

#### Where were we when this project started?

- Focus on urban areas
- Systematic under representation of atmospheric PIM concentrations by bottom up models
- SPEW (AR5)
- -- Used in-field EF for BC and OC from one study.
- GAINS
- Used highest PM emission, from heating stove in New Zealand, multiplied by BC fraction.
- EDGAR
- Took emission factors from SPEW. Not clear how technologies are chosen and EFs are translated.

## Objective 1

Update emissions inventories with particulate (BC, OM, PM<sub>2.5</sub>) and gaseous (CO<sub>2</sub>, CO, CH<sub>4</sub>, NMHC, SO<sub>2</sub>) species from in field measurements of household stoves and rural small scale industries in 4 sites across the Himalayas:

- Nepal-Mid hills and plains
- China-Tibet
- China-Yunnan
- Haryana, India

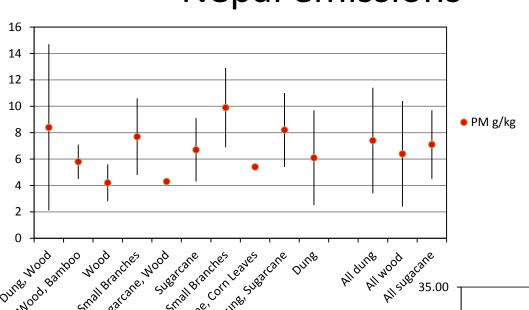


### India emissions

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Smith et al 2000

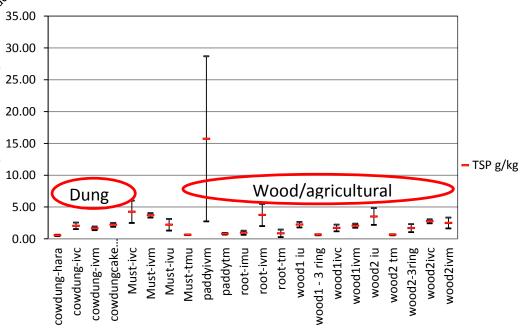
#### Nepal emissions





Smith et al 2000

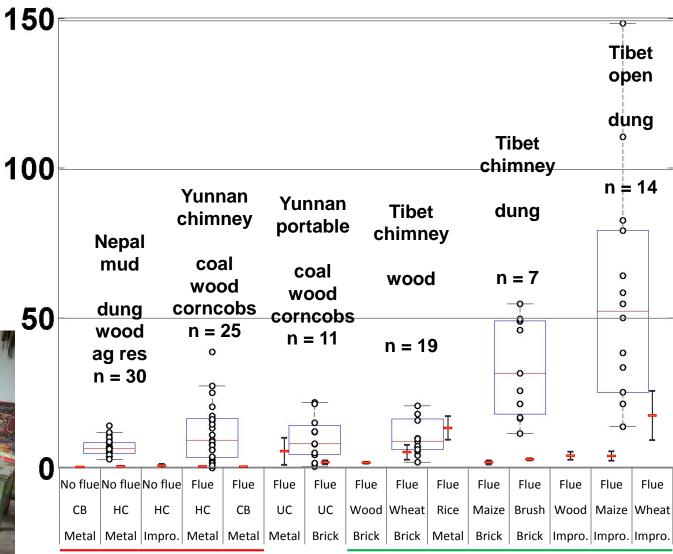






EF<sub>PM</sub> [g/kg]

