User Guide for India's 2047 Energy Calculator

Cooking Sector

NOTE: The documentation refers to GDP Growth rate of 7.4% CAGR till 2047. For more information on GDP-Demand scenarios, please visit www.indiaenergy.com

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I. Overview of the Sector

I.a Current Scenario

Currently, in a country with 25 cr. households, 31% urbanisation (Census 2011) and a per capita income of Rs 39,143 (CSO 2013) approximately 1104 TWh of energy is used for domestic cooking. Primary source of fuel used for cooking determines energy and time required for cooking as well the health impacts due to cooking activities. Currently, 87% of rural households and 26% of urban households depend on biomass for cooking. Using biomass is inconvenient as procuring the fuel takes up time, requires effort and its use poses severe ill effects on health. In fact, 400 million people in India (of which 90% are women) are exposed to the negative health impacts associated with indoor air pollution from use of biomass, resulting in respiratory, pulmonary and vision problems. In addition to the health impacts, there is more drudgery as women spend up to 5-8 hours per day on cooking activities, with 20% of that time devoted to the collection of fuel (Global Alliance for Clean Cookstoves 2013). Additionally, energy per unit of biomass is less than half that of modern sources of fuel and its efficiency of use is significantly lower (Ravindranath and Ramakirshna 1997) (Venkatraman, et al. 2010). When it comes to modern fuels, only 29% of households use LPG and 0.1% of households use electricity as a primary source of cooking fuel (Census 2011). This could be because of lack of reliable affordable access to electricity and bottlenecks in supply of LPG, especially in rural areas. Switching to modern fuels such as electricity, PNG and LPG is desirable as they are more efficient, clean and will not affect final energy demand significantly.

I.b The increasing role of modern fuel sources

The implicit assumption in this estimation is that the role of modern sources of energy will increase significantly in the coming years. Although there is little understanding of the nature of evolution of domestic and commercial cooking, it is assumed that with growth and development, cooking fuel preferences in India will largely resemble developed nations of today. Currently, 63% of the households in USA use electricity for cooking, 35% use natural gas and 5% use LPG (IEA 2009). 51% of UK's cooking demand is met by gas and 48% is met by electricity (Department of Energy and Climate Change, UK). With increased access to modern fuels, households will switch between fuels based on convenience, location, real, pecuniary costs and purchasing power.

I.c Fuel Switching and its Determinants

Fuel switching to modern sources will be more prevalent in rural areas due to the current dependence on biomass and inconveniences/risks associated with it. Even though households will continue to use multiple sources of fuel to optimise on available resources, the switching from traditional fuels to modern fuels as the primary source of fuel for cooking will greatly increase welfare. However, rural consumption has been increasing at 8% per annum and rural households keep aside about 5% to 6% of their monthly expenditure for cooking fuel related needs (NSSO 2009). Therefore in the future, cost could become more of a concern in influencing the use of modern fuels like LPG in rural areas. Pro-poor

growth policies like conditional cash transfers and subsidies can expand consumption choices of the poor by boosting purchasing power (Gertler, et al. 2013). Therefore, in the future, implementation of cash transfer programs can assist households in choosing cleaner, more convenient fuels without costs being a barrier to uptake. Moreover, the investment needed to switch to modern fuels or switch between modern fuels is not prohibitive. Therefore cost of fuels and price of cooking appliances are not considered a barrier to accessing modern cooking fuels.

