GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

Proposed Safety Tiers for Cookstoves

Nathan Johnson

Iowa State University

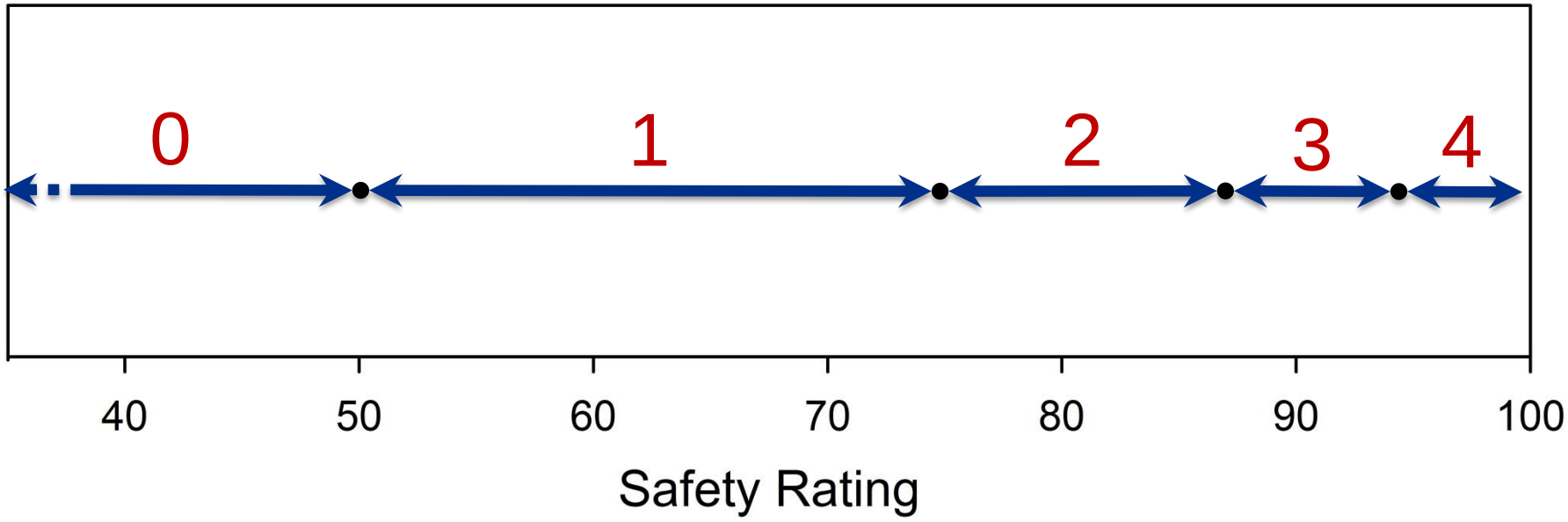
Protocol History

- Limited data on cooking hazards, risk
- Equipment and methodology developed within the limitations of field testing
- Developed principally for biomass cookstoves
- Used by universities, non-governmental organizations, governmental organizations, and companies

Safety Assessment Criteria & Multipliers

1.	Sharp Edges and Points	1.5
2.	Cookstove Tipping	3.0
3.	Containment of Fuel	2.5
4.	Obstructions Near Cooking Surface	2.0
5.	Surface Temperature	2.0
6.	Heat Transmission to Surroundings	2.5
7.	Temperature of Operational Construction	2.0
8.	Chimney Shielding	2.5
9.	Flames Surrounding the Cookpot	3.0
10.	Flames/Fuel Exiting Fuel Chamber, Canister, or Pipes	4.0

Proposed Tiers: Safety



Tiers based on Biomass Stove Safety Protocol developed at Iowa State University and initial ISO discussions

Proposed Tiers: Safety

	Lima	Interim	Today
Tier 0	<45	<45	<45
Tier 1	≥45	≥45	≥45
Tier 2	≥77	≥62	≥75
Tier 3	≥89	≥78	≥88
Tier 4	≥95	≥95	≥95

