Indoor air pollution and Decarbonization from residential sector of India

NIES JAPAN **Satish Kumar YAWALE[1], Tatsuya HANAOKA[2], Manmohan KAPSHE[3]**

1: National Institute for Environmental Studies, 2: National Institute for Environmental Studies (NIES), Tsukuba Japan, 3: Maulana Azad National Institute of Technology (NITB) Bhopal India.

1. Background

Indoor air pollution is cited as the second leading risk factor for mortality and morbidity from traditional energy (biomass) consumption in Indian households. Per capita GDP and urbanization accelerate the energy transition and helps in reducing the indoor air pollution. However, due to this transition from traditional energy to advance energy (LPG and electricity), carbon emission might increase rapidly.

Q. What is the energy and emission profile over the next half century (up to 2070) ?

Q. By 2070, will low-developing states of India remain vulnerable to indoor air pollutions and carbon emission ?

Q. What is the role of renewables in reducing indoor air pollution and mitigating carbon emission from residential sector?

2. Methodology

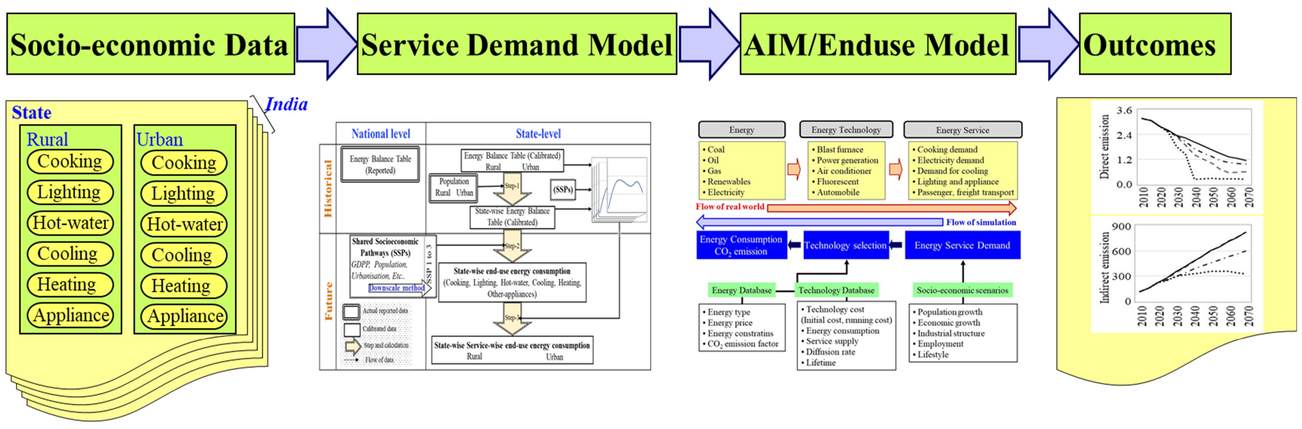


Table 1: Emission factors of pollutants by each energy type.

##Gas / Energy	PM[#]	BC	OC[#]	CH_4	CO	N_2O[#]	SO_2[#]	CO_2	NO_X[#]
Biomass	2.1E-4, 1.0E-3[e], 9.2E-4[f], 4.0E-4[#1], 5.8E-4[b], 7.7E-4[g], 3.0E-4[h], 2.8E-4[#1], 1.6E-4[#1], 8.6E-4[i], 2.7E-4[j]	8.0E-5	1.9E-4, 2.3E-4[e], 2.1E-4[f], 7.2E-5[a], 1.5E-4[b], 2.0E-4[g], 8.0E-5[c], 4.3E-5[d], 2.3E-4[i]	4.3E-4	4.9E-3	1.3E-5	4.6E-5, 7.2E-5[a], 2.7E-5[b], 7.3E-5[c], 2.9E-5[d]		4.0E-5, 7.0E-5[a], 4.0E-5[b], 2.8E-4[c], 4.3E-5[d]
Coal	2.9E-4	1.0E-4	1.3E-4	3.0E-4	3.5E-3	1.7E-6	5.2E-4	9.1E-2	8.0E-5
Charcoal	5.9E-5	2.2E-5	3.5E-5	1.3E-4	6.1E-3	7.8E-6	4.8E-4	9.5E-2	4.5E-5
Kerosene	7.2E-5	4.1E-4	7.1E-6	1.0E-5	5.8E-4	1.9E-6	5.7E-5	6.7E-2	
LPG	6.9E-6		1.3E-6	3.0E-6		3.2E-6	6.8E-6	6.4E-2	
Electricity	5.0E-05	2.8E-7	8.7E-7	1.0E-6	4.0E-5	5.2E-6	2.0E-4	5.6E-2	1.3E-4