Urban households will switch from LPG to PNG due to convenience and efficiency concerns. This switch will be aided by the fact that the piped gas network can be made easily available in densely populated urban areas as it is more efficient, convenient than LPG. Even in rural areas, PNG networks could be established in certain densely populated settlements, which could aid PNG penetration. Even though electricity is an efficient, convenient source of cooking fuel, and assuming reliable hours of electricity supply is possible for all households in the future, majority of urban and rural households may not switch to electricity, although it will still play a major role. This is assumed based on a strong preference for gas based cooking in India. Access to LPG in rural India is bound to increase from its current levels given the push from programs like RGGLVY (Ministry of Petroleum and Natural Gas 2009). Therefore, in the future, most of India will use a mix of LPG, PNG and electricity to satisfy its cooking needs. Adoption of biogas will be prevalent especially during the transitory phase in rural areas where households are weaning away from biomass to modern sources of fuel. However with increased penetration of modern fuels the rate of biogas adoption will increase at a decreasing rate. The use of solar cookers will also increase with better cookers available in the market but due to the convenience, reliability of modern sources, path dependence on cook stoves due to prevalent cooking habits, their uptake may not be much and their use will be in conjunction with other sources of fuel. Therefore in all four pathways, households decrease use of biomass and switch between LPG, PNG and electricity to meet their unchanging specific energy demand for cooking.

II. Existing Legal/Regulatory and Policy Framework

Cooking can be done with many different sources of fuel and most of the governance frameworks which affect energy needed for cooking are tied to the fuel used. Given below are the Ministries and Regulatory Bodies which the provision of these cooking fuels is influenced by.

Fuels	Policies of	Regulated/Monitored by
LPG	Ministry of Petroleum and Natural Gas (MoPNG)	Petroleum and Natural Gas Regulatory Board (PNGRB)
PNG	Ministry of Petroleum and Natural Gas	Petroleum and Natural Gas Regulatory Board
Electricity	Ministry of Power (MoP)	State Electricity Regulatory Commission (SERC)
Biogas	Ministry of New and Renewable Energy (MNRE)	State Nodal Agency/Agency appointed by MNRE

The efficiency of cook stoves has a direct influence on fuel consumption of the stove. Domestic Gas Stoves are part of the voluntary standards and labelling program of the Bureau of Energy Efficiency. The National Biomass Cook stoves Initiative has been improving the efficiency and reducing emissions from biomass cook stoves.

National Programs with respect to energy needed for cooking:

- *Rajiv Gandhi Grameen LPG Vitaran Yojana (RGGLVY)* –Launched in 2009 by MoPNG, the scheme aims to increase rural access of LPG by setting up distribution agencies by providing dealerships for small sized low cost agencies which provide at least 600 cylinders per month. The agencies are meant to be small scale, self-operated by young entrepreneurs selected by a draw of lots from among candidates who meet financial and educational criteria. There is no home delivery of cylinders in this scheme and it would work for densely populated rural clusters. The scheme aims to ensure that 75 per cent population has LPG connections by releasing 5.5 crore new LPG connections. As on 7th May 2013, 1845 distributors have been appointed under RGGLVY (PIB, 2013)
- *National Biomass Cook stoves Programme (NBCP)*-Launched in 2009 by MNRE, National Biomass Cook stoves Initiative succeeded the National Program for Improved Chulhas (NPIC). Fuel efficiency was the major focus of NPIC but with better understanding of health benefits, need for quality service and climate change the NBP aimed to provide the same quality of energy service as LPG with biomass cook stoves (Venkatraman, Sagar, Habib, Lam, & Smith, 2010). Therefore the focus of the NBCP was to develop cook stoves which are fuel efficient, and cost efficient with reduced emissions. Now, re-christened the Unnat Chulha Abhiyan, the program aims to install 2.75 million chulhas in the 12th Five Year Plan.87% of these stoves are family type or household cook stoves and the rest are community sized cook stoves. The program also aims to support R&D activities on development of efficient and

cost effective designs, support performance testing as per BIS, revise test protocols and standards, explore delivery models and leverage on PPPs.

- *Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)*-Launched in 2005, the scheme aims to provide universal access to electricity by extending the grid and by providing free connections to BPL households. Until the 11th plan the scheme covered villages with more than 300 households and managed to provide connections to over 2 crore BPL households in more than 1 lakh villages. Unfortunately there were delays in project implementation and cost overruns. Moreover APL households still had to pay connection charges which excluded many households who found the charge unaffordable. In the 12th plan the focus is to provide access to villages with more than 100 households, promote productive load and strengthen distribution network (Planning Commission, 2013). The total outlay for the plan from the 10th plan to the 12th plan works out to about Rs.70, 000 crores.
- *National Biogas and Manure Management Program (NBMMP)* - With the estimated possibility of more than 12 million family size biogas plants in the country (MNRE, 2013) and the co-benefit of organic rich fertiliser for farm use, biogas can be an important source of fuel for cooking in certain rural areas. Being in implementation since 1981,the program has installed 45 lakh plants by 31st March 2013.With monitoring and implementation agencies in place as well as with the biogas technology now reaching a stage of becoming robust and mature it is possible to scale up this technology in the future (Planning Commission, 2013). Moreover with rising LPG prices more and more rural consumers are opting for biogas plants as a viable alternative.

