Policy Approaches for a Kerosene to Solar Subsidy Swap in India

REPORT

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Executive Summary

India has almost reached the historic goal of universal electrification. But the challenge of supplying 24x7 Power for All remains. Millions of households still rely on kerosene for lighting, including those who cannot afford electricity or with unreliable electricity supplies.

Delivering uninterrupted and high-quality power to every household will take time, given the challenges of low and dispersed electricