



DISCUSSION PAPER

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CLEAN FUEL FOR COOKING: SOLUTION TO ACHIEVE BETTER AIR QUALITY



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TABLE OF CONTENTS

List of Abbreviation	v
1. Introduction	1
1.1 Cooking energy sector in retrospect	3
1.2 National Clean Air Programme and PMUY – the linkages	4
2. Promoting LPG refills among PMUY beneficiaries	4
3. Cost Estimation for Additional Support Required for Increasing LPG Refills	5
4. Prospective Channels for Mobilizing Financial Resources	7
4.1 Channel 1—Introduction of cess on petrol and diesel	7
4.2 Channel 2—Introduction of cess on PNG for domestic use	8
5. Is the Prescribed Strategy a Viable Proposition?	8
6. The Way Forward	9
References	10

LIST OF ABBREVIATION

AQG	Air Quality Guideline
C&AG	Comptroller and Auditor General of India
DALYs	Disability-Adjusted Life Years
DBTL	Direct Benefit Transfer of LPG
HAP	Household Air Pollution
HSD	High Speed Diesel
kg	Kilogram
LPG	Liquefied Petroleum Gas
MS	Motor Spirit
MJ	Mega Joule
NPIC	National Programme on Improved Chulha
NPBD	National Programme on Biogas Development
NCAP	National Clean Air Programme
OMC	Oil Marketing Company
PMUY	Pradhan Mantri Ujjwala Yojana
PMAY	Pradhan Mantri Awas Yojana
PM 2.5	Particulate Matter 2.5
PNG	Piped Natural Gas
SCM	Standard Cubic Meter

1. INTRODUCTION

A general hypothesis is that with growth in income, there is also an increase in the use of modern fuels for cooking. In India (like many other developing countries) even though the overall poverty rates have been falling for several decades, the reliance of households on solid biomass and traditional inefficient cookstoves has remained a reality (Ministry of Finance 2019). It is estimated that over 800 million people in India lacked access to clean cooking fuel in 2014 (Sustainable Energy for All 2017). This implies that rural households that are not poor have also been using solid biomass¹ for meeting their cooking energy needs.

The use of solid biomass in inefficient cookstoves reportedly causes an estimated 1.3 million premature deaths every year in India (World Health Organization 2016). The use of traditional stoves for cooking, and more so in poorly ventilated space, increases the direct exposure of individuals (primarily women and accompanying children in the Indian context) to household air pollution (HAP) (Smith and Pillarisetti 2017 ; and Kar, et al. 2012.). It also feeds to the growing menace of ambient air pollution — 30% of the ambient pollution in India is attributed to HAP (World Health Organization 2016) thereby impacting not just rural habitations but also urban homes. The ambient pollution often cycles back indoors through open doors and windows. Further, the toxic fumes that emanate from the burning of solid biomass fuels also have a negative effect on the climate. The soot released from traditional stoves contains black carbon that has the highest radiative forcing², after carbon dioxide (Rehman, et al. 2011 and Bond, et al. 2011). Thus, from the lens of social welfare, gender equality, climate action and public health, the menace caused by HAP cannot be overlooked.

While the need for clean fuel for cooking in Indian homes is well-established, due to range of issues — preference for eating food cooked using solid biomass, affordability, availability, and accessibility among others — the use of cleaner fuels has been limited, primarily in the rural areas (World Health Organization 2018a). As per a recent

report, 56% of the population was estimated to be reliant on solid biomass for cooking even in 2017 (Balakrishnan, et al. 2019). In the same year, 0.48 million deaths and 3.3% (15.8 million) Disability-Adjusted Life Years (DALYs) were attributed to HAP. On the other hand, at the point of use or at the consumer's end, cooking fuels such as electricity, Liquefied Petroleum Gas (LPG), biogas, solar energy, and biofuels have been categorized as cleaner fuels by the (World Health Organization 2018b). Among these different fuels, LPG is usually considered as an aspirational fuel by many rural households (Jain, et al. 2018). It is worthwhile to mention that Tripathi and Sagar (2019) estimate the cost of economic loss per non-LPG household due to health burden arising from HAP at INR 69000 per year. Further, when a household shifts from biomass to LPG completely, the estimated time saving is equivalent to economic activities which is worth INR 3500 per household in a year.³ Despite the recognition of the benefits associated with the adoption of LPG for clean cooking, the total number of LPG connections in urban and rural households in India has been growing at a compounded annual growth rate of only 7% from 2007-08 to 2017-18 with total connections at the end of 2017-2018 being 224.3 million (Petroleum Planning and Analysis Cell, 2019). At the same time, the use of electricity for cooking is at a nascent stage and solar and biogas grid for cooking are still at a developmental stage in India.