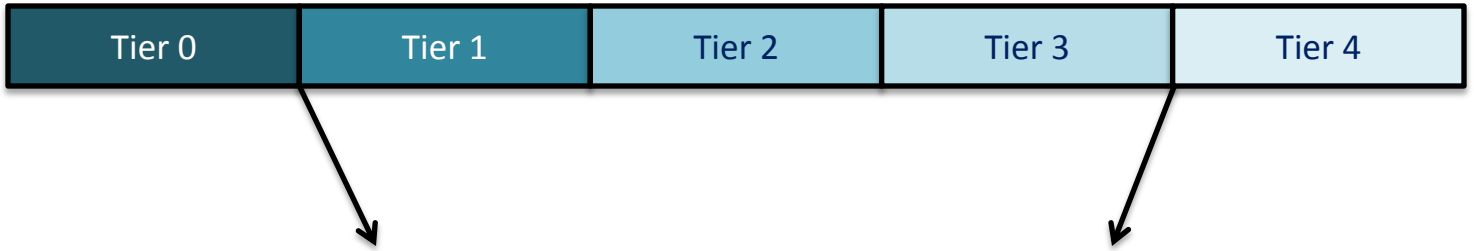
GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

Proposed Emissions Tiers for Cookstoves

Jim Jetter

U.S. Environmental Protection Agency

Tier "Bookend" Numbers



Performance Indicator	3-Stone Fire	Aspirational Goal
Fuel Use	Low Power Specific Energy Consumption: 0.050 MJ/(min x L) High Power Thermal Efficiency: 15%	Low Power Specific Energy Consumption: 0.017 MJ/(min x L) High Power Thermal Efficiency: 45%
Emissions	Low Power CO: 0.20 g/(min x L) High Power CO: 16 g/MJ delivered Low Power $PM_{2.5}$: 8 mg/(min x L) High Power $PM_{2.5}$: 979 mg/MJ delivered	Low Power CO: 0.09 g/(min x L) High Power CO:8 g/MJ delivered Low Power $PM_{2.5}$: 1 g/(min x L) High Power $PM_{2.5}$: 41 mg/MJ delivered
Indoor Emissions	CO: 0.97g/min $PM_{2.5}$: 40mg/min	CO: 0.42g/min $PM_{2.5}$: 2mg/min
Safety	Iowa State University Rating System: 45	Iowa State University Rating System: 95

