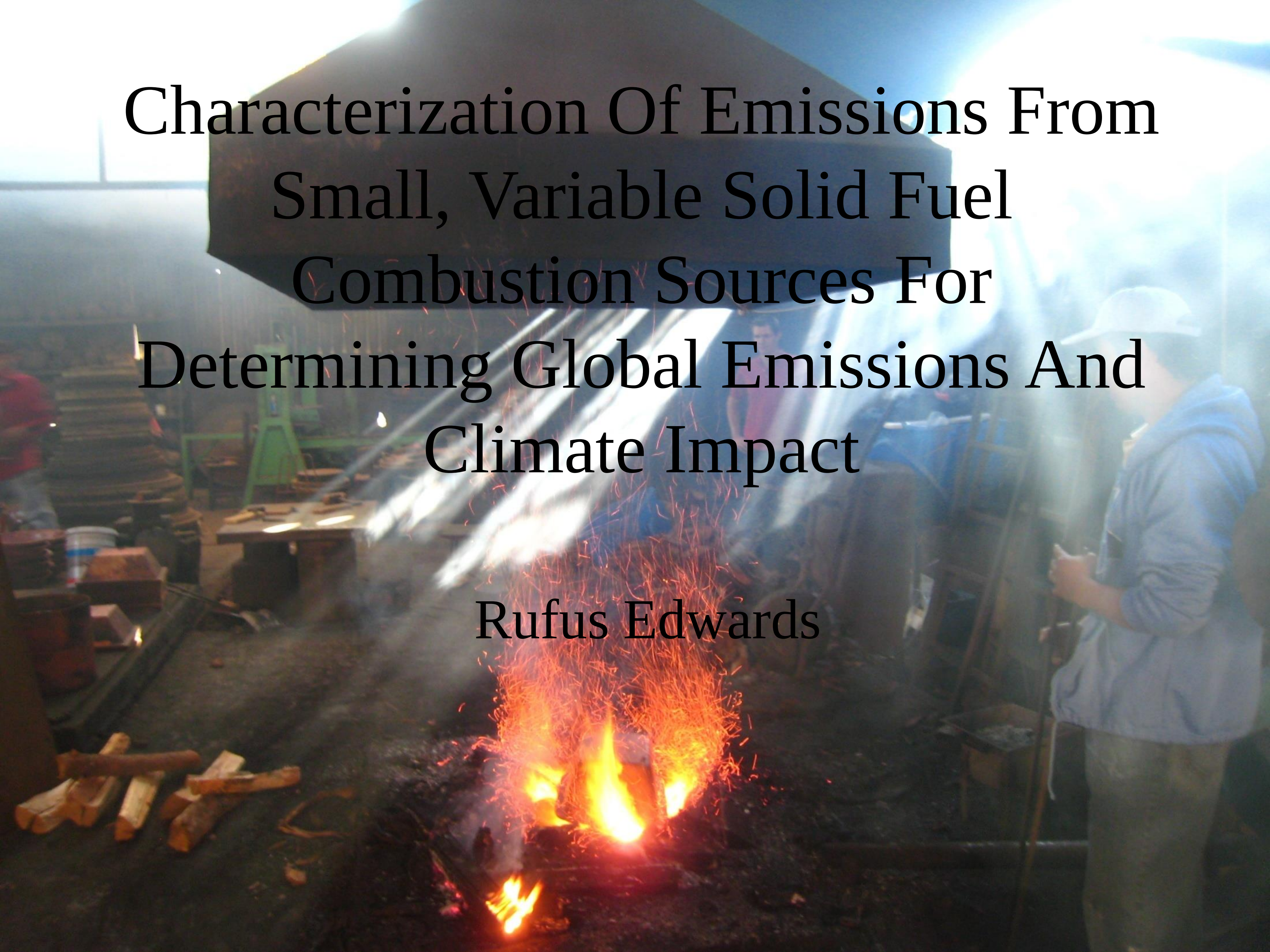


Characterization Of Emissions From Small, Variable Solid Fuel Combustion Sources For Determining Global Emissions And Climate Impact

Rufus Edwards

Where were we when this project started?

- Focus on urban areas
- Systematic under representation of atmospheric PM 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, $PM_{2.5}$) and gaseous (CO_2, CO, CH_4, NMHC, SO_2) 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