III. Drivers

Energy needed for cooking depends largely on the fuel used, energy conversion efficiency of the fuel, population growth, economic growth, government policies and urbanisation. Data suggests that on an average, a household uses about 8 to 10 LPG cylinders or 170 scm of PNG or 1022 kWh of electricity annually for cooking. Whether it is LPG, PNG or electricity, energy use due to modern fuels after accounting for stove efficiencies, roughly translates to an average use of 7 MJ/day or 1.94 kWh/ day. Therefore the average useful energy needed for cooking per day per household is approximately 7 MJ/day. There can be variations in the demand for energy needed for cooking a meal due to increased use of energy saving appliances like pressure cookers or due to change in eating habits (using pre-cooked or partially prepared meals, eating out, increased consumption of meat etc.).For this estimation, it is assumed that the average useful energy is constant over time. Given the average energy needed for cooking, there is no distinction made between commercial cooking and household energy demand for cooking as the cooking energy needed is to satisfy the requirement of the same population. Therefore energy needed for commercial cooking is implicit in this assessment. Hence, for estimating future demand for cooking, quantum of energy needed is assumed to increase proportional to the increase in number of households, economic growth, rate of urbanisation, fuel used, efficiency of fuel used and efficiency of cook stoves.

The drivers of cooking demand in the country as listed as follows:

- Fuel used and the energy conversion efficiency of the fuel
- Increasing energy efficiency of gas, electric and biomass stoves
- Government Programs for adoption of modern sources of fuel and efficient biomass cook stoves.
- Support provided to incentivise households to adopt modern sources
- Transformation in biomass cook stove manufacturing industry

IV. Assumptions

- On an average a household needs 7 MJ of useful energy per day to cook[1].
- Given this assumption, there is no distinction made between commercial cooking and cooking within the household as the average useful energy needed is the same and both cooking is done to satisfy the needs of the same population.
- It is assumed that with growth and development, cooking fuel preferences in India will largely resemble developed nations of today[2]. Therefore the role of modern sources of energy will increase significantly in the coming years.
- All biomass cook stoves will be replaced by efficient clean biomass cook stoves by 2032 in every scenario[3].
- The primary source of fuel accounts for most of the fuel used for cooking by the household. Therefore stacking of fuels though present is assumed to be such that there is only one and not two or three predominant sources of fuel.
- Implementation of cash transfer programs and similar subsidy programs will assist households in choosing modern, more convenient fuels without costs being a barrier to uptake.
- The investment needed to switch to modern fuels or switch between modern fuels is not prohibitive.
- Urban households will switch from LPG to PNG due to convenience and efficiency concerns. This switch will be aided by the fact that the piped gas network can be

[1] Data suggests that on an average, a household uses about 8 to 10 LPG cylinders or 170 scm of PNG or 1022 kWh of electricity annually for cooking. Whether it is LPG, PNG or electricity, energy use due to modern fuels after accounting for stove efficiencies, roughly translates to an average use of 7 MJ/day or 1.94 kWh/ day. There can be variations in the demand for energy needed for cooking a meal due to increased use of energy saving appliances like pressure cookers or due to change in eating habits (using pre-cooked or partially prepared meals, eating out, increased consumption of meat etc.)