Proposed Tiers: Overall Emissions

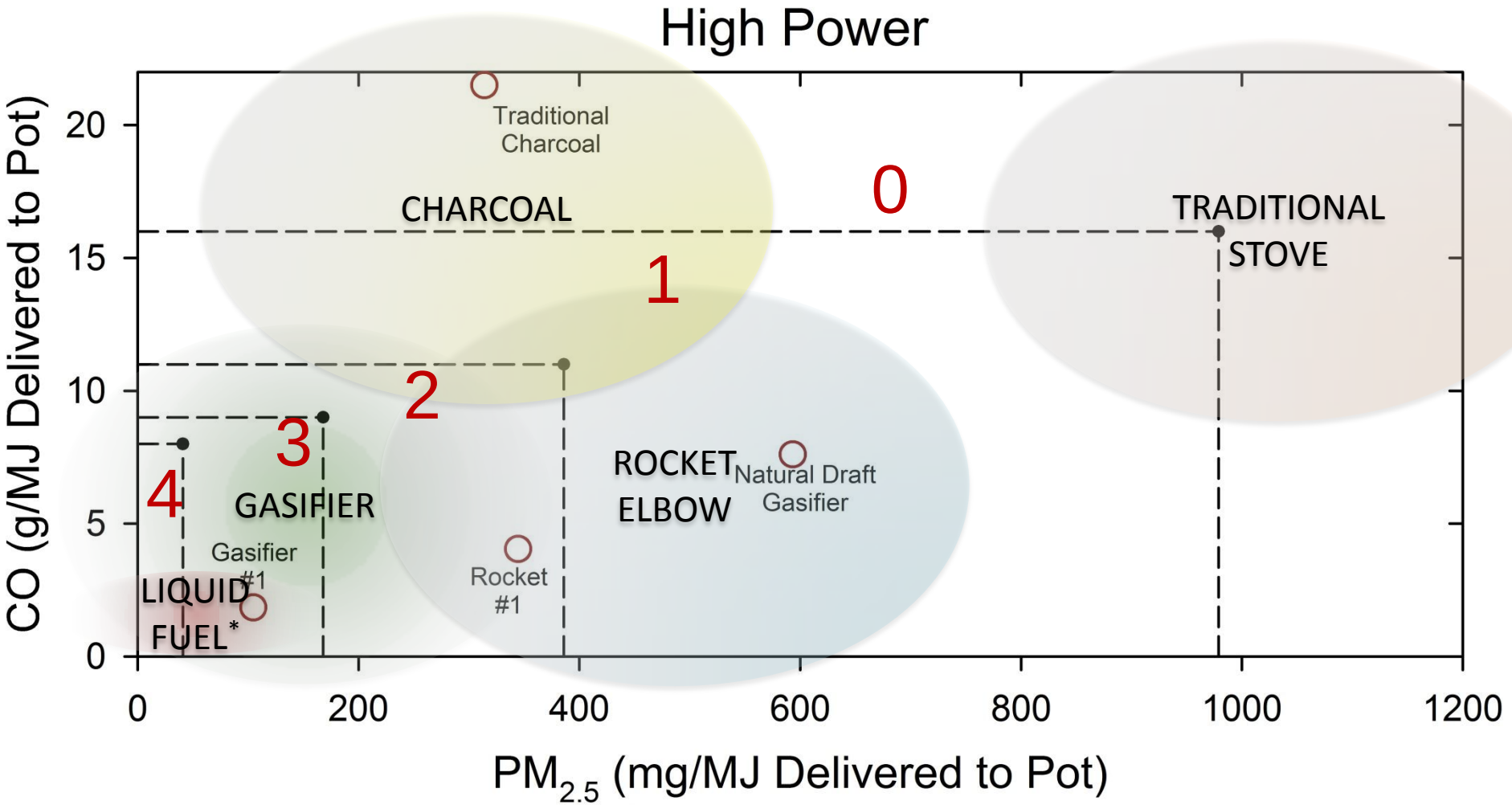
- Stoves will be given a single emissions rating
  - Rating will be based on lowest score from the 4 emissions criteria

	High Power CO (g/MJ delivered)	Low Power CO (g/(min x L))	High Power PM2.5 (mg/MJ delivered)	Low Power PM2.5 (mg/(min x L))
Tier 0	>16	>0.20	>979	>8
Tier 1	<16	<0.20	<979	<8
Tier 2	<11	<0.13	<386	<4
Tier 3	<9	<0.10	<168	<2
Tier 4	<8	<0.09	<41	<1