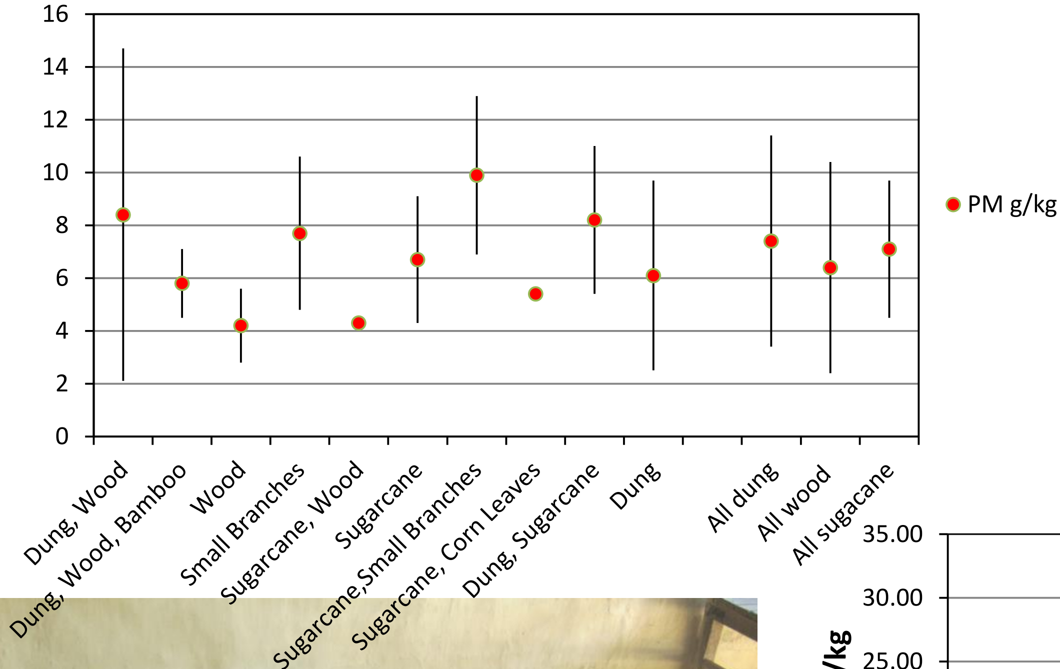
India emissions

	n	MCE	CO_2 (g substance/ kg fuel)	CO	$PM_{2.5}$	EC	OC	TIME (min)
Fixed Chula w/o Chimney	16	0.92 (±0.01)	1651 (±20.8)	152.2 (±19.0)	12.0 (±8.7)	0.8(±0.9)	10.9(±9.8)	167 (±12)
Phillips	13	0.94 (±0.01)	1704 (±16.2)	100.8 (±13.8)	6.6 (±3.9)	0.9(±0.6)	6.3(±2.2)	216 (±31)
Haro	5	0.89 (±0.02)	1584 (±48.5)	189.9 (±39.8)	44.8 (±32.6)	1.7(±1.8)	41.5(±32.4)	167 (±36)
Angithi	2	0.86 (±0.04)	1541 (±77.9)	243.9 (±69.4)	24.6 (±10.0)	4.8	8.3	111 (±9)

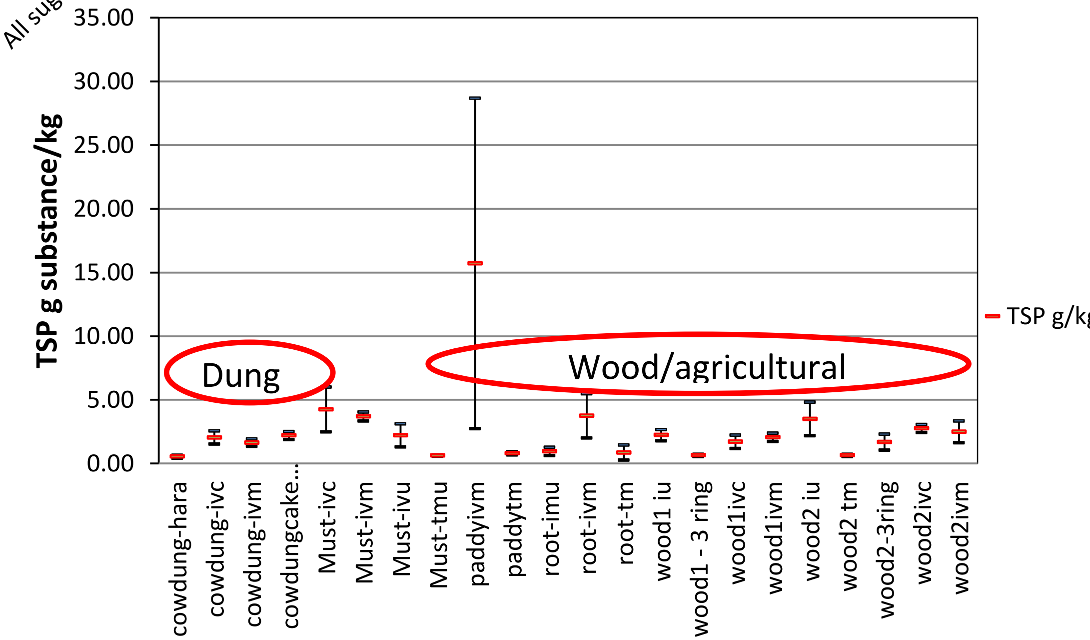
*Sample sizes for EC OC smaller than total