#### Yunnan and Tibet

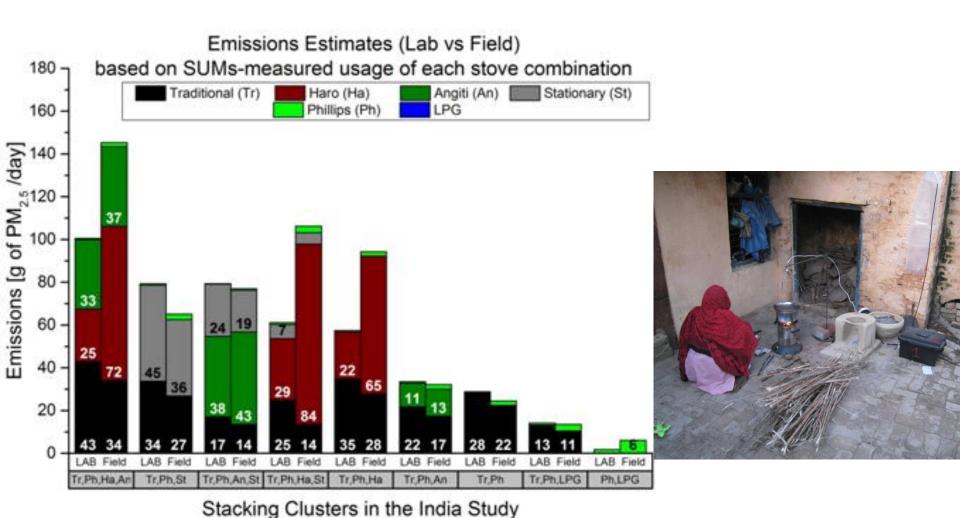


Coal Briquette

Raw Coal

Wood agricultural residues
Zhang et at 2000

Lab and field emissions estimates of stacking clusters in India weighed by daily usage measured with the SUMs.



Low levels of displacement of traditional stoves, combined with low usage levels of the Phillips stove led to limited reductions emissions

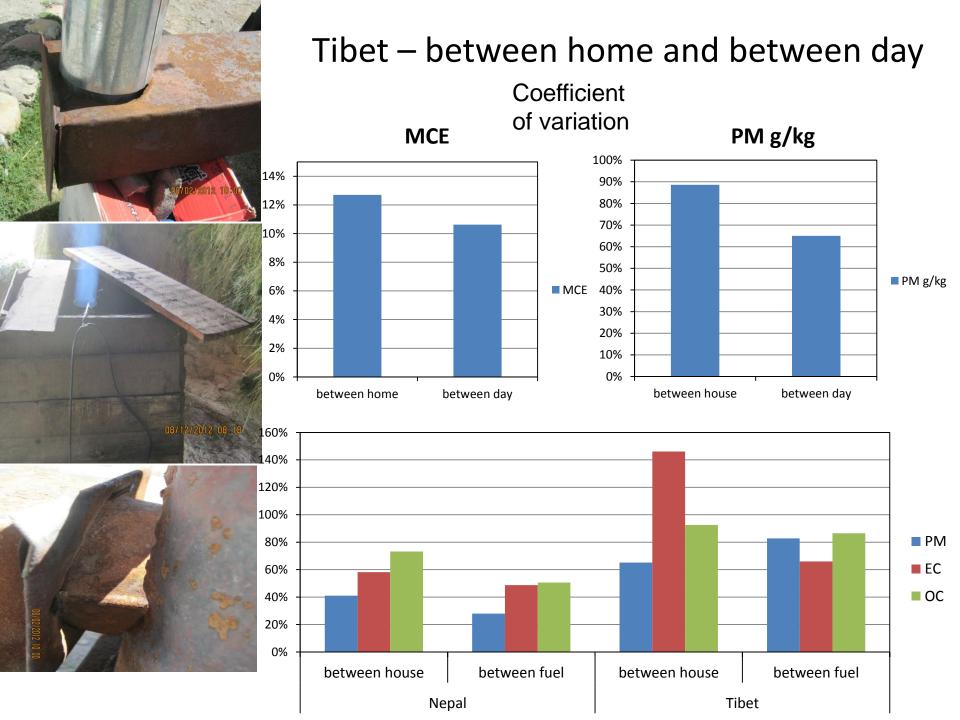


- Adoption rates are not 100% even when stoves are bought.
- Unless incentives are provided traditional stoves remain in use, especially for longer duration tasks
- Developing mechanisms to completely displace traditional stoves increasingly important
  - ie contract for carbon credits
  - linking stoves to prenatal care programs as has been proposed in India.
  - Linking to social programs as El Salvador and Mexico

# Objective 2

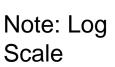
Identify major variability in emissions quantities and properties. Estimate sample sizes needed in future emissions measurements for updating global inventories, and determine how broad in scope our inventories need to be.