PM: Particulate Matters BC: Black Carbon OC: Organic Carbon CH_4: Methane CO: Carbon Mono-oxide N_2O: Nitrous Oxide SO_2: Sulphur Di-oxide CO_2: Carbon Di-oxide NO_X: Oxides of Nitrogen

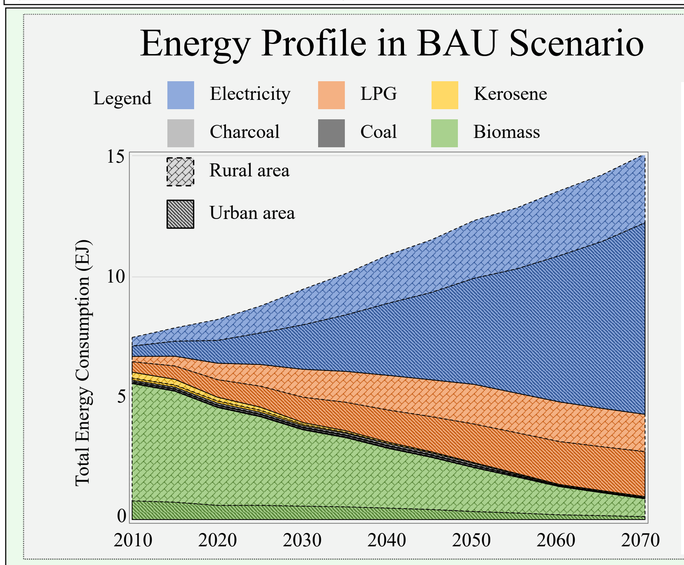
[#]Note: The superscript represents emission factors in specific state (*a*: Gujarat, *b*: Himachal Pradesh, *c*: Maharashtra, *d*: Rajasthan, *e*: Delhi, *f*: Bihar & Jharkhand, *g*: Haryana, Punjab & Chandigarh, *h*: Madhya Pradesh & Chhattisgarh, *i*: Uttar Pradesh and Uttarakhand, *j*: West Bangle)

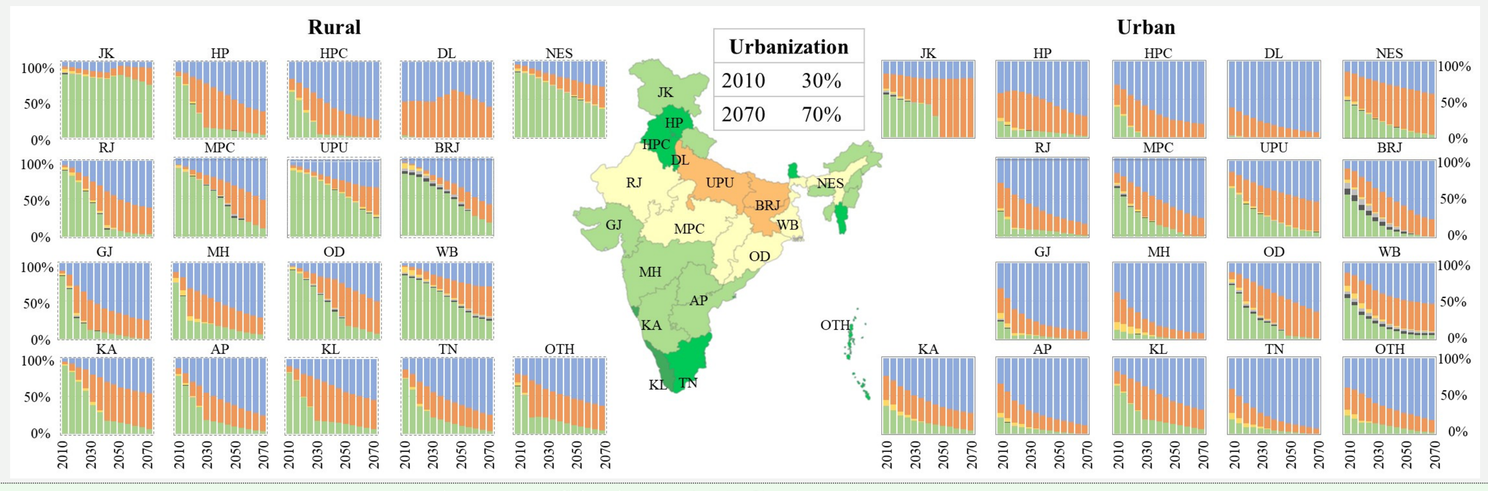
[#1]Sen et al. (2014) and Saud et al., (2011a; 2011b); Sen et al. (2014); Saud et al. (2011a; 2011b); Saxena et al. (2016). Parashar et al. (2005), Pandey, Sadavarte, Rao, & Venkataraman, 2014; Sharma & Dasappa, 2017; Roden, Bond, Conway, & Pinel, 2006; Akagi, et al., 2011; TERI GOI, 2006; Saud, et al., 2013.

