Energy Poverty and Climate Change Mitigation: the case of Household Sector in India

Chetana Chaudhuri

Doctoral Fellow

Jawaharlal Nehru University

India

- Climate Change is a global problem and all the countries are going to face the consequences.
- This problem is closely linked to the issue of growth and development, especially in the developing countries.
- The Fourth Assessment Report of IPCC states that global warming can have devastating impact on the climate of earth and are capable of affecting the health status of millions of people, through increases in malnutrition, disorder in child growth and development, with increased death, disease and injury due to heat waves, floods, storms, fires and drought.
- All the nations together have to reduce our carbon footprint.

- India is the second most populous country of the world with population of 1.21 billion (Census 2011).
- Census 2011 reveals that 66 percent households live in rural area.
- a major portion of the households depends on biomass and fossil fuel for their basic direct energy end-uses like cooking and lighting.
- The equipment used for these purposes are of very low energy efficiency, which leads to increase in budget for energy.

- Easy availability of fuelwood attracts people to use fuelwood for cooking, which not only leads to environmental degradation, but also huge opportunity cost of collecting fuelwoods and high human health risk due to indoor air pollution.
- People use kerosene in inefficient lamps which leads to inefficient use of fossil fuel as well as cause health hazard.
- With such level of poverty and deprivation, the overall development will occur if the growth process becomes more inclusive, where the "inclusiveness" implies the fast removal of poverty , generation of employment and equitable distribution of benefits of growth and particularly human capability development through education, health, and other basic amenities like clean energy, safe water etc.

- The problem of climate change has been recognized by all the countries.
- IPCC was set up in 1988
- United Nations Framework Convention on Climate Change (UNFCCC) was adopted at Rio Summit in 1992
- Kyoto Protocol(1997) introduced three market based mechanisms: Joint Implementation (JI), Clean Development Mechanism (CDM) and Emission Trading (ET).
- Developed countries can invest in emission-reduction mitigation projects through CDM in developing countries and can earn certified emission reduction credits. These credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol.

- Here in this paper, we try to see the relevance of CDM in household sector of India.
- To do so, we first we discuss the present situation of energy poverty in India.
- In India, people are not only deprived of the access of clean energy, but also the physical amount of energy is not sufficient.
- Additionally, we have seen the total physical amount of different energy carriers used in Indian household for cooking and lighting, which leads to emission of green house gases in the atmosphere.

Share of households using various energy carriers for cooking (%)

Rural						
Expenditure Class	% of population in an expenditure group	Biomass	Kerosene	LPG	Others	Total
< $0.5 a day	43.72	35.18	0.16	0.62	2.14	38.09
between $0.5 and $1 a day	45.80	39.78	0.39	5.99	1.80	47.96
between $ 1 and $2 a day	9.27	6.51	0.20	4.52	0.55	11.78
more than $2 a day	1.21	0.55	0.04	0.96	0.62	2.17
Total	100.00	82.02	0.79	12.09	5.11	100.00

Share of households using various energy carriers for cooking (%)

Urban						
Expenditure Class	percentage of population in an expenditure group	Biomass	Kerosene	LPG	Others	Total
< $0.5 a day	13.88	6.58	0.49	1.95	1.09	10.12
between $0.5 and $1 a day	41.11	10.36	2.96	19.93	2.39	35.64
between $ 1 and $2 a day	31.83	1.85	2.58	27.74	3.07	35.24
more than $2 a day	13.18	0.15	0.34	14.97	3.53	19.00
Total	100.00	18.94	6.38	64.59	10.09	100.00

Share of households using various energy carriers for lighting (%)

Rural					
Expenditure Class	percentage of population in an expenditure group	Kerosene	Electricity	Others	Total
< $0.5 a day	43.72	19.29	18.42	0.38	38.09
between $0.5 and $1 a day	45.80	12.95	34.60	0.42	47.96
between $ 1 and $2 a day	9.27	1.22	10.50	0.06	11.78
more than $2 a day	1.21	0.09	2.07	0.02	2.17
Total	100.00	33.53	65.59	0.87	100.00

Share of households using various energy carriers for lighting (%)

Urban					
Expenditure Class	percentage of population in an expenditure group	Kerosene	Electricity	Others	Total
< $0.5 a day	13.88	2.31	7.69	0.12	10.12
between $0.5 and $1 a day	41.11	2.09	33.29	0.26	35.64
between $ 1 and $2 a day	31.83	0.39	34.57	0.28	35.24
more than $2 a day	13.18	0.06	18.25	0.70	19.00
Total	100.00	4.85	93.79	1.36	100.00

Per capita energy consumption for cooking (in physical unit)(per day in MJ)

Rural				
Expenditure Class	percentage of population in an expenditure group	Biomass	Kerosene	LPG
< $0.5 a day	43.72	1.80	0.17	0.03
between $0.5 and $1 a day	45.80	2.25	0.19	0.32
between $ 1 and $2 a day	9.27	2.06	0.18	1.22
more than $2 a day	1.21	1.99	0.16	1.90

Per capita energy consumption for cooking (in physical unit)(per day in MJ)