Example Stoves

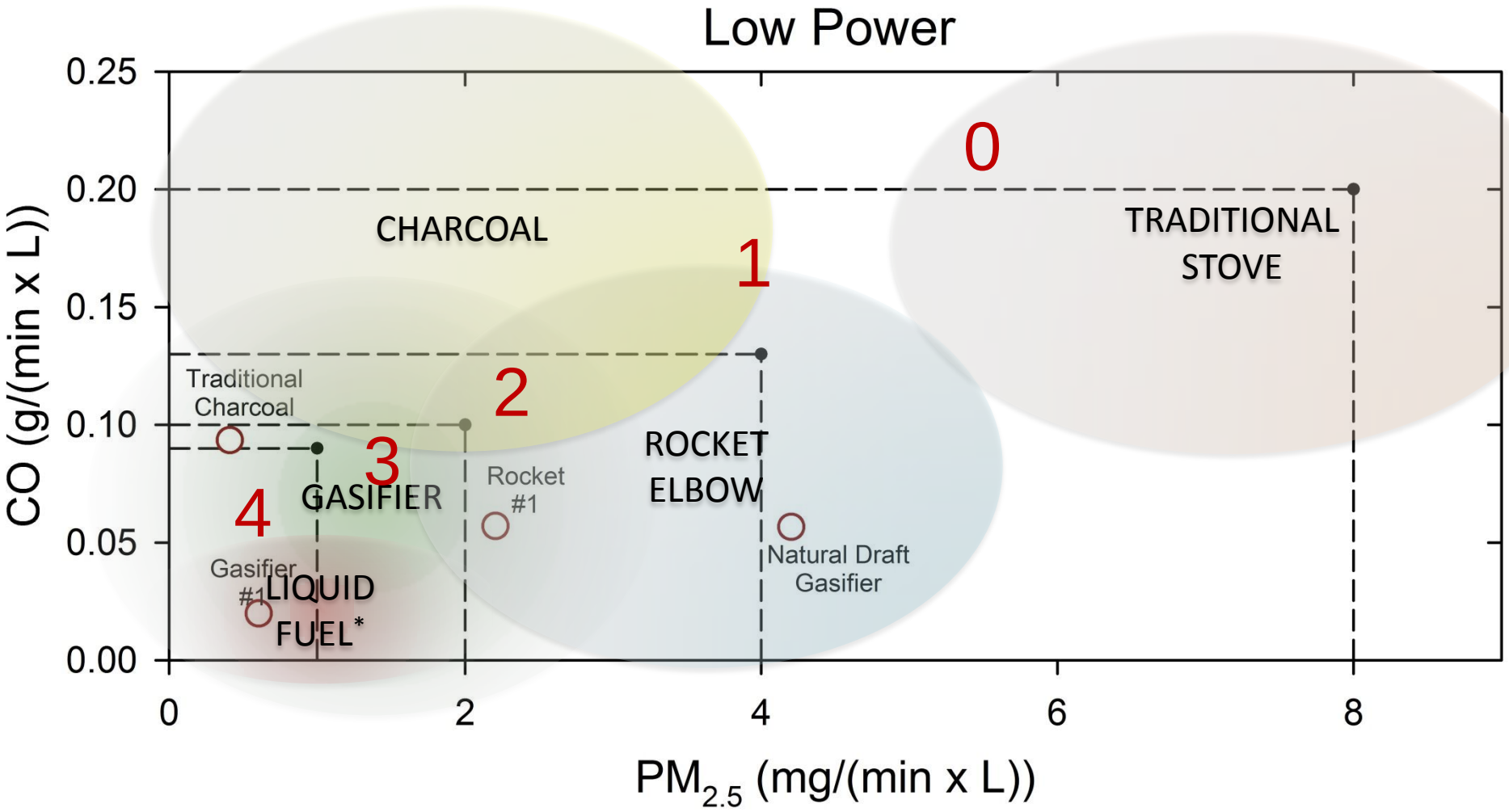
	CO, high	CO, low	PM, high	PM, low		Emissions Tier
Rocket Stove 1	6.1	0.12	345	1.3	→	Tier 2
Gasifier Stove	8.6	0.08	168	1.5	→	Tier 3
Charcoal Stove	15	0.19	55	0.5	→	Tier 1
LPG Stove	3.0	0.06	12	0.7	→	Tier 4

Proposed Tiers: Emissions



*Liquid fuels include LPG, kerosene, and ethanol

Proposed Tiers: Emissions



*Liquid fuels include LPG, kerosene, and ethanol

Proposed Tiers: Emissions

	High Power CO (g/MJ)	Low Power CO (g/min/L)
Tier 0	> 16	> 0.20
Tier 1	≤ 16	≤ 0.20
Tier 2	≤ 11	≤ 0.13
Tier 3	≤ 9	≤ 0.10
Tier 4	≤ 8	≤ 0.09

	High Power PM (mg/MJ)	Low Power PM (mg/min/L)
Tier 0	> 979	> 8
Tier 1	≤ 979	≤ 8
Tier 2	≤ 386	≤ 4
Tier 3	≤ 168	≤ 2
Tier 4	≤ 41	≤ 1

GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

Proposed Indoor Emissions Tiers for Cookstoves

Michael Johnson
Berkeley Air Monitoring Group

Notes on Indoor Emissions

Why do we need separate indoor emissions guidelines?