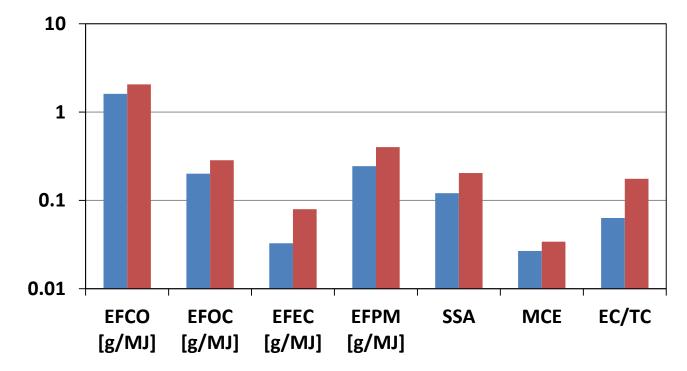




#### Yunnan: between meal and between house

- Between meal variability (average standard deviation within houses)
- Between house variability (standard deviation of houses)

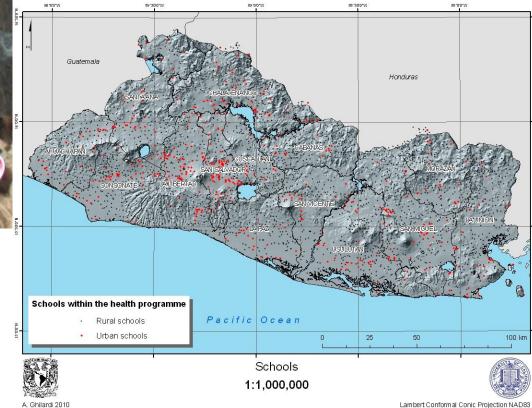




# Objective 3



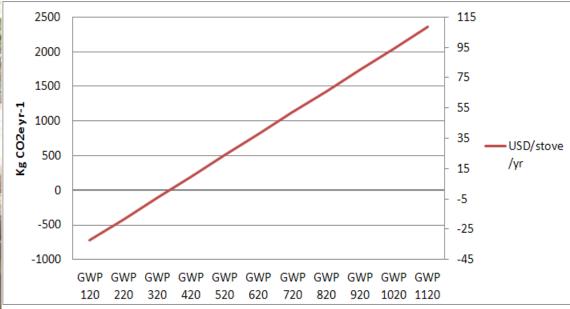
Estimate the potential of advanced combustion biomass stoves to mitigate emissions



#### Potential for mitigation

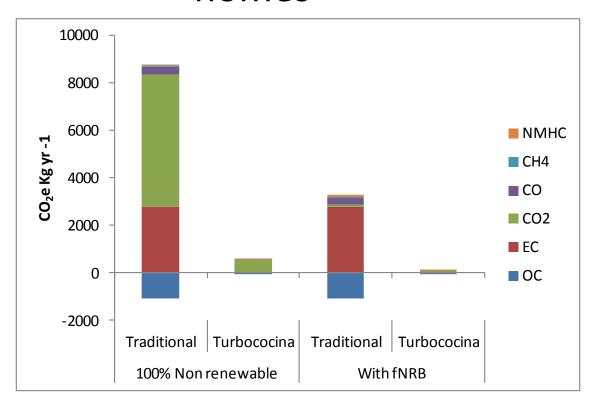
kg yr-1		PM	EC	OC	GWC	USD/Stove/yr
Homes	Traditional	61	3.1	30.3	1701	_
	Turbococina	0.5	0.06	0.24	50	78
		99%	98%	99%	97%	
Schools	Traditional	58	2.9	28.8	1616	_
	Turbococina	0.5	0.07	0.24	51	74
		99%	98%	99%	97%	





@ 47 USD (Mg C)<sup>-1</sup> – equivalent to USD (tonne CO<sub>2</sub>)<sup>-1</sup>

# Potential for mitigation in homes





Using GWC for EC of 900.