Urban				
Expenditure Class	percentage of population in an expenditure group	Biomass	Kerosene	LPG
< $0.5 a day	13.88	1.09	0.16	0.37
between $0.5 and $1 a day	41.11	0.68	0.18	1.31
between $ 1 and $2 a day	31.83	0.21	0.12	2.37
more than $2 a day	13.18	0.09	0.04	3.03

Per capita energy consumption for lighting (in physical unit)

Rural			
Expenditure Class	percentage of population in an expenditure group	Kerosene (litre)	Electricity (KWH)
< $0.5 a day	43.72	4.11	44.23
between $0.5 and $1 a day	45.80	4.76	107.74
between $ 1 and $2 a day	9.27	4.34	218.13
more than $2 a day	1.21	4.04	352.20

Per capita energy consumption for lighting (in physical unit)

Urban			
Expenditure Class	percentage of population in an expenditure group	Kerosene (litre)	Electricity (KWH)
< $0.5 a day	13.88	3.89	83.62
between $0.5 and $1 a day	41.11	4.35	182.59
between $ 1 and $2 a day	31.83	2.93	372.45
more than $2 a day	13.18	0.99	735.70

Total consumption of fuels for cooking (in physical unit)

Rural				
Expenditure Class	percentage of population in an expenditure group	Biomass (Million Tonnes)	Kerosene (Million Litre)	LPG (Million Tonnes)
< $0.5 a day	43.72	77.45	844.73	0.12
between $0.5 and $1 a day	45.80	101.31	1025.03	1.45
between $ 1 and $2 a day	9.27	18.76	189.09	1.11
more than $2 a day	1.21	2.37	22.91	0.22
Total	100	199.88	2081.75	2.90

Total consumption of fuels for cooking (in physical unit)

Urban				
Expenditure Class	percentage of population in an expenditure group	Biomass (Million Tonnes)	Kerosene (Million Litre)	LPG (Million Tonnes)
< $0.5 a day	13.88	5.49	94.11	0.19
between $0.5 and $1 a day	41.11	10.13	311.71	1.96
between $ 1 and $2 a day	31.83	2.40	162.61	2.73
more than $2 a day	13.18	0.43	22.62	1.45
Total	100.00	18.45	591.05	6.33

Total energy consumption for lighting (in physical unit)

Rural			
Expenditure Class	percentage of population in an expenditure group	Kerosene (million litre)	Electricity (GWH)
< $0.5 a day	43.7	1368.7	14719.0
between $0.5 and $1 a day	45.8	1660.9	37559.5
between $ 1 and $2 a day	9.3	306.4	15393.2
more than $2 a day	1.2	37.1	3238.1
Total	100.0	3373	70910

Total energy consumption for lighting (in physical unit)

Urban			
Expenditure Class	percentage of population in an expenditure group	Kerosene (million litre)	Electricity (GWH)
< $0.5 a day	13.9	152.5	3274.8
between $0.5 and $1 a day	41.1	505.1	21181.2
between $ 1 and $2 a day	31.8	263.5	33456.4
more than $2 a day	13.2	36.7	27372.3
Total	100.0	958	85285

Projection of Energy Poverty

- The prevalent energy consumption pattern provided the basis of calculating the estimate of future demand of a particular energy carrier.
- Per capita expenditure is considered to be the basis of choice of a particular carrier.
- A logit model is used to estimate the future consumption of biomass as a fuel.

- With current growth rate of GDP and per capita final expenditure, we obtain the GDP elasticity of PFCE. We assume that the rate growth of the per capita consumption expenditure to be the same as that of the per capita PFCE. As per the data of the NAS of CSO, the GDP elasticity of PFCE is found to be 0.56. With this elasticity, a 7% growth of GDP would imply 3.9% annual rate of growth of PFCE expenditure of the household. Assuming the population growth rate of India to be 1.64% for the future as given by the projection given in the Census of India 2011, we obtain the per capita GDP growth rate of consumption to be 2.2% approximately for the 7% GDP growth rate. We assume that the elasticity of household consumption with respect to GDP to be the same as that of the private final consumption expenditure. Using this as the growth rate of marginal per capita consumption expenditure we get the estimated number of households depending on the unclean sources of energy.

	total number of households depending on the unclean fuel for cooking in 2020 (million)	
	Biomass	Kerosene
Rural	238.7	115.6
Urban	38.3	67.1

As we can see from the table, without any policy intervention, by 2020, still 4387 million households in rural area will depend on biomass as their primary fuel. These households have huge potential of emission in the atmosphere also. Burning of these fuels will not only pollute atmosphere but also will lead to deforestation, higher dependence on fossil fuel and large environmental and ecological footprint.