With slow rate of growth of LPG, the Government of India launched the Pradhan Mantri Ujjwala Yojana (PMUY) in May 2016 to facilitate underprivileged households' access to LPG for cooking (Cabinet Committee on Economic Affairs 2018). The scheme aimed to empower women and safeguard their and the children's health. The PMUY was launched based on a study that was commissioned by the government in 2015, which clearly revealed that high upfront costs and high refill costs were acting as the main barriers for the non-adoption of LPG over biomass (CRISIL 2016). Under the scheme, the central government

¹ Includes firewood, twigs, crop waste among others

² Radiative forcing is the difference between insolation absorbed by the earth and energy radiated back to space

³ Tripathi and Sagar use estimates by Pillarisetti et al, (2016) of time saving amounting 170 hours in a year per household, (when it shifts from biomass to LPG) using the empirical data from Haryana. This 170 hours is equivalent to 21.3 days of employment, which amounts to economic activity worth Rs.3500 per household per year (21.3 * Rs. 168 - the daily wage rate of Bihar, minimum among all the states).

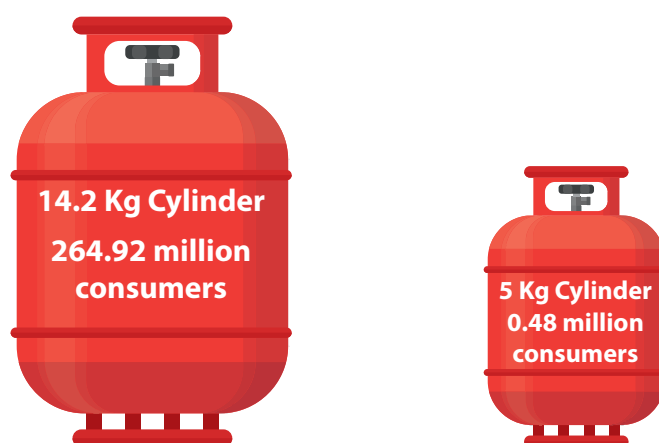
subsidises INR 1,600 to state-owned fuel retailers for every LPG gas connection (INR 1450 is security towards one cylinder and INR 150 is security towards regulator. The balance amount towards stove, installation charges and first LPG refill that each household has to pay is adjusted against future subsidy disbursements for refills). As of September 2019, PMUY has achieved its target of providing 80 million poor households⁴ with LPG connections that have increased the LPG coverage to over 94% households, a sharp rise from 56% in 2015 (Ministry of Petroleum and Natural Gas 2019a and Comptroller and Auditor General of India 2019). The public sector oil marketing companies (OMCs) have provided LPG access using both 14.2 kg and 5 kg LPG cylinders for domestic use (Figure 1). However, less than 1 per cent of the total number of active household LPG consumers (265.4 million) have subscribed to 5 kg cylinders (Petroleum Planning and Analysis Cell 2019 and Ministry of Petroleum and Natural Gas 2019b).

The PMUY can be considered laudable for its unique approach, design, and implementation and has covered around 80 million unprivileged consumers in 715 districts. The public sector OMCs overcame many of the challenges relating to distribution, import facility, low consumer density, capacity of bottling plants and transport to inaccessible rural areas to achieve this huge milestone. While the achievement is commendable, PMUY is also

facing several impediments that are affecting significant adoption of LPG Cylinders in rural areas, despite high rate of connections. These include affordability of refills, cultural or behavioural beliefs, and issues with supply chain and access amongst others. It is also noted that beneficiaries are unable to gauge when their LPG cylinder is close to being empty. As a result, they are not able to make financial plans for their next purchase (Giri and Aadil 2018). Similarly, the expansion of distribution infrastructure has also been slow compared with the increasing consumer base, thus becoming another hurdle in smooth delivery of services.