- Stoves designed to vent emissions outside the kitchen can improve indoor air quality.
- A way to link stove performance with indoor air quality guidelines.

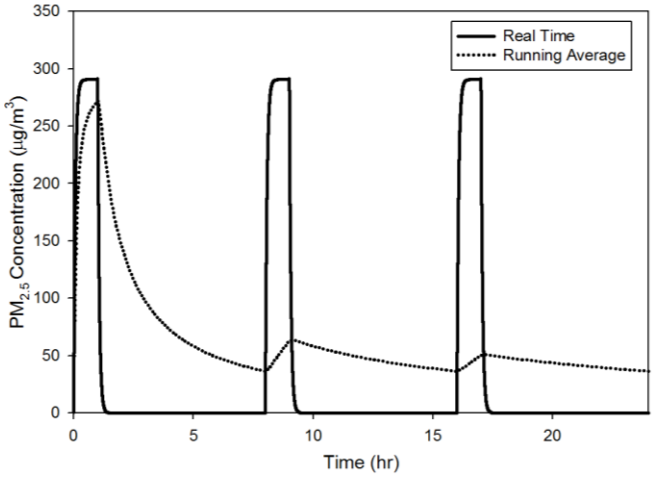
Looking to the WHO air quality guidelines group to inform future refinement of indoor emissions tiers.

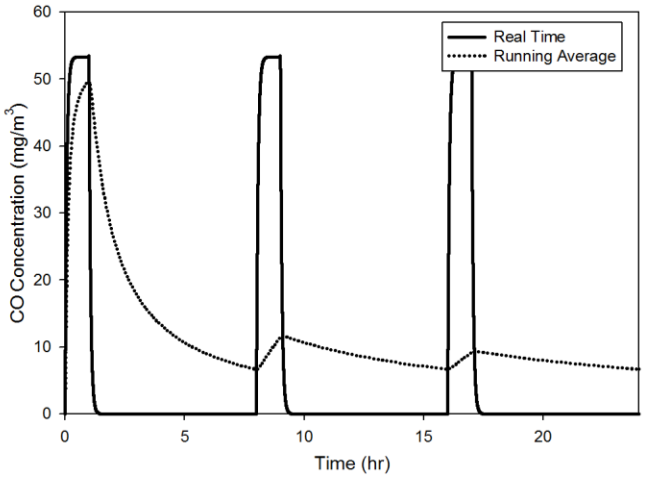
More work needs to be done to better link stove performance, air quality, exposure and health. The current proposed tiers make use of what is available now.

Linking indoor emissions with indoor air quality

Simple, commonly used model

- Constant $PM_{2.5}$ and CO emissions rates
- Stove burns for 60min, 3 times a day
- Room size: $30m^3$
- Air exchange: 15/hr
- Instantaneous, perfect mixing
- 24hr average does not exceed WHO guidelines of $35\mu g/m^3$ for $PM_{2.5}$ and $7mg/m^3$ for CO.