Smith et al 2000

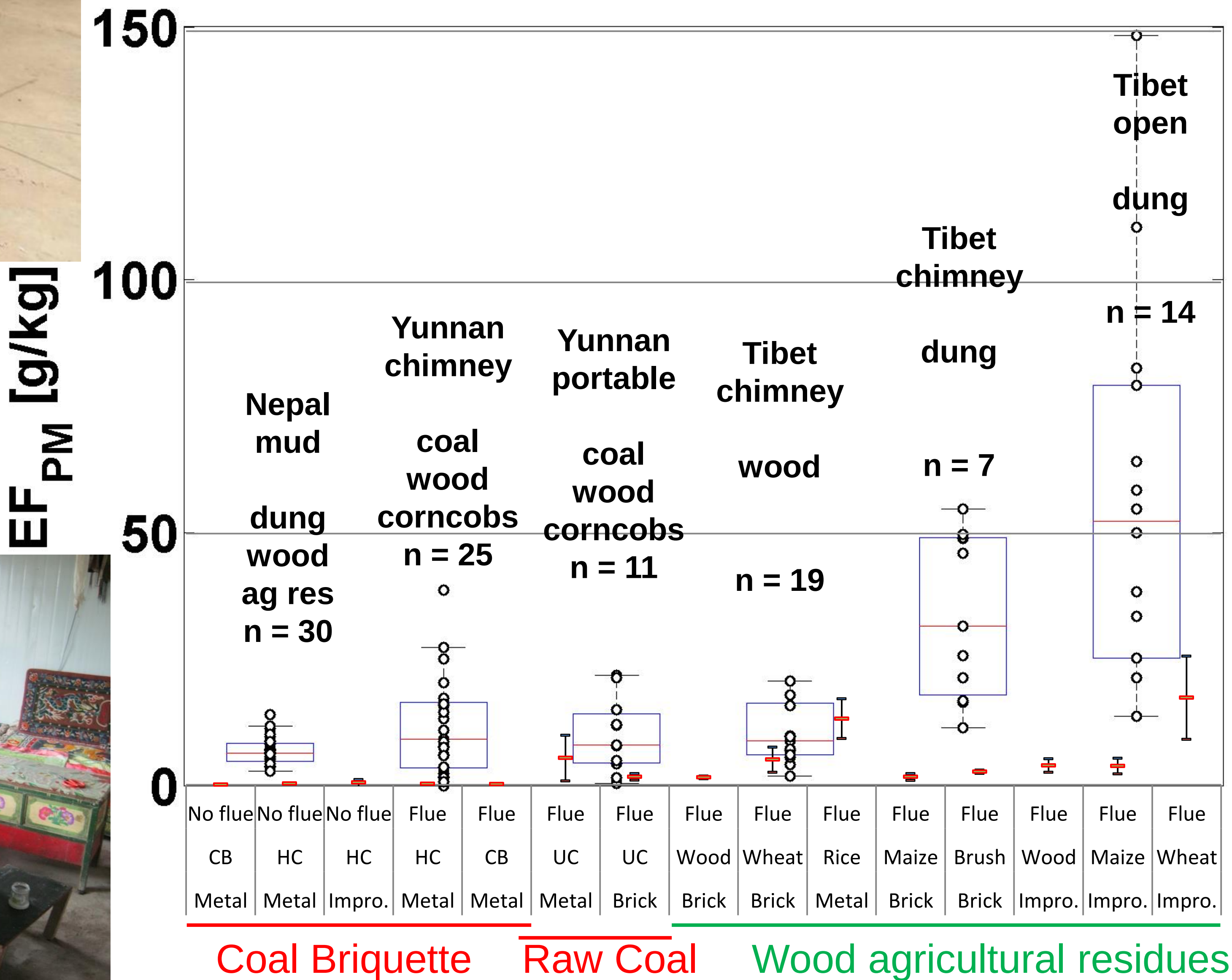
Nepal emissions



Smith et al 2000

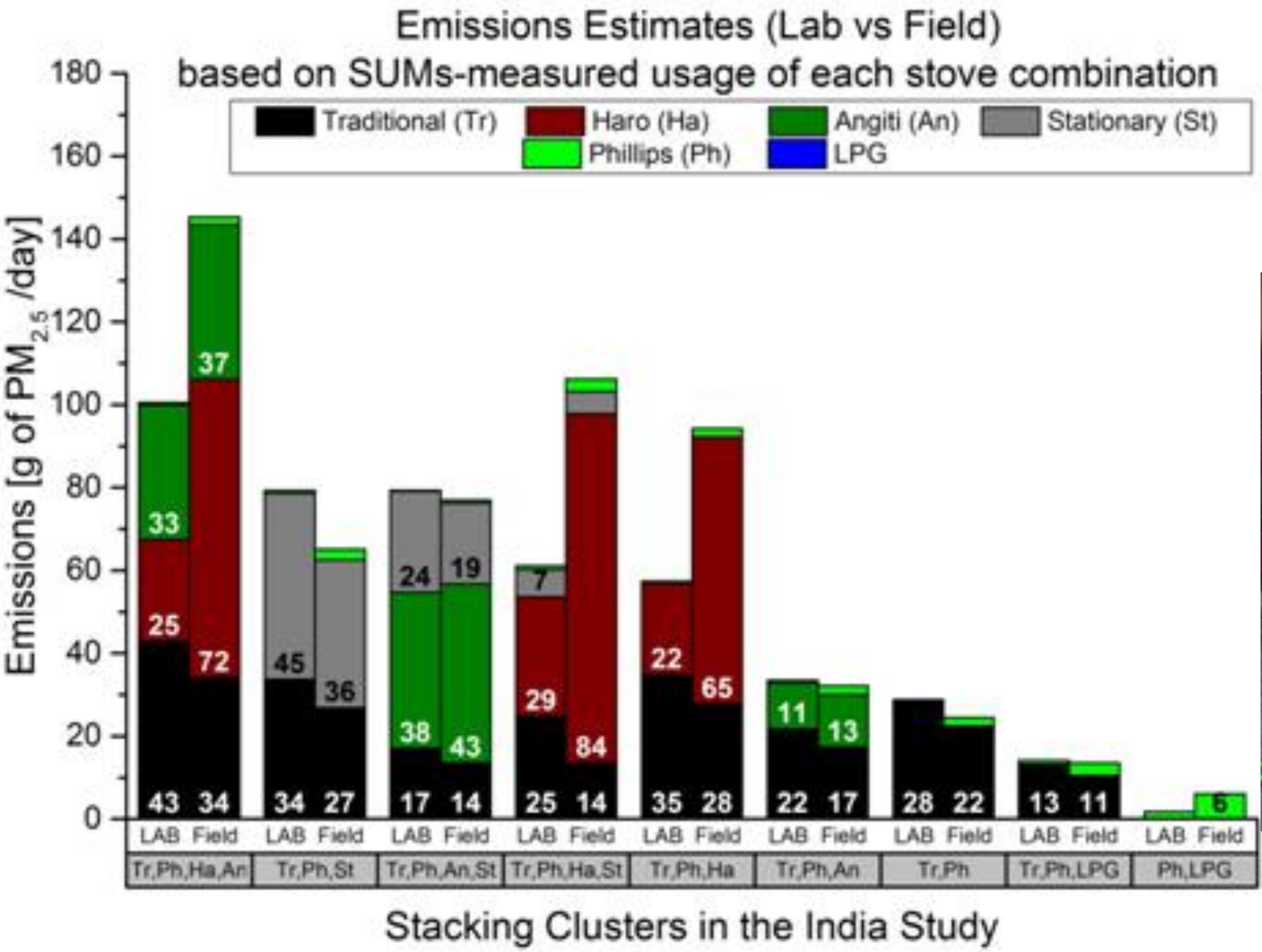


Yunnan and Tibet



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 and stacking is important

- 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

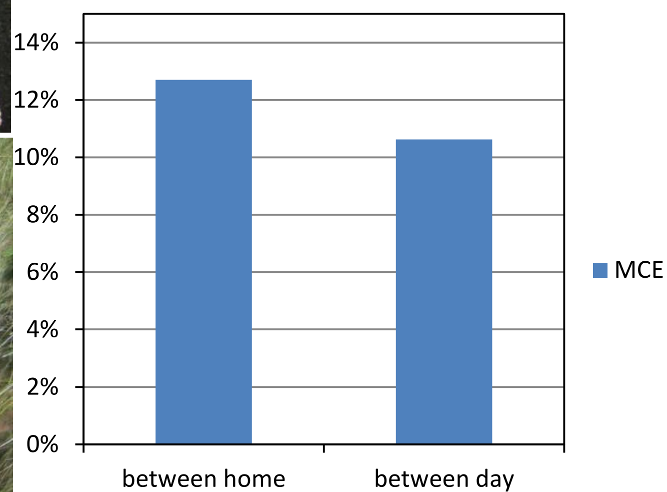
Objective 2

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.