While most of the above challenges are being addressed, a crucial task is to ensure continued refilling of LPG cylinder by the underprivileged households. In a recently published review report by the Comptroller and Auditor General (C&AG) of India, it was outlined that among the 31.8 million PMUY consumers, who had completed one year of subscription or more as on December 31, 2018, 17.61% consumers never came back for second refill and 33.02% consumers used 1 to 3 refills only (Comptroller and Auditor General of India 2019). As per our analysis, based on publically available data for refills availed by PMUY consumers from May 2016 till June 2019, 24.6% consumers, out of the total PMUY consumers never came back for a refill, 29.6% availed only 1 to 3 refills and the

Total Active Households Consumers of LPG: 265.4 million



⁴ It is noteworthy that PMUY LPG connection and consumption data is only disaggregated to a state level, but is not available in urban and rural disaggregation. See (Dabadge, Sreenivas and Josey 2018)

rest have taken 4 and more refills⁵. This essentially means that the average number of refills for households, who have refilled less than 4 cylinders during the period, is little more than one refill every year. This is indicative of continued reliance of households on solid biomass for cooking. Various surveys also indicate that the share of total LPG consumers who use LPG as their primary cooking fuel is about 60%, a percentage largely unchanged since 2011 (International Institute for Population Sciences (IIPS) and ICF international 2017).

The C&AG in review report of the PMUY has thus recommended that for the consumers in nil or low consumption category, sustained usage must be encouraged (Comptroller and Auditor General of India 2019). This implies a greater push is required to encourage the refill of LPG cylinders by PMUY consumers, which is an indicator of adoption of clean fuel by households. Further, according to National Sample Survey Office (2014), the per capita monthly consumption of LPG is 1.926 kg in urban areas⁶. If this consumption value is considered as a benchmark for all PMUY households with a family size of five members, then the total number of 14.2 kg LPG refills consumed annually per households will be 8.13 cylinders. While the government is working with the OMCs, commercial establishments such as Common Service Centres and civil society organizations to identify ways for enhancing the accessibility of LPG delivery in remote areas, the issue of affordability by households requires deeper thought considering that nearly three-quarters of all rural households in India are reported to be earning INR 5,000 or less per month, according to the last Socio-Economic and Caste Census (Ministry of Rural Development 2011).

Therefore, this Discussion Paper aims to analyse and estimate the financial support that may be required to

encourage PMUY consumers to switch to LPG for cooking their major meals, over and above the existing subsidy and other financial incentives, as well as to identify a suitable financing strategy to support the uptake of refills without impacting the fiscal deficit of the central government.

1.1 Cooking energy sector in retrospect

One of the earliest large-scale programmes for clean cooking energy in India commenced during the Sixth Five Year Plan — the National Programme on Improved Chulha (NPIC)⁷. By the end of the Eighth Five Year Plan, 12.7 million improved chulhas were installed across the country under NPIC⁸. Along with the NPIC, the National Programme on Biogas Development (NPBD), and its later version called National Biogas and Manure Management Programme) were promoting household and community biogas plants and solar cookers were being promoted under the Integrated Rural Energy Programme (Ministry of New and Renewable Energy 2007a and Ministry of New and Renewable Energy 2007b). Even until recently, improved biomass cookstoves, family size biogas systems, solar cookers, and LPG were being simultaneously promoted. However, none of these programmes could attain the required scale or could ensure the sustained use of stoves. Some of the reasons cited for the failure of the NPIC and NPBD are lack of convenience, unavailability of low-cost finance, maintenance issues, inconvenience in managing compatible and adequate fuel (in case of biogas)(Planning Commission of India 2002, Kishore and Ramana 2002 and Palit and Bhattacharyya 2014).

On the other hand, while PMUY has achieved the scale and has been successful in providing 80 million households with LPG connections within 3 years of its launch to meet the target of universal access to clean cooking, the average uptake of refills is less than 5 cylinders per household. The more serious aspect is that 50% of the households have taken only 0-3 refills during the last 3 years as mentioned previously. (Ministry of Petroleum and Natural Gas. 2019c)

⁵ Based on PMUY data available on the official website which was accessed online on December 16, 2019.