Tier 4 Indoor Emission Rates

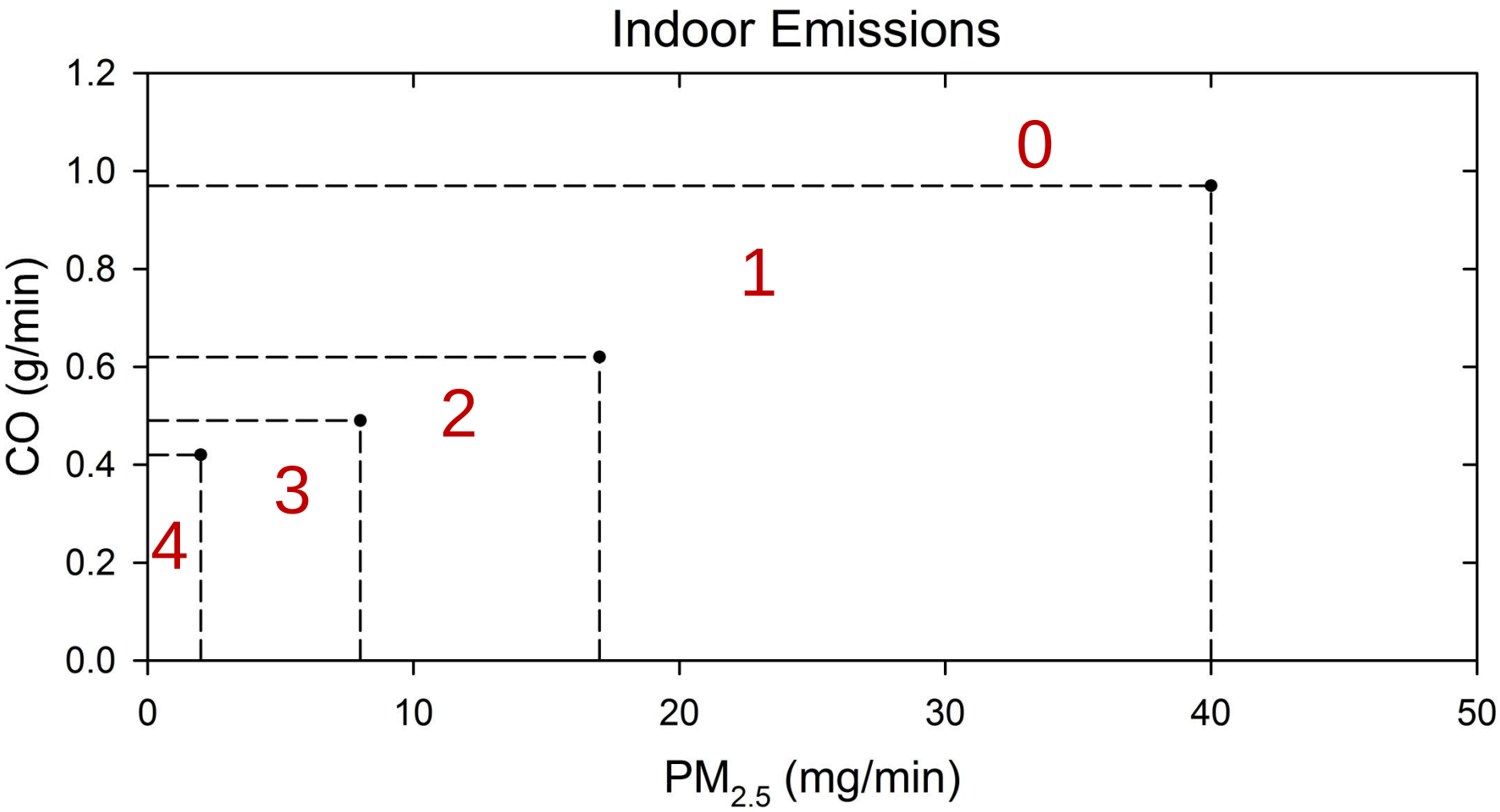
	Tier 4
$PM_{2.5}$(mg/min)	2
CO (g/min)	0.4