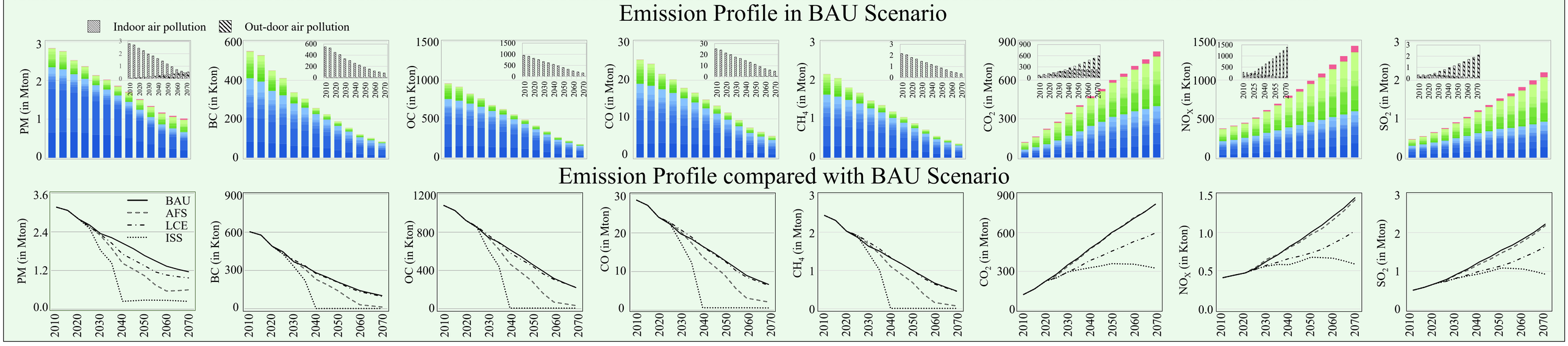
Table 2: Assumption, policy options and enhancement for decarbonization pathways.

Scenarios	Enhancement	Policy options	Assumptions
Business As Usual (BAU)			The historical trends will be continued. Urban population of India would be 70% in 2070 compared to 33% in 2020.
Advance Fuel Substitution (AFS)	Advance fuel for cooking service Solar device installation at site	Supply of more LPG than demanded Enhance the solar utilization Subsidy on solar water heater, lighting and solar cooker	To enhance the SDG-7, clean & affordable energy. To accelerate the use of solar in the residential sector. Energy access of advance fuel increases
Low Carbon Electrification (LCE)	Electricity from Renewable sources Advance fuel for cooking service	GOI plans to implement 40% of electricity from renewable source Enhancing solar utilization	To analyze the GOI plan 40% of renewable electricity by 2030 and continue till 2070. To meet NDC target.
Integrated for Sustainable Society (ISS)	Integrate all enhancements together	Renewable electricity in India. (2030-39%; 2050-50% and 2070- 70%)	All the measures taken in advance fuel substitution and low carbon electrification are integrated. In addition, energy use in cooking service will majorly change.

3. Results







4. Key Findings

Majority of the India's population reside in low developing states (LDS). Household in LDS relied on traditional biomass because of less income. Therefore, LDS are vulnerable to the indoor air pollution. Due to energy transition in next half century, indoor air pollution will decrease whereas outdoor air pollution from electricity consumption will increase rapidly.

Impact on both environment and health would be severe if no counter measure were taken to mitigate these pollutions.

With enhancement in fuel subsidy, India would achieve net-zero BC emission by 2040.

Additional enhancement in renewable electricity would help in mitigating 70% of the CO2 emission in 2070.