⁶ As per National Sample Survey Office (2014) the per capita monthly consumption in rural areas was reported to be 0.378 kg. In our calculations we have considered the consumption data for urban households as a benchmark because the LPG was not the primary cooking fuel in a majority of rural homes during that period due to a range of issues including poor accessibility and lack of affordability.

⁷ Started during the financial year (1983-84) and also referred to as National Program on Improved Chullahs (NPIC) and was included in Minimum Needs Programme for domestic cooking energy: As per 8th five year plan, Volume II, Sectoral Programmes of Development.

⁸ As per Ninth Five Year Plan 1997-2002 Volume II Thematic Issues and Sectoral Programmes.

1.2 National Clean Air Programme and PMUY – the linkages

The Government of India in its National Clean Air Programme (NCAP) has acknowledged the PMUY as a measure to mitigate degradation of air quality in various cities, towns, and villages (Ministry of Environment, Forest and Climate Change 2019). For instance, emphasis has been laid on widening the penetration of the PMUY across 102 cities and towns, introduction of proper ventilation in buildings and the integration of PMUY with the Pradhan Mantri Awas Yojana (PMAY) “the housing scheme for the underprivileged population”.

In a study in rural India, based on a simulation, 24-hours human exposure rate ($\mu\text{g}/\text{m}^3$) was found to meet the WHO Air Quality Guidelines (AQG) Interim Target-1 of $35 \mu\text{g}/\text{m}^3$ only in two cases: (a) 100% LPG fuel (b) 85% LPG and 15% wood (Table1). Similarly, based on an experiment in real-time field setting, it was found that in the breathing zone, black carbon⁹ concentrations from the traditional mud, natural draft, and forced draft stoves were $128 \pm 65 \mu\text{g} \text{ m}^{-3}$, $78 \pm 30 \mu\text{g}/\text{m}^3$ and $38 \pm 28 \mu\text{g}/\text{m}^3$, respectively (Kar, *et al.* 2012).

Thus, it can be inferred that successful implementation of PMUY has a direct implication on both household and

ambient air pollution¹⁰. Further, the positive externality of LPG use in areas such as climate change mitigation, public health, and gender are also well documented. For instance, with the reduction in HAP, life expectancy in India could be increased by 0.7 years (Balakrishnan *et al.* 2019). Owing to the potential of PMUY to cut toxic emissions, it can also be regarded as a pollution abatement and public health initiative and millions of premature deaths could be saved (Tripathi and Sagar 2019). As mentioned previously, a conservative estimate for health benefit stands as INR 69000 per non-LPG household (as per WHO CHOICE method).

2. Promoting LPG refills among PMUY beneficiaries

Despite the intending benefits of use of LPG, the retail price of LPG has been acknowledged as a major bottleneck towards complete shift of PMUY beneficiaries to LPG as the primary cooking fuel. While some practitioners and researchers opine that 5 kg cylinders could help in boosting both LPG consumption and refills among poor households (Harish and Smith *et al.* 2019), this will only help in addressing affordability related concerns of a household in a limited way (by distributing the expenditure over a period of time depending on usage pattern) rather

Table 1: 24-hours human exposure rate ($\mu\text{g}/\text{m}^3$) by fuel type

Type of fuel	24-hours human exposure rate ($\mu\text{g}/\text{m}^3$)
100% LPG	$35 \mu\text{g}/\text{m}^3$
100% dung	$516 \mu\text{g}/\text{m}^3$
100% wood	$161 \mu\text{g}/\text{m}^3$
33% LPG-33% dung-33%wood	$267 \mu\text{g}/\text{m}^3$
50% LPG and 50% dung	$304 \mu\text{g}/\text{m}^3$
50% LPG and 50% wood	$207 \mu\text{g}/\text{m}^3$
85% LPG and 15% dung	$82 \mu\text{g}/\text{m}^3$
85% LPG and 15% wood	$35 \mu\text{g}/\text{m}^3$

Source: (Dees, *et al.* 2018)

⁹ Black carbon is a major constituent of the soot that emanates while cooking using traditional cookstove and solid biomass fuel.