Approximately Equivalent

Concentrations

	WHO Guideline
$PM_{2.5}$ IAQ ($\mu g/m^3$)	35
CO IAQ(mg/m^3)	7

Proposed Tiers: Indoor Emissions



Proposed Tiers: Indoor Emissions

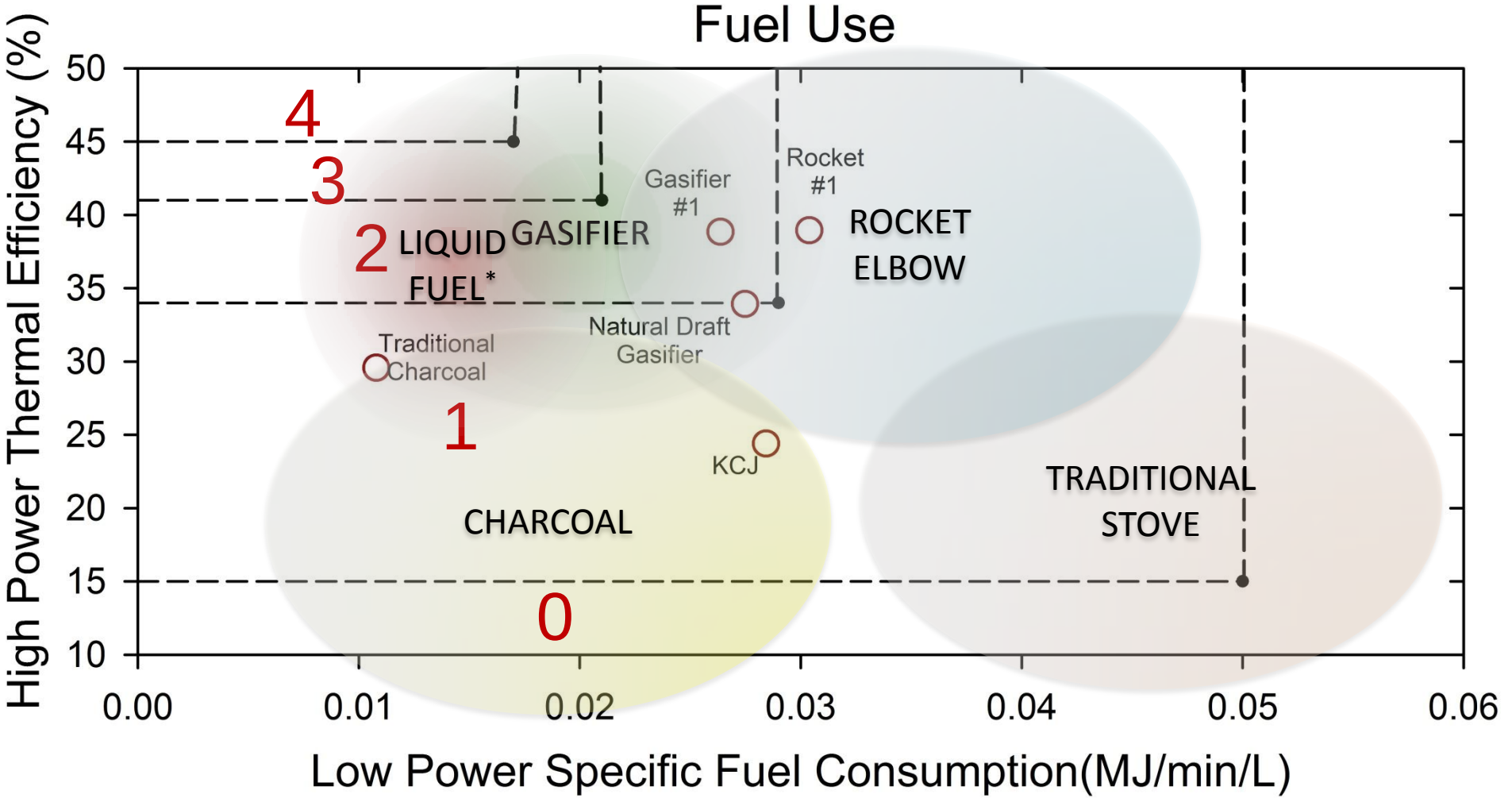
	IAQ CO (g/min)	IAQ PM (mg/min)
Tier 0	>0.97	>40
Tier 1	<0.97	<40
Tier 2	<0.62	<17
Tier 3	<0.49	<8
Tier 4	<0.42	<2