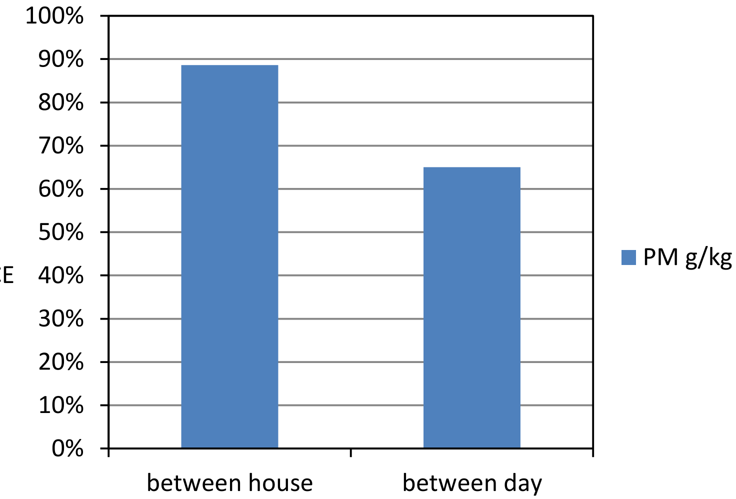
Tibet – between home and between day

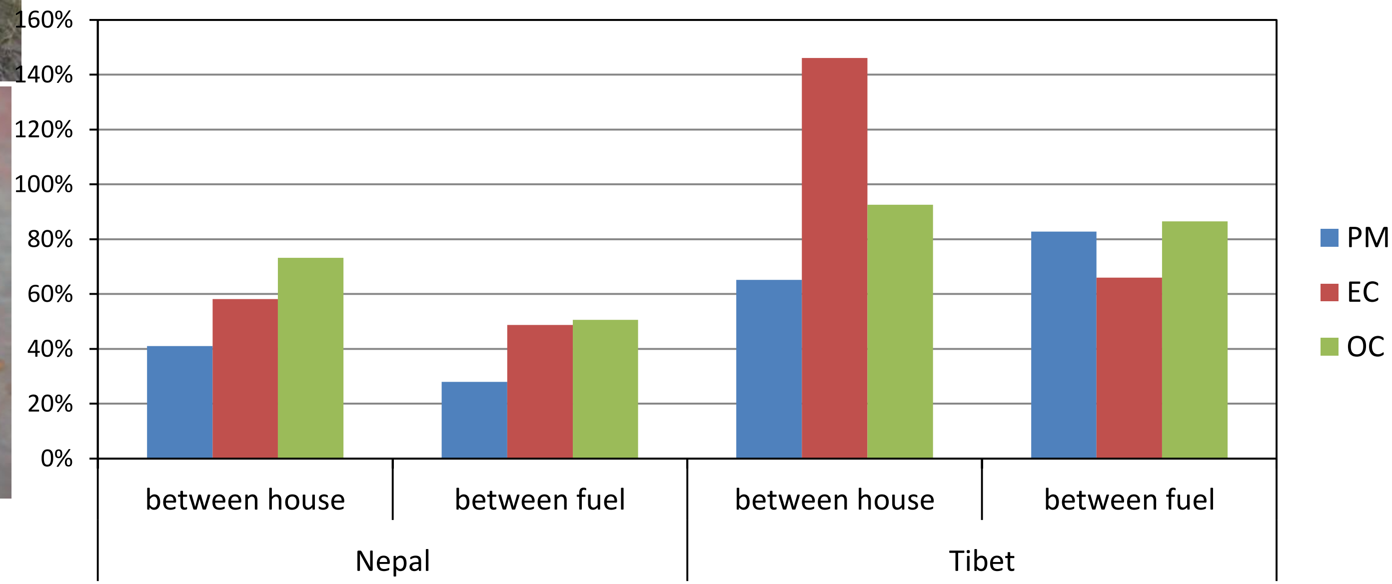
Coefficient of variation

MCE



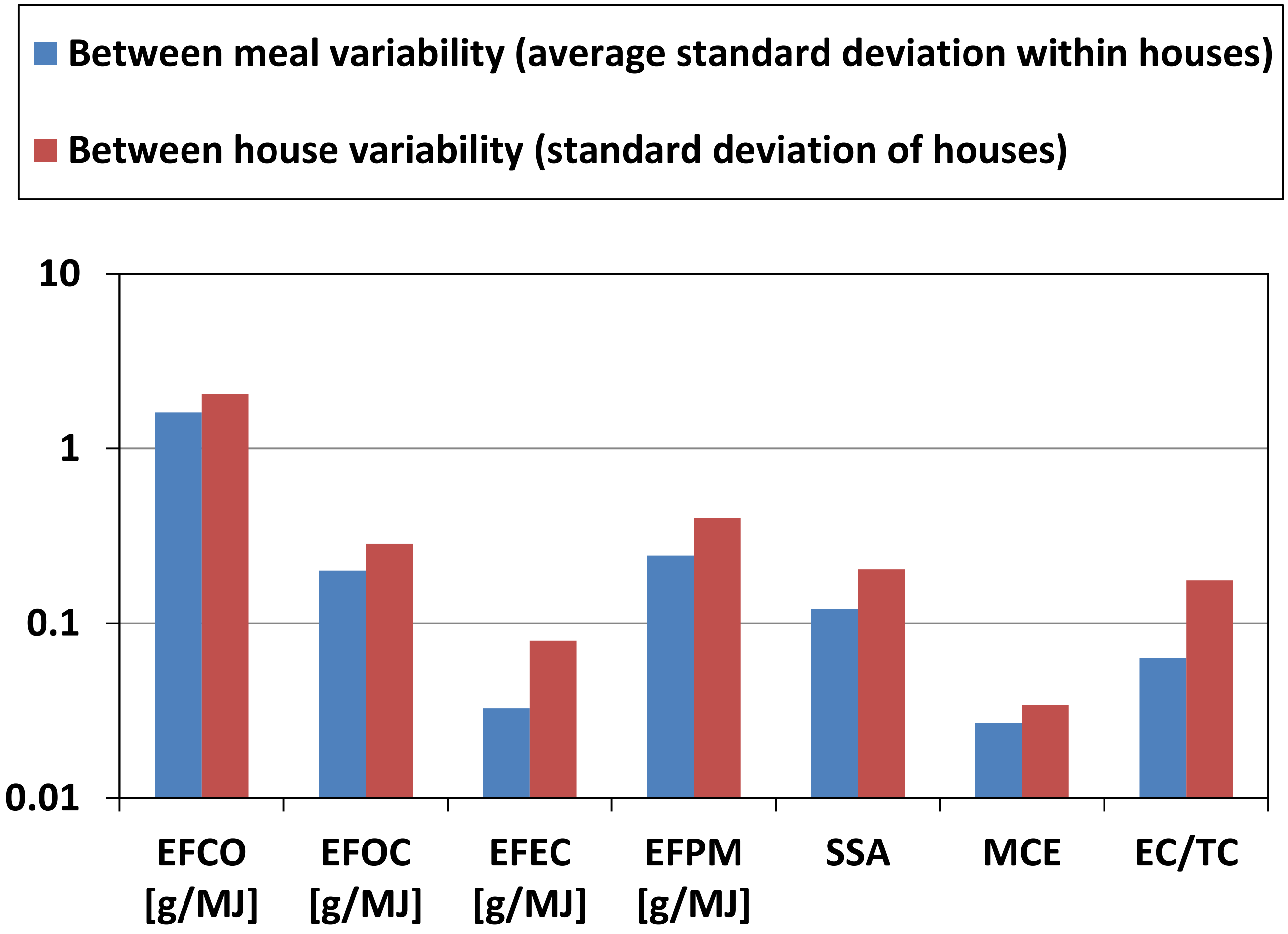
PM g/kg





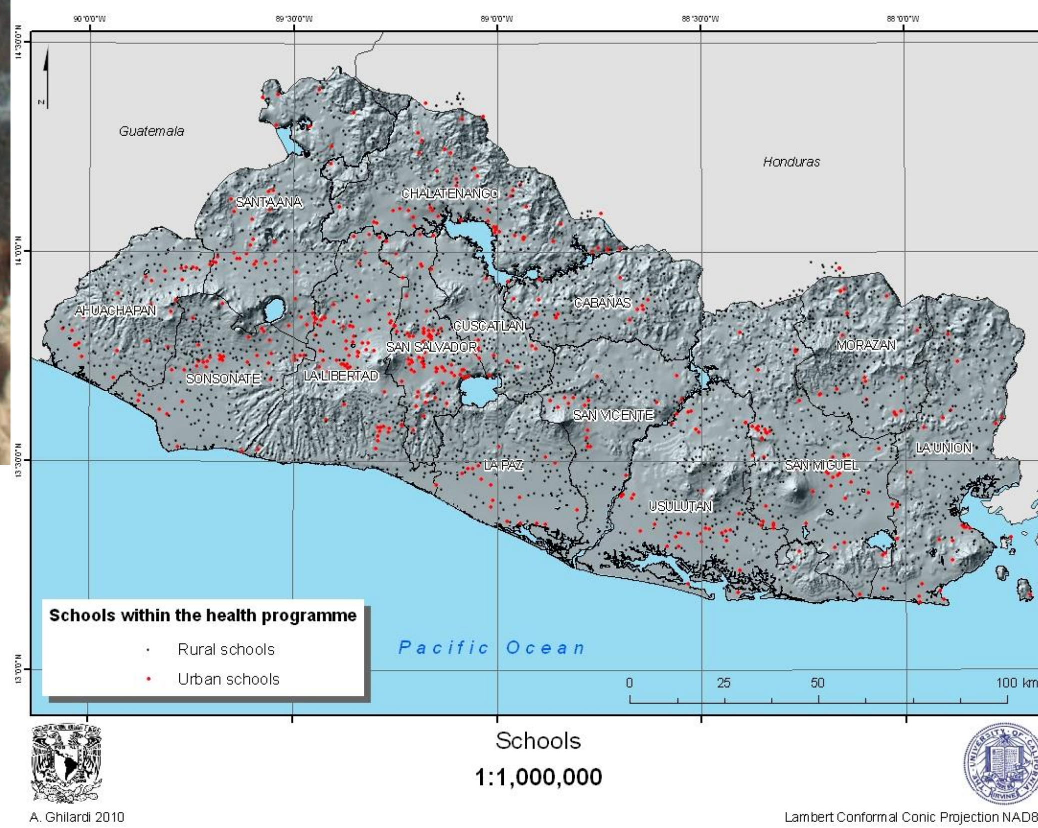
Yunnan: between meal and between house

Note: Log Scale