[2] Currently, 63% of the households in USA use electricity for cooking, 35% use natural gas and 5% use LPG (IEA , 2009). 51% of UK's cooking demand is met by gas and 48% is met by electricity (Department of Energy and Climate Change,UK)

[3] This will happen if challenges before the nascent cook stove industry are addressed. A survey of 10 cook stoves manufactures in India shows that companies were unable to reach the poorest of the poor families who primarily use biomass for cooking as current prices exclude these households (Shrimali, Slaski, Thurber, & Zerriffi, 2011). With the right combination of enterprise funding, government support, management expertise, better designs, enterprises can scale up operations, reduce costs and increase market penetration.

made easily available in densely populated urban areas as it is more efficient, convenient than LPG. Even in rural areas, PNG networks could be established in certain densely populated settlements, which could aid PNG penetration.

- Reliable hours of electricity supply may not be incentive enough for majority of urban and rural households to switch to electricity. This is assumed based on a strong preference for gas based cooking in India. Access to LPG in rural India is bound to increase from its current levels given the push from programs like RGGLVY.

Therefore, in the future, most of India will use a mix of LPG, PNG and electricity to satisfy its cooking needs.

V. Cost

A method similar to the one described for residential lighting and appliances is used for cook stoves. Technology price of cook stoves will depend on technology improvements and material shortages. The cost incurred per household will depend on lifespan on stove, use over multiple fuels and change of stove due to fuel substitution. Improved biomass cook stove industry whose penetration we assume will ensure replacement of traditional biomass cook stoves by 2032 will see a reduction in costs only with scaling up of production and improvements in technology. Moreover provision of LPG, PNG and electricity connections would entail capital and recurring costs for laying and maintaining the network to ensure last mile connectivity[4]. For the purpose of this estimation, it is assumed that:

- Each household has only one cook stove determined by the primary source of fuel used.
- The life span of each cook stove remains constant over time even though there is efficiency improvement.
- Real costs change due to technology improvements or due to material shortages. The real costs for all stoves (except biomass improved cook stoves) increase over time.
- LPG and PNG use the same cook stove.
- At present penetration of improved cook stoves is low, the price estimation for biomass cook stove is the average price of traditional and improved stoves weighted by number of users of each technology in each year.
- Current stock of all cook stoves is expected to retire over the given lifespan of the stove. Therefore if the lifespan of gas stoves is 15 years then 1/15th of the current stock will retire in the next year.
- For last mile infrastructure provision, LPG, PNG and electricity connections may entail costs similar to the connection charges paid upfront by the consumers.
- In order to maintain the network and ensure the network is augmented to support additional demand more investments may be needed which needs to be accounted for. The network replacement or augmentation cost is the investments needed for last mile connectivity (proxy by connection charges) annualised over the lifetime of the investment. The operations and maintenance costs to maintain connection is a percentage of the costs incurred by the consumers annually.

The user defines a fuel substitution trajectory when the user chooses a pathway for cooking demand across 2012-2047. Based on the assumption of each household/establishment using one fuel specific cook stove, the assumed lifespan and the price range for the cook stoves are given below.

[4] Biomass cook stoves may also require additional expenditure to maintain installed cook stoves. Estimations for this expenditure are not considered as part of this exercise.

Source	Average Life Span	Minimum Price (Rs)	Maximum Price (Rs)	Change in Price (2012-2047)
LPG/PNG [5]	15	1500	4000	5% increase
Electric[6]	10	1900	4000	5% increase
Improved Biomass[7]	5	950	4000	70% reduction
Traditional Biomass	Not applicable	100	300	Not applicable
Kerosene[8]	5	500	1000	35% increase
Biogas	15	1500	4000	5% increase
Coal[9]	3	100	300	60% increase

Table 3: Cost of cook stoves

The cost of infrastructure needed to provide and maintain last mile connectivity is provided below:

Infrastructure costs			
Source	Connection costs	Annualised O&M	Network Augmentation cost /year
LPG[10]	1400	2%	36
PNG[11]	2500	5%	114
Electricity[12]	3000	5%	216

Table 4: Cost of providing last mile connections

It should be noted that in case of electricity, the cost of providing last mile connections accrue to all residential electricity uses not just cooking.