GLOBAL ALLIANCE FOR CLEAN COOKSTOVES

Fuel Use and Thermal Efficiency Tiers of Performance

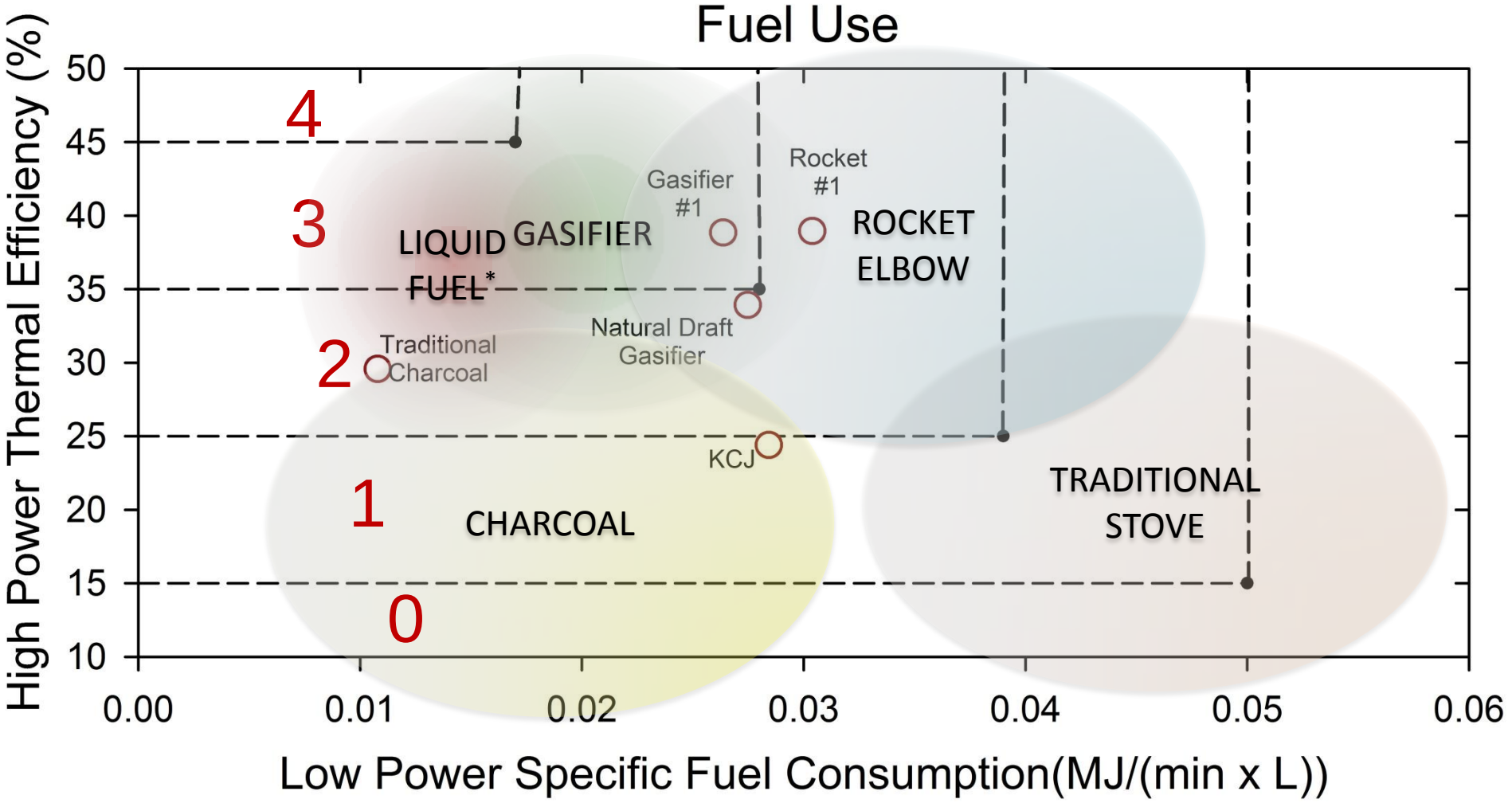
Christian L'Orange
Engines and Energy Conversion Laboratory
Colorado State University
Fort Collins CO USA

Proposed Tier: Fuel Use



*Liquid fuels include LPG, kerosene, and ethanol

Revised Proposed Tier: Fuel Use



*Liquid fuels include LPG, kerosene, and ethanol

Proposed Tiers: Fuel Use

	High Power	Low Power
	Thermal Efficiency (%)	Specific Consumption (MJ/min/L)
Tier 0	<15	>0.050
Tier 1	≥15	≤0.050
Tier 2	≥25	≤0.039
Tier 3	≥35	≤0.028
Tier 4	≥45	≤0.017