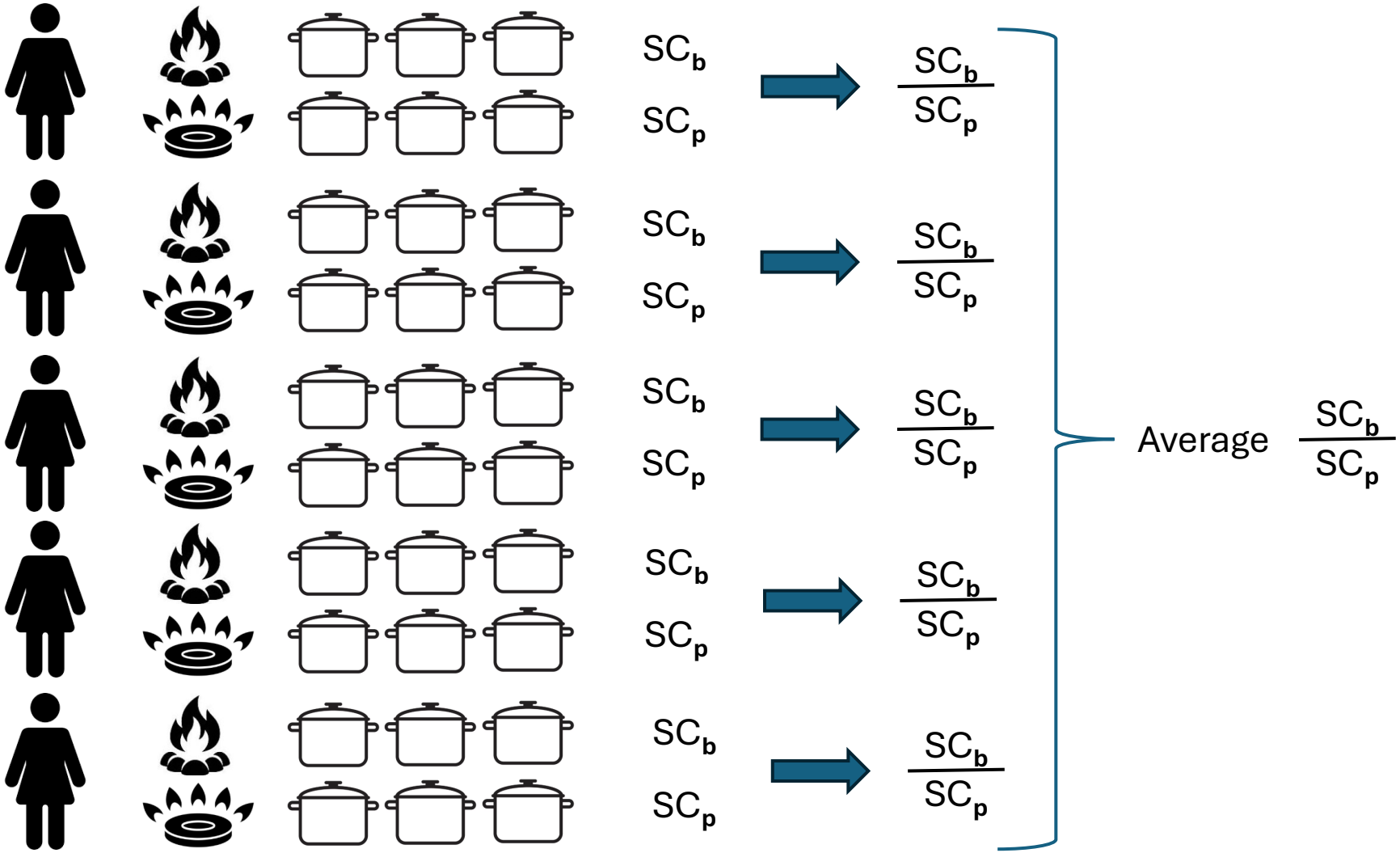
CCT

- Each cook prepares the same meal 3 times on the baseline stove and 3 times on the project stove
- The 30 meals must be the same quantities each time



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Summary

- Carbon financing is supporting our sector
- Quality field data is essential for high-value emissions reductions
- RTCKs and regional labs can help?
- Please join us in 3 weeks for Jaden's webinar on Field Testing
  - **Thursday, May 21st, 8am-9am PST**: Field Testing, Jaden Burger -- This webinar provides an overview of the various field tests for cook stoves available, what they measure, and when to implement them.

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Questions?

- Thank you!
- And thanks to the Osprey Foundation for supporting this webinar
- Feel free to reach out: nordica@aprovecho.org

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