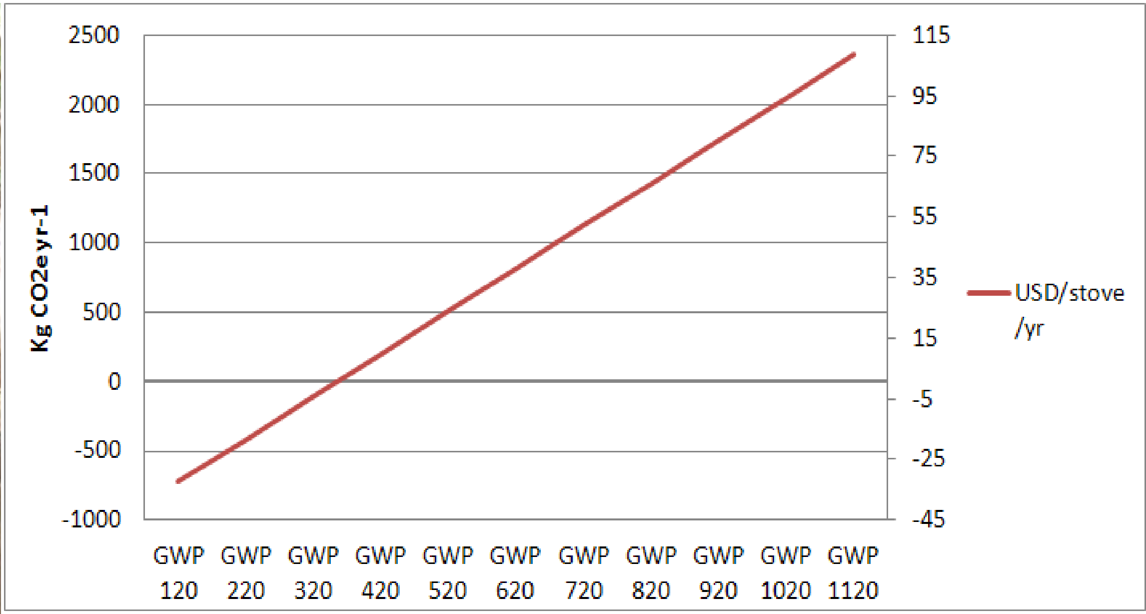
Objective 3

Estimate the potential of advanced combustion biomass stoves to mitigate emissions



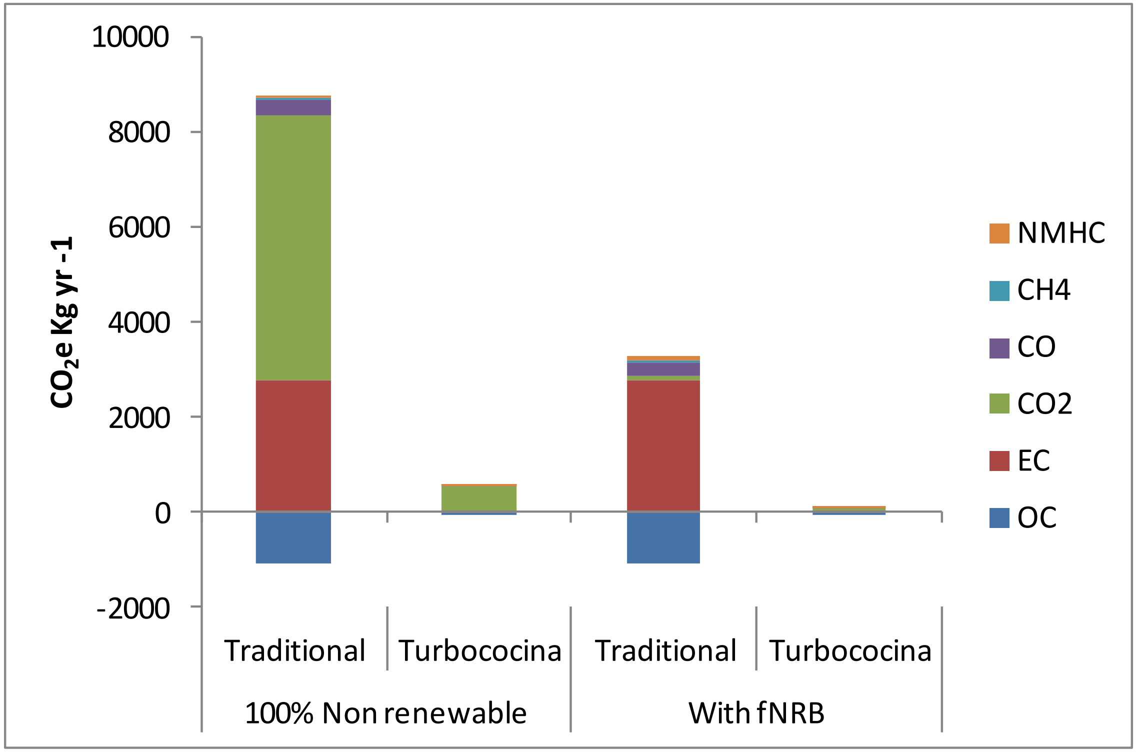
Potential for mitigation

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)$^{-1}$ – equivalent to USD (tonne CO_2)$^{-1}$

Potential for mitigation in homes



Using GWC for EC of 900.
Equivalent to 100 USD per stove per year @ 47 USD tonne CO_2e^{-1}
IMPLICATIONS
- Amounts are significant to defray technology costs if they truly reduce emissions
- If realistic fNRB estimates used CO_2e 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 $PM_{2.5}$