¹⁰ HAP also leads to ambient air pollution as mentioned previously in this brief. Therefore, the abatement of HAP will also lead to the abatement of ambient air pollution.

than the annual expenditure on LPG, considering the net price per kg of LPG (with subsidy) remains same for a 5 kg or a 14.2 kg refill. Thus the annual expenditure on LPG by a household is less likely to vary between a 5 kg cylinder and a 14.2 kg cylinder. A 5 kg cylinder may however help the LPG distributors improve the ease of supply to remote areas following a hub and spoke model.

Further, the prevailing retail price of a 14.2 kg cylinder as on July 2019 is INR 737.50 and the subsidized price of a cylinder is INR 497.37 for PMUY beneficiaries (i.e. the cash compensation on LPG to consumers using Direct Benefit Transfer of LPG (DBTL) per cylinder is INR 240.13) (Petroleum Planning and Analysis Cell 2019). However, as observed from various studies, the subsidized price of a 14.2 kg cylinder is still higher than the willingness to pay among poor households. For instance, results from a household survey by CRISIL in 2016 indicate the willingness to pay for one 14.2 kg LPG cylinder to be INR 313/ month in rural areas and INR 333/month in urban areas in India (CRISIL 2016). Similarly, the CEEW study (Jain, *et al.* 2018) observes that the rural households interested in adopting LPG were willing to pay around INR 300 per month. This was also highlighted during a stakeholder consultation with clean cooking experts organized by TERI on September 26th, 2019. Hence, it appears that a second level of monetary intervention of INR 182 for a 14.2 kg cylinder, over and above the existing subsidy, would be required by PMUY beneficiaries who go for less than 4 refills in a year.

3. Cost Estimation for Additional Support Required for Increasing LPG Refills

In this section, we look at the cost associated with increasing the subsidised LPG refills to PMUY beneficiaries. As mentioned previously, the refill data of the PMUY indicates that 14.6 million (24.6%) beneficiaries did not come back for a refill (Ministry of Petroleum and Natural Gas 2019c). According to the same source, another

29.6% of the total connections under PMUY (17.5 million beneficiaries) have availed less than 4 refills (between 1 and 3 refills), as compared to 45.8% of total connections under PMUY (27.1 million beneficiaries) which had 4 or more refills from May, 2016 till June, 2019¹¹. It becomes evident that the average number of refill availed by PMUY consumers, who are in the bracket of less than 4 refills in the said period, is less than 2 refills. It can be sufficiently concluded that most of these households continue to rely on solid biomass for cooking. Consequently, the motivation for exploring interventions for providing an additional monetary support required for the uptake of at least *eight* numbers of 14.2 cylinders annually for each beneficiary household.

A few cases with a set of assumptions were built in order to estimate the total cost of providing the additional support required to boost refills (Table 2).

Case 1 represents the cost of providing *eight* 14.2 kg cylinders at a price of INR 313 (including additional support over and above the current subsidy) to all the 59.25 million PMUY beneficiaries as of December 31, 2018. The total additional support will amount to INR 201.05 billion.

Case 2 shows the cost of providing eight 14.2 kg cylinders at a price of INR 313 with an additional monetary support over and above the current subsidy to only the 32.14 million PMUY beneficiaries who are reportedly in the category of 0 to 3 refills as of December 31, 2018. This amounts to INR 109.06 billion towards additional monetary support.

Case 3 shows the cost of providing eight 14.2 kg cylinders at a price of INR 313 with an additional monetary support over and above the current subsidy to 32.14 million PMUY beneficiaries, who are reportedly in the category of 0 to 3 refills, plus the cost of providing two 14.2 kg cylinders at a subsidised price of INR 313 to 27.11 million PMUY beneficiaries who reported 4 or more refills as of December 31, 2018¹². The additional support for this group of consumers will amount to INR 132.06 billion.

¹¹ Based on PMUY data available on the official website which was accessed online on December 16, 2019.