Equivalent to 100 USD per stove per year @ 47 USD tonne CO<sub>2</sub>e<sup>-1</sup> IMPLICATIONS

- Amounts are significant to defray technology costs if they truly reduce emissions
- -If realistic fNRB estimates used CO<sub>2</sub>e emission reductions are dominated by particulate emissions

#### Health co-benefits

	PM mg/min
TRADITIONAL	481.8
TURBOCOCINA	15.6



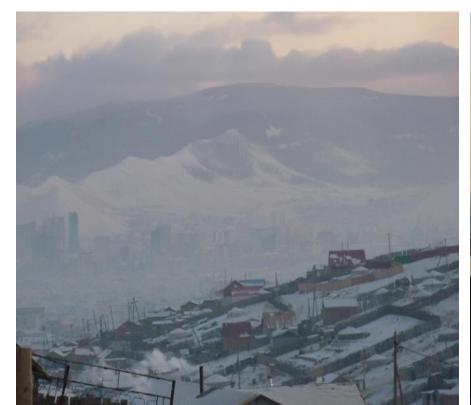
Table R1.2: Emission rate targets for meeting WHO annual mean AQGs for PM<sub>2.5</sub>

Emissions rate targets (ERT)	Emission rate (mg/min)	Percentage of kitchens meeting AQG (10 μg/m³)	Percentage of kitchens meeting AQG IT-1 (35 μg/m³)
Unvented			
Intermediate ERT	1.75	6	60
ERT	0.23	90	100
Vented			
Intermediate ERT	7.15	9	60
ERT	0.80	90	100

WHO air quality guidelines for indoor air quality: household fuel combustion

# Emissions indoor air and health estimates in Ulaanbaatar, Mongolia

	Traditional	Ulzii	Khas	Dul	Total
Ger	20	26	0	16	62
House with heating wall	16	13	14	7	50
House without heating wall	3	9	9	6	27
Total	39	48	23	29	139







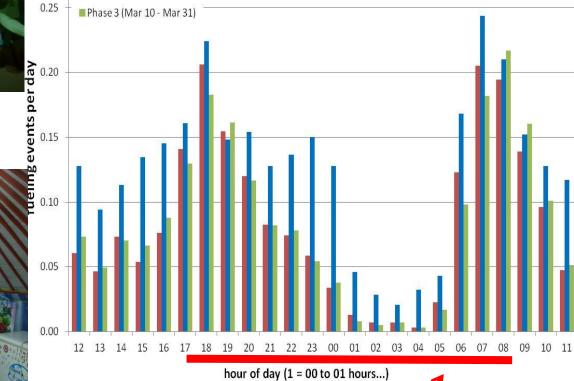
#### Measurement period

**All Stoves** 

■ Phase 1 (Oct 20 - Nov 08)■ Phase 2 (Jan 12 - Jan 26)

**Temporal Distribution of Fueling Events** 

2012-2013 Household Survey 24-Hour Recall for Primary Stoves



**Emissions** 

monitoring

period





# Emissions reductions weighted by frequency of stove types in 97,230 MCA stoves distributed

	MCA stove	n	mean	SD	Diff.	Sig. (2-tailed)
Nighttime PM <sub>2.5</sub>	MCA	98	2.3	4.3		
(g PM <sub>2.5</sub> /kg coal)	Traditional	95	6.5	7.0	65%	<0.01
Nighttime PM <sub>2.5</sub>	MCA	97	32	71		
(g PM <sub>2.5</sub> /day)	Traditional	95	102	148	69%	<0.01
Nighttime CO	MCA	98	60	32		
(g CO/kg coal)	Traditional	95	72	32	16%	0.01