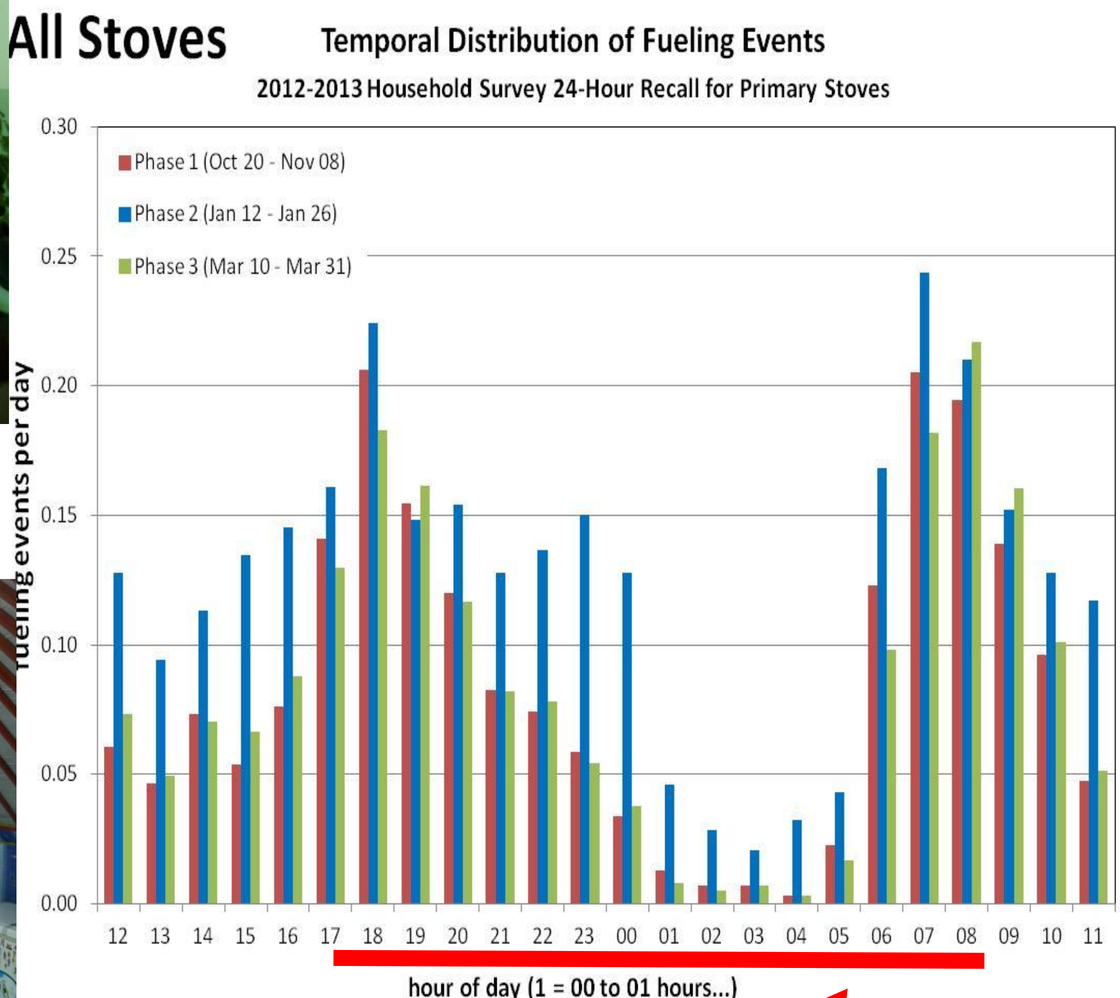
Emissions rate targets (ERT)	Emission rate (mg/min)	Percentage of kitchens meeting AQG (10 µg/m³)	Percentage of kitchens meeting AQG IT-1 (35 µg/m³)
Unvented			
Intermediate ERT	1.75	6	60
ERT	0.23	90	100
Vented			
Intermediate ERT	7.15	9	60
ERT	0.80	90	100

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



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 $PM_{2.5}$ ($g\ PM_{2.5}/kg$ coal)	MCA	98	2.3	4.3		
	Traditional	95	6.5	7.0	65%	<0.01
Nighttime $PM_{2.5}$ ($g\ PM_{2.5}/day$)	MCA	97	32	71		
	Traditional	95	102	148	69%	<0.01
Nighttime CO (g CO/kg coal)	MCA	98	60	32		
	Traditional	95	72	32	16%	0.01

70% from gers, 50% from houses

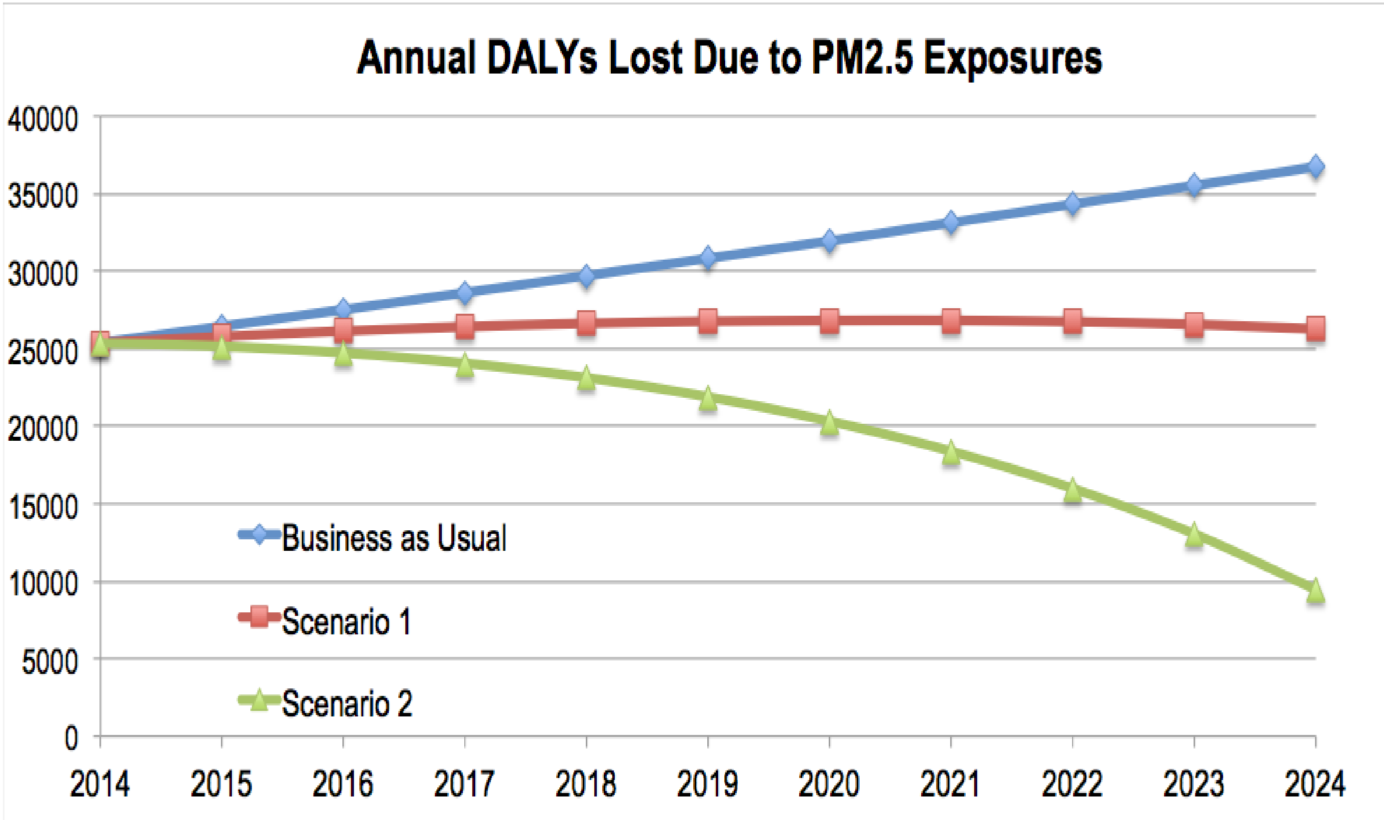
Modeled health impacts : 2012- 2013 reduction in health burden