Therefore the stock of fuel specific cook stoves changes when:

i. Households/establishments switch from one fuel to another
ii. The useful life of the cook stove is over and the appliance needs to be replaced.

Only addition to the current stock of appliances is considered while calculating costs. Cost of energy saved due to increase in energy efficiency and also influence of behavioural/technological changes in adoption of cook stoves is not calculated in this estimation.

[5] Based on prices of stoves by TTK and Stovekraft, the largest LPG cook stove makers in India
[6] Based on prices of appliance by TTK, Stovekraft and Bajaj.
[7] Based on survey results (Shrimali, Slaski, Thurber, & Zerriffi, 2011)
[8] Based on manufacturers prices
[9] Assumed to be same as traditional biomass cook stove.
[10] http://164.100.47.134/lsscommittee/Petroleum%20&%20Natural%20Gas/15_Petroleum%20And%20Natural%20Gas_16.pdf
[11] 2http://www.adanigas.com/Common/Uploads/CommercialPNG/2_CPNGDL_3_CPNGDL_Com_rate_nonREFUNDABLEcard1.pdf
[12] http://powermin.nic.in/whats_new/pdf/Continuation_RGGVY_12th&13th_Plan_Sept2013.pdf

VI. Scenarios

T&D losses for India are one of the highest in the world. With the objective to reduce T&D losses and strengthen the distribution sector, Ministry of Power and GoI has launched several programmes such as APDRP, R-APDRP, IPDS and National Smart Grid Mission.

Level One is the most pessimistic situation. Level Two is slightly less pessimistic and takes into account some technological improvements. Level Three is more optimistic, and considers government policy intervention towards a better future. Level Four is the most optimistic; it is an ideal situation that is drawn from whatever is physically possible from today.

Level 1: By 2047, due to the push by government programs to switch to modern fuels, 40% of rural households switch to LPG. In urban areas, due to increased access to PNG there is switching from LPG to PNG resulting in 35% of urban households using PNG while half the households LPG. With reliable electricity supply to all households, 15% and 18% of urban and rural households respectively use electricity for cooking. Biogas users increase gradually from 4% of the rural population to 7% of the rural population. Average efficiency of LPG and PNG cook stoves improves by 15% and electricity stoves show an improvement of 5%.The use of traditional biomass stops by 2037, thanks to promotion of modern fuels and improved cook stoves. Moreover, improved cook stoves which replace them are 40% more efficient than today. In Level 1, India will need 694 TWh by 2032 and 565 TWh by 2047 for its cooking needs. This translates to 19 million tons of LPG, 10 billion scm of PNG, 66 TWh of electricity, 3 billion scm of biogas and 33 million tons of biomass.

Level 2: Level 2 assumes that due to effective implementation of rural programs for increasing access to electricity (RGGVY) and LPG (RGGLVY), by 2032, 45% of rural households depend on LPG, 15% of rural homes use electricity, 5% of the houses depend on biogas and 35% still manage with biomass. However, with increasing acceptance of electricity based cooking and due to reliable supply of power, by 2047, 26% of rural households use electricity and only 42% of rural households use LPG. Establishment of a PNG network in some rural areas leads to 3% of rural households using PNG, while 9% of households use biogas. Therefore by 2047, only 20% households continue to use biomass where all traditional biomass stoves were replaced by improved cook stoves by 2036. Due to a policy push in urban areas for increased PNG use, 40% of urban India utilise it by 2047 and only 42% will depend on LPG. 18% of urban India will switch to electricity and biomass use in urban areas is to be eliminated by 2032. Gas cook stoves will be 25% more efficient and electric hobs will be 10% more efficient. Biomass cook stoves will be 80% more efficient than stoves today due to increased Government attention. It could explain its persistence 40 years from now. Given these assumptions, India will need 582 TWh by 2032 and 491 TWh by 2047 for its cooking needs. This translates to 17 million tons of LPG, 11 billion scm of PNG, 84 TWh of electricity, 4 billion scm of biogas and 15 million tons of biomass.