Potential for CDM

- Introduction of efficient technology will not only reduce energy consumption level, but also enhance the quality of life.
- Keeping this in mind, CDM is considered as an option to mitigate the problem.
- Till 1st August, 2012, 4386 CDM projects has been registered by CDM Executive Board, among which 858 projects are in India.
- Cost and benefir analysis of the abatement programme can show us the advantage of introduction of CDM.

rural	Efficiency	Capital Cost	Fuel Use	Unit	Energy use/unit	Energy use	Fuel Price	Energy cost/ year	Annualised capital cost	Total annual cost	CO2 emissions/ unit	Total CO2 emissions
	%	Rs	per family / year		GJ/unit	GJ	Rs/ unit	Rs	Rs/ year	Rs	kg/GJ	Kg
COOKING												
Traditional woodstoves	15	25	1522.6	kg	0.01884	28.687	2	3045.3	6.5949	3051.90	105	3012.2
Effcient woodstoves	30	1600	761.32	kg	0.01884	14.343	2	1522.6	260.39	1783.04	105	1506.1
Traditional kerosene stoves	30	125	102.65	lt	0.05366	5.5086	12.6	1293	25.675	1319.12	70.4	387.80
Efficient kerosene stoves	45	300	68.436	lt	0.05366	3.6724	12.6	862.29	48.823	911.120	70.4	258.53

urban	Efficiency	Capital Cost	Fuel Use	Unit	Energy use/unit	Energy use	Fuel Price	Energy cost/ year	Annualised capital cost	Total annual cost	CO2 emissions/ unit	Total CO2 emissions
	%	Rs	per family/ year		GJ/unit	GJ	Rs/ unit	Rs	Rs/ year	Rs	kg/GJ	Kg
COOKING												
Traditional woodstoves	15	25	1288.2	kg	0.0188	24.270	2	2576.43	6.1048	2582.5388	105	2548.43
Effcient woodstoves	30	1600	644.10	kg	0.0188	12.135	2	1288.21	245.65	1533.8713	105	1274.21
Traditional kerosene stoves	30	125	140.48	lt	0.0536	7.5385	12.6	1770	23.959	1794.0244	70.4	530.713
Efficient kerosene stoves	45	300	93.654	lt	0.0536	5.0256	12.6	1180.04	46.060	1226.1032	70.4	353.808

	Capital Cost	Fuel Use	Unit	Energy use/unit	Energy use	Fuel Price	Energy cost/ year	Annualised capital cost	Total annual cost	CO2 emissions/ unit	Total CO2 emissions
LIGHTING	Rs	KWh / year		GJ/unit	GJ	Rs/ std unit	Rs	Rs/ year	Rs	Kg/KWh	Kg
Incandescent bulb (40 W) (450 lumens)	12	43.8	KWh	0.00036	0.01576	3	131.4	4.428044	135.8280	0.6972	30.53736
Compact Flurosecnt Bulb (10W) (450 lumens)	175	10.95	KWh	0.00036	0.00394	3	32.85	64.57564	97.42564	0.6972	7.63434
Incandescent bulb (60 W) (800 lumens)	12	65.7	KWh	0.00036	0.02365	3	197.1	4.428044	201.5280	0.6972	45.80604
Compact Flurosecnt Bulb (13W) (800 lumens)	181	14.235	KWh	0.00036	0.00512	3	42.705	66.78966	109.4946	0.6972	9.924642

COOKING	Investment	energy saving	Emission Reduction	CER price	CER revenue per year	Revenue over 10 years	Net profit	Payback period	NPV revenue at 8% discount rate	Net profit at 8% discount rate
	$	GJ/year	Kg	$/tCO2	$	$	$		$	$
from Traditional woodstoves to Effcient woodstoves	32	14.3438	1506.106	8	12.0488	120.488	88.488	5	48.1075	16.107
from Traditional kerosene stoves to Efficient kerosene stoves	2.5	1.83622	129.2699	8	1.03416	10.3416	7.8415	5	4.12909	1.6290

LIGHTING	Investment	energy saving	Emission Reduction	CER price	CER revenue per year	Revenue over 10 years	Net profit	Payback period	NPV revenue at 8% discount rate	Net profit at 8% discount rate
	$	GJ/year	Kg	$/tCO2	$	$	$		$	$
from Incandescent bulb (40 W) (450 lumens) to Compact Flurosecnt Bulb (10W) (450 lumens)	3.5	0.0118	22.9030	8	0.18322	1.83224	-1.6677	5	0.73156	-2.76844
From Incandescent bulb (60 W) (800 lumens) to Compact Flurosecnt Bulb (13W) (800 lumens)	3.62	0.0185	35.8813	8	0.28705	2.87051	-0.7494	5	1.14611	-2.47389

Conclusion

- In a developing country like India with a large volume of population, improvement of energy efficiency can be a useful measure for reduction of GHG.
- As we have seen energy efficiency in household sector for cooking devices can be a source of profit. The analysis here is done for a single household. The cumulative profit for a project of size 10000 or more households can be of huge potential.
- Apart from the monetary benefit, the household can benefit from the saved energy and the saved additional expenses assigned to it.
- Energy efficiency CDM projects depend on a lot of other factors, which are some time project specific like location, attitude of people, duration of the project, choice of technology and carrier etc. But it can be concluded that cooking energy efficiency projects has huge potential for shifting fuels to cleaner one and also for generating significant financial flow.

Thank You