- 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 population-weighted 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.

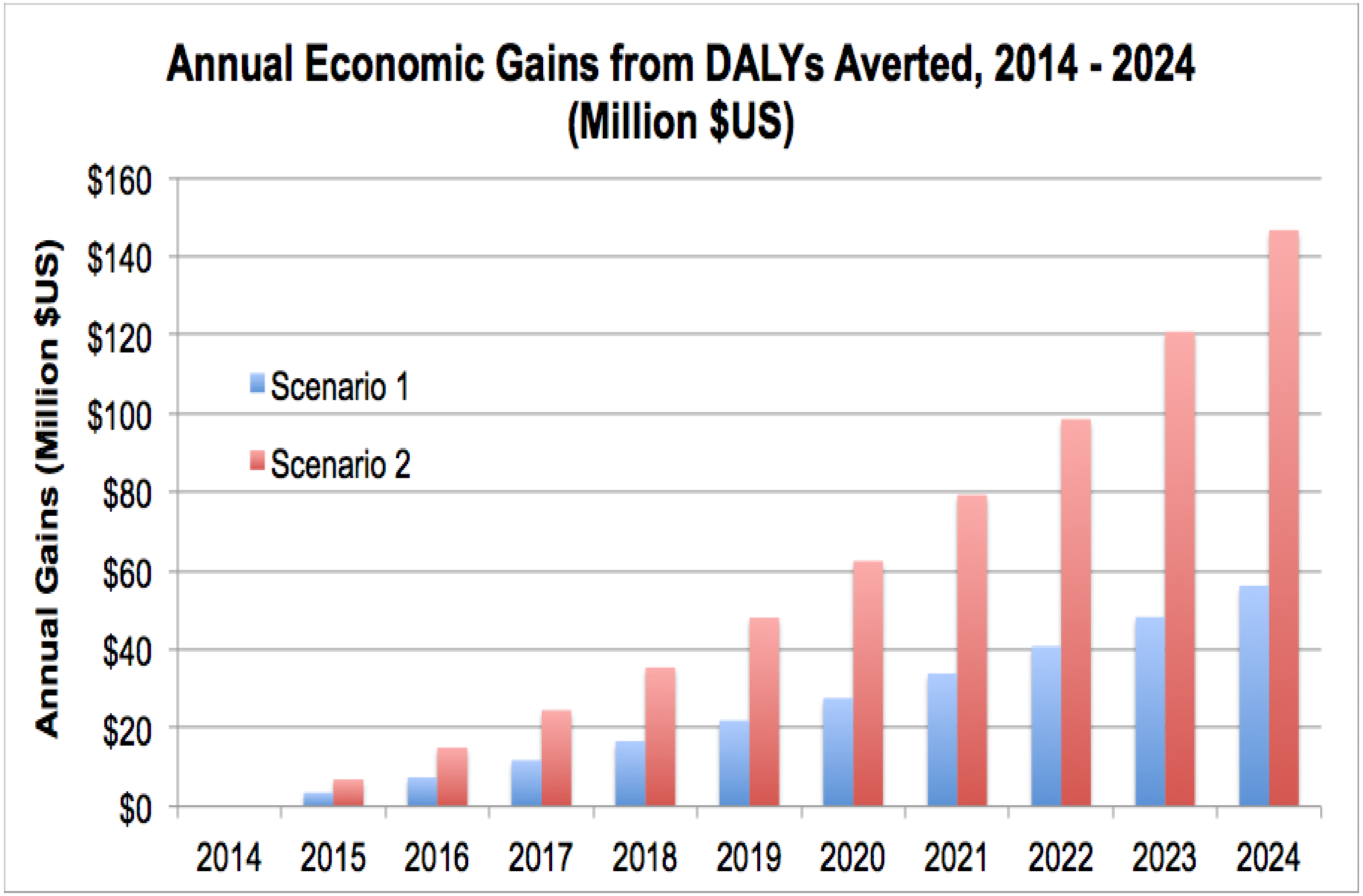
“What health benefits could be expected from cleaner household stoves and fuels and associated emissions reductions in other sectors by 2025?”



- **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.

Courtesy; Chimedsuren O. and Smith K.R. et al ., 2014; Air Pollution and Health in Ulaanbaatar – final project report

Economic gains



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

Courtesy; Chimedsuren O. and Smith K.R. et al ., 2014; Air Pollution and Health in Ulaanbaatar – final project report

Thank you

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