Level 3: Level 3 assumes that dedicated efforts by Central and State Governments to increase supply and service quality in rural areas leads to active adoption of electricity, LPG with 30% of rural households using electricity and 40% of the households using LPG and 12% using Biogas by 2047. Therefore only 14% of the households continue to rely on biomass, with all households switching to improved cook stoves by 2032, and 4% uses biogas. In urban areas, keen efforts to increase PNG network leads to 45% of urban households depending on it as a primary source for cooking energy by 2047. LPG is used for cooking only in 35% of urban homes and 20% of the homes use electricity .Biomass use in urban areas stops by 2032. Efficiencies of gas stoves increase by 40% and electric stoves increase by 15%. Biomass cook stoves are 1.2 times more efficient. Thus, India's energy demand for cooking will be 493 TWh by 2032 and 435 TWh by 2047. This translates to 13 million tons of LPG, 12 billion scm of PNG, 92 TWh of electricity, 4 billion scm of biogas and 9 million tons of biomass.

Level 4: In Level 4, by 2047, 38% of the rural households use LPG and 38% depend on electricity. 15% of households use biogas and only 4% of rural households use biomass with traditional cook stoves being phased out in 2027. PNG penetration in urban India increases to 55% and LPG users falls to 25%. However, at least 20% households use electricity. Gas stoves are 60% more efficient than today and bio mass stoves are 1.6 times more efficient. Electric hobs are 20% more efficient which lowers demand significantly. Thus, India's energy demand for cooking will be 428 TWh by 2032 and 383 TWh by 2047. This translates to 10 million tons of LPG, 12 billion scm of PNG, 102 TWh of electricity, 5 billion scm of biogas and 2 million tons of biomass.