¹² Assuming that this group of households have already availed 6 cylinders annually and are provided 2 refills, between November to February, at an additional support of INR 184 over and above existing subsidy. As per our recommendation case 3 will not be applicable for PMUY beneficiaries who have already availed 7 or 8 refill annually.

Table 2: Cases to boost LPG refills through additional support

Case No	PMUY consumers of 14.2 kg cylinder	No of consumers in million	Existing subsidy in INR	Additional support per cylinder in INR - proposed	No of cylinders in a year*	Total Cost in billion INR	Retail price per 14.2 kg cylinder in INR (without proposed additional support)	Retail price per 14.2 kg cylinder in INR (with proposed additional support #)	Reduction in retail price after introduction of additional support (in %)
Case 1	All PMUY consumers as of December 31, 2018	59.25	240.13	184.00	8	201.05	497.37	313	37.07
Case 2	All PMUY consumers as of December 31, 2018 who have reported only (0-3) refills	32.14	240.13	184.00	8	109.06	497.37	313	37.07
Case 3	All PMUY consumers as of December 31, 2018 who have reported (0-3) Cylinder refills	32.14	240.13	184.00	8	132.06	497.37	313	37.07
	All PMUY consumers as of December 31, 2018 who have reported 4 or 4+ refills**	27.11	240.13	184.00	2				
Case 4	50% of the 80.34 million PMUY consumers as of December 16, 2019 with an assumption that these consumers have only availed (0-3) refills	40.17	240.13	184.00	8	136.30	497.37	313	37.07

* Number of cylinder refills proposed as part of the prescribed strategy.

** With an assumption that this group of households have availed 6 cylinders of 14.2 kg each and are provided 2 refills, between November to February, at an additional support of INR 184 over and above existing subsidy.

Retail price of per 5 kg cylinder with proposed additional support will stand at INR 110 (on a pro rata basis).

Finally, **Case 4** indicates cost of providing eight 14.2 kg cylinders at a price of INR 313 with an additional monetary support over and above the current subsidy to 40.17 million (i.e. 50% of 80.34 million) PMUY consumers as of December 16, 2019 (considering that approximately 50% of all PMUY consumers were reported to have availed 0-3 refills based on actual refill data available till December 31st, 2018) (Ministry of Petroleum and Natural Gas 2019c). The additional outgo for this case will amount to INR 136.30 billion.

4. Prospective Channels for Mobilizing Financial Resources

The above estimation indicates that the additional outgo would range between INR 109.06 billion and INR 201.05 billion (depending from case to case: Table 2) if 8 refills are to be availed by the PMUY households. Having estimated this monetary requirement, it is critical to also explore the channels to mobilize revenue in order to meet the cost required for an additional, second-level monetary support over and above existing subsidy so that there is no impact on the fiscal situation of the government.

Taking the example from the electricity sector where cross-subsidy has been utilised very effectively to improve and sustain access to underprivileged households, one way for the additional resource mobilisation could be to levy a pollution cess on Petrol and Diesel and levy a rural energy cess on PNG used by urban households. The resources generated may be used to provide the additional support towards the refills for underprivileged consumers.

4.1 Channel 1—Introduction of cess on petrol and diesel

The central government currently levies an excise duty of INR 18.65 per litre on petrol and INR 14.57 per litre on diesel (Petroleum Planning and Analysis Cell 2019). A flat one rupee (1 INR) increase as additional cess for both petrol and diesel can increase the OMCs/central government's revenue receipts by INR 134.1 billion in a financial year (Table 3). In other words, we recommend levying a cess on these two polluting fuels and redirecting the funds accrued thereby to boost the adoption or usage of clean cooking solutions, in the form of LPG, among households who do not refill or continue to use solid biomass for cooking their major meals because of affordability concerns.