70% from gers, 50% from houses

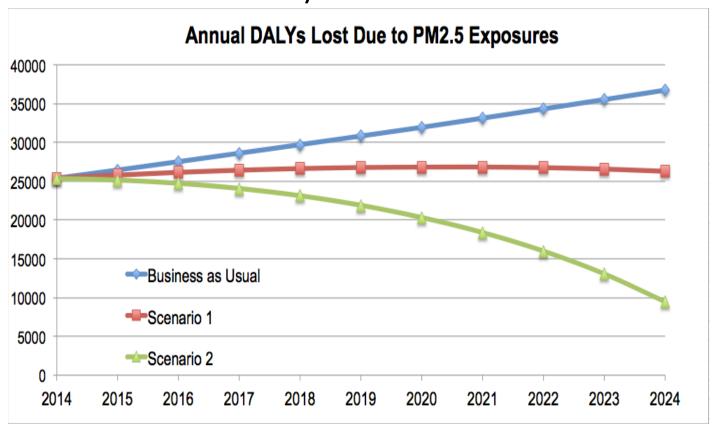
# Modeled health impacts: 2012-2013 reduction in health burden

- Population-weighted annual average exposures to PM2.5 were estimated using the measured wintertime heating season indoor concentrations and modeled wintertime heating season outdoor concentrations, combined with seasonal time activity patterns, estimated non-heating season concentrations (Since health impacts based on annual exposures), and environmental tobacco exposures
- The MCA stove program led to an estimated 11.5% reduction in populationweighted annual average exposures to PM2.5 in Ulaanbaatar

Disease	Air pollution-related disease incidence	Overall incidence
Lung cancers	9% reduction	2.2% reduction
Chronic obstructive pulmonary disease	8.3% reduction	1.7% reduction
ALRI in children between 0-4 years old	8.1% reduction	3.2% reduction
Ischemic heart disease	4.9% reduction	1.0% reduction
Strokes	2% reduction	0.9% reduction

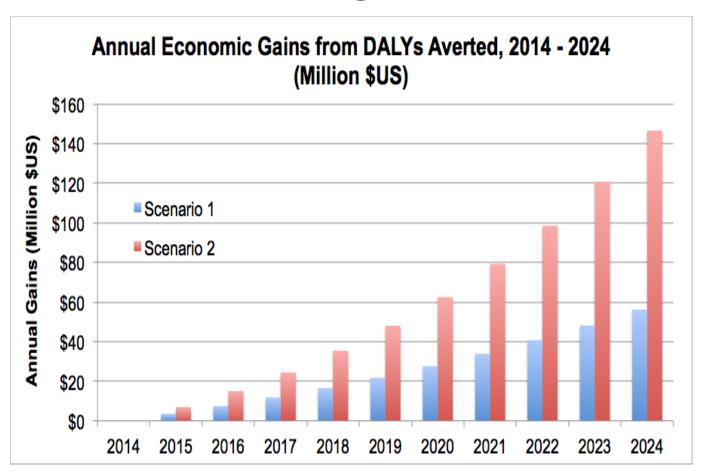
Note: these calculations focus only on one year of impacts (2012-13), and the overall impacts of the stove program should be assessed over the functional lifetime of the MCA stoves.

"What health benefits could be expected from cleaner household stoves and fuels and associated emissions reductions in other sectors by 2025?"



- Trends as of 2014 (business as usual): assumes universal use of reduced emissions coal stoves
- Scenario 1: Moderately accelerated improvements: improvements in all sectors including full deployment of even cleaner coal stoves.
- Scenario 2: Maximum rate of improvement: feasible but ambitious rates of change in all sectors including elimination of solid fuels in households.

## **Economic gains**



Estimates are based on the 2012 GDP per Capita, \$5374 per Year