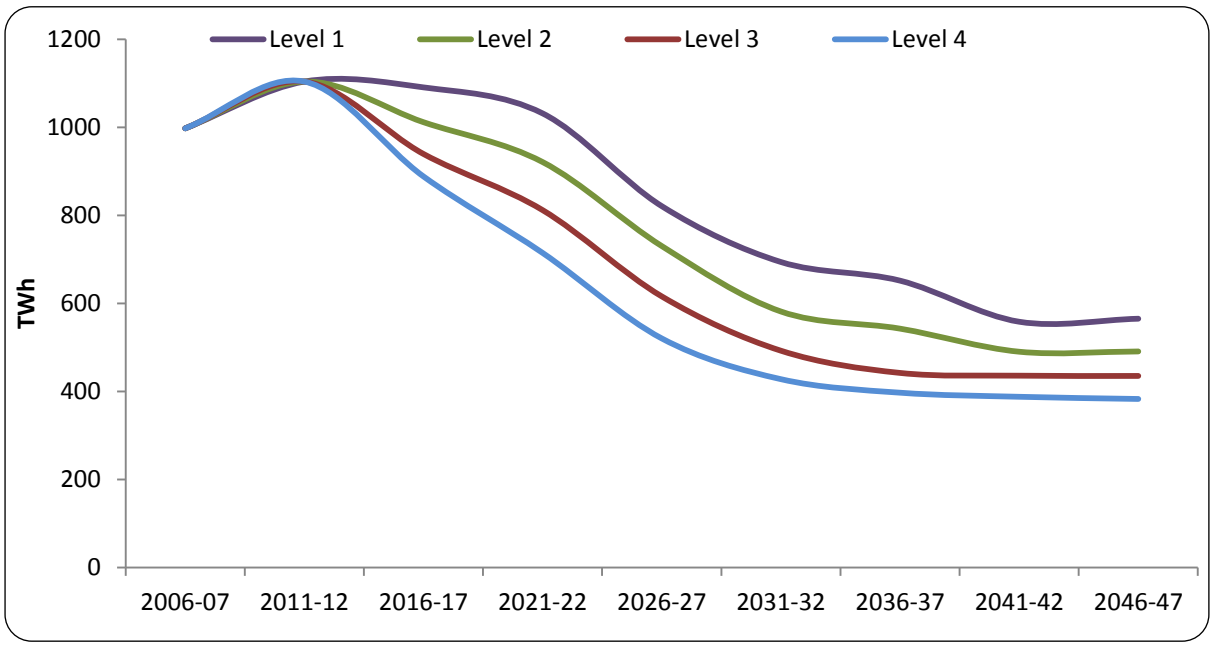

Figure 2: Total Energy Demand for cooking

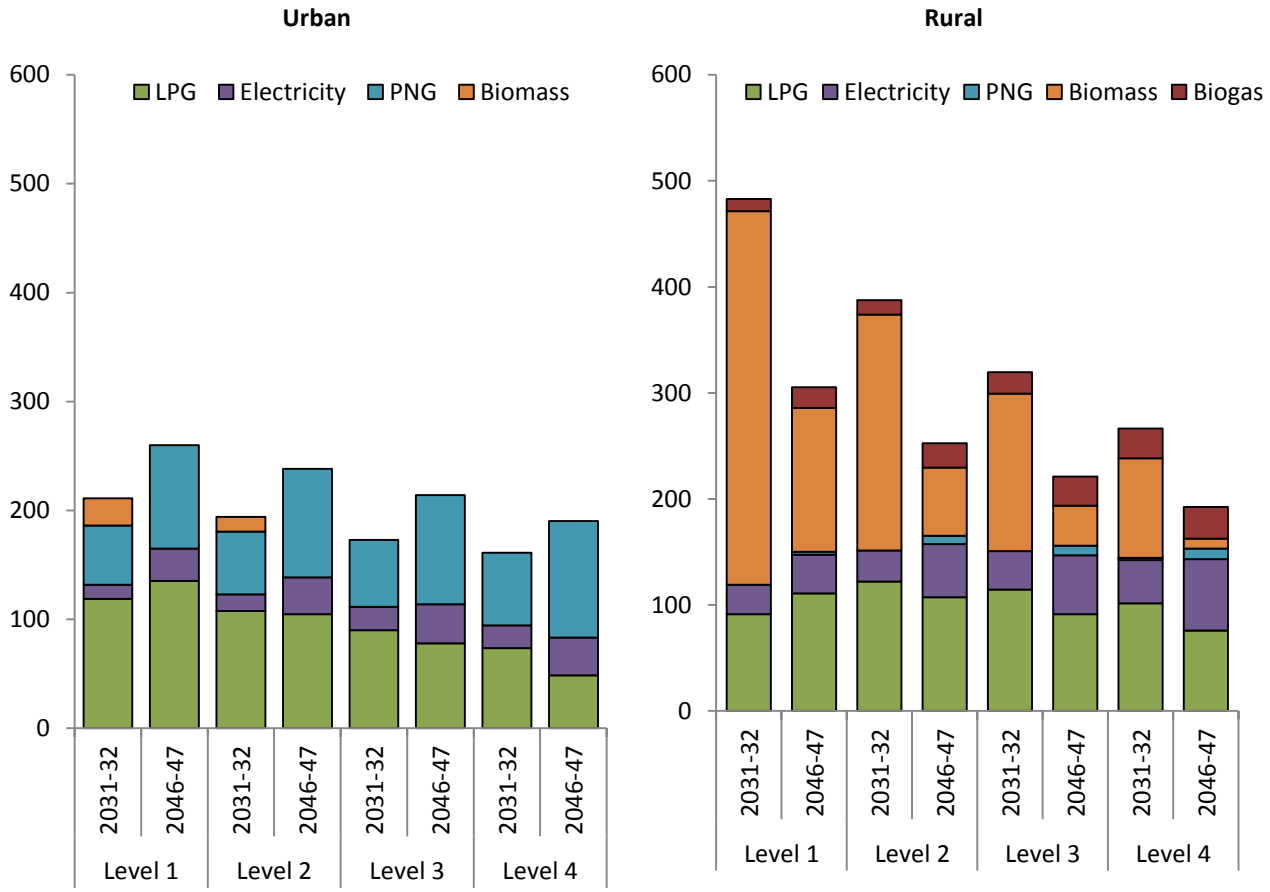

Figure 3: Fuel wise energy demand (TWh) for cooking in 2032 and 2047 by urban and rural households

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