Table 3: Revenue estimates from Excise duty on Petrol and Diesel for the prescribed strategy

Total petrol consumption (MS) in financial year 2018-2019 [#]	Tonne	28284300
Total petrol consumption (MS) in financial year 2018-2019	Million Ltr	39767.7
Current Excise Duty on Petrol*	INR/Ltr	18.65
Total Diesel Consumption (HSD) in financial year 2018-2019 [#]	Tonnes	83528200
Total Diesel Consumption (HSD) in financial year 2018-2019	Million Ltr	94303.3
Current Excise Duty on Diesel*	INR/Ltr	14.57
Additional Central Cess	INR/Ltr	1
Additional collection due to levy of pollution cess on petrol (estimated based on consumption during 2018-2019)	Billion INR	39.8
Additional collection due to levy of pollution cess on diesel (estimated based on consumption during 2018-2019)	Billion INR	94.3
Total revenue collection due to pollution cess for both Petrol and Diesel	Billion INR	134.1**

Source: [#] Consumption of petroleum products, Petroleum Planning and Analysis Cell, 2019; https://www.ppac.gov.in/content/147_1_ConsumptionPetroleum.aspx

*Excise duties, Ready Reckoner, Oil industry information at a glance, page 58, June 2019;

**Estimated by authors.

4.2 Channel 2—Introduction of cess on PNG for domestic use

The total piped natural gas (PNG) connections across all states in India are 5.04 million as on July 2019 (Petroleum Planning and Analysis Cell 2019). Assuming that the average PNG consumption per households per day across India is 0.5 Standard Cubic Meter (SCM), the total consumption of PNG is 2.52 million SCM per day¹³, which is equal to 920.4 million SCM per year. Further, on applying a price of INR 30.1 per SCM of PNG¹⁴, the annual expenditure of all subscribers amounts to INR 27.7 billion i.e. on average INR 457.7 per household per month. An increase in price by INR 2/SCM, through an introduction of a cess to central government, will set the retail price as INR 32.1/SCM (Box 1). Consequently, this will increase the monthly expenditure of a household PNG subscriber to INR 488.2. The additional revenue mobilized for the central government due to this will be INR 1.8 billion annually.

Box 1: LPG and PNG cost comparison (in Mega Joule)

The market price of a 14.2 LPG cylinder is INR 737.5, which means, that 1 kg of LPG costs around INR 52. Further, when converted, 1 kg of LPG is equivalent to 49 Mega Joule (MJ) of energy. This means that 1 MJ of LPG costs INR 1.05. Similarly, 1 SCM of PNG is equivalent to 39 MJ and costs INR 30.1. Thus, 1 MJ derived from the use of PNG costs INR 0.77.

Thus, 1 MJ of PNG costs INR 0.29 less than 1 MJ of LPG i.e. 27 % less than LPG. An increase in PNG price by INR 2 per SCM (i.e. 6% increase) will still cost INR 0.24 less than 1 MJ of energy of LPG (i.e. 22.35% cheaper than LPG when compared in terms of per MJ derived for cooking.).

5. Is the Prescribed Strategy a Viable Proposition?

Our analysis shows that by the adoption of Channel 1, the central government/OMCs can realize the revenue, which can be leveraged for eliminating the challenge of PMUY refills for the Case 2 and Case 3 (Table 4). As the economic loss associated with health burden arising from continued exposure to HAP is substantial, encouraging intervention for refills is desirable. The estimation also show that the net gain (revenue–expenditure) from Channel 1 for the Case 2 and Case 3 is positive (Table 4). The projected economic loss arising from health burden in non-LPG households varies from 20.34 to 30.96 times the expenditure required to advance complete transition to LPG for cooking across various cases (see Table 4). This implies that the prescribed strategy makes a strong case as the economic loss arising from health burden is much higher than the cost of abatement. Incidentally, the prescribed abatement strategy will also have a positive externality, thereby leading to an improvement in ambient air quality, considering that almost 30% of the ambient pollution in India is attributed to burning of solid biomass in households.

Learning from the experience in the electricity sector, where cross-subsidy has been leveraged as a financial instrument for provisioning access to rural and remote areas, here cross-subsidy is leveraged for the benefit of PMUY beneficiaries and to contain the poor air quality in the homes and outside. The proposed strategy will enable generation of requisite revenue without hampering the fiscal deficit of the central government. However, the revenue so generated has to be ring fenced and transparently used only for the cause of increasing the refills for underprivileged households, so that those who pay additional amount towards petrol, diesel and PNG should feel that the amount being collected is being used for a social cause.

¹³ Author's estimation based on consultation with PNG consumers in the Delhi and NCR and the article: DNA India, 2012. Piped gas becomes more attractive for the kitchen. Accessed online from <https://www.dnaindia.com/mumbai/report-piped-gas-becomes-more-attractive-for-the-kitchen-1740662> on December 16, 2019.

¹⁴ Indraprastha Gas Limited (IGL) price of PNG in Noida as on 30.10 2019.

Table 4: Estimate of financial gains from uptake of LPG refills

Channel Type	Revenue in Billion INR	Case No	Expenditure in Billion INR	Estimated net gain in Billion INR = Revenue - Expenditure	Ratio of Revenue to Expenditure	No of PMUY beneficiaries in Billion	Cost of economic loss per non-LPG household due to health burden arising from HAP per year (in INR) (Based on Tripathi and Sagar, 2019)	Cost of economic loss due to health burden arising from HAP in Billion INR	Ratio of Economic loss due to health burden arising from HAP to Expenditure
Channel 1: Increase in Petrol and Diesel excise duties by INR 1 per litre	134.1	Case 1	201.05	-66.95	0.67	0.059	69000	4088.54	20.34
	134.1	Case 2	109.06	25.04	1.23	0.032		2217.74	20.34
	134.1	Case 3	132.06	2.04	1.02	0.059		4088.54	30.96
	134.1	Case 4	136.30	-2.20	0.98	0.040		2771.80	20.34
Channel 2: Increase in PNG price through a PNG cess of INR 1 per SCM	1.8	Case 1	201.05	-199.25	0.01	0.059	69000	4088.54	20.34
	1.8	Case 2	109.06	-107.26	0.02	0.032		2217.74	20.34
	1.8	Case 3	132.06	-130.26	0.01	0.059		4088.54	30.96
	1.8	Case 4	136.30	-134.50	0.01	0.040		2771.80	20.34

6. The Way Forward

The transition of households to clean fuel for cooking is an urgent development target that has been prioritized by the Government of India. With the recent push, the uptake of LPG by underprivileged households through the PMUY has surpassed connection targets set by the government. However, the refill, which is an indicator of primary reliance on LPG for cooking, has not been met by a large percentage of the households. The cost of inaction is far higher than the cost associated with complete elimination of the challenge of clean energy for cooking.

In addition to boosting refills of 14.2 kg cylinders through our prescribed strategy, 5 kg cylinders may also be promoted among poor households to increase the periodic and annual affordability of LPG. The 5 kg cylinders can further help in enhancing reach of LPG among poor households who are located in remote and hilly areas. Further, double cylinders - either 5 or 14.2 Kg - should be promoted so that consumers have a backup when one cylinder is exhausted and they don't have to use again solid biomass for cooking. At the same time, it is important to note that the complete transition of

households to cleaner fuel and efficient cookstoves is a gradual process which is dependent on a range of factors other than affordability. Hence, in the short term, provisioning forced draft improved biomass cookstove to households, who continue to stick to solid biomass for cooking, is likely to reduce environmental damage and also the direct exposure of inhabitants to toxic emissions.

Our prescribed strategy for improving the LPG refills through an additional monetary support is only an interim strategy, for a targeted group of PMUY beneficiaries, while the country achieves its clean air targets by direct reduction of ambient air pollution because of shift from solid biomass use to LPG for cooking. In the long run, it is expected that the number of PNG consumers will increase to 70% of the country's population as per the target set by Ministry of Petroleum and Natural Gas (2018). Hence, as the PNG network across Indian homes expands, the revenue from cess will increase, and as per our prescribed strategy, the cess on petrol and diesel could be reduced with any increase in international prices. At the same time, the cess from PNG could also be used to strengthen the PNG network, especially to low-income habitations in cities, towns and peri-urban areas thus reducing the dependence on subsidised LPG in such areas. Nevertheless, in the interest of public health, if the aforementioned strategy is adopted by the Government of India, it will be of utmost importance to explicitly inform the end-users that any additional support provisioned is a temporary intervention, considering the air pollution emergency in the country. The additional support can be gradually reduced as households shift from lower income category as well as start preferring to use LPG by virtue of it being a cleaner fuel and its convenience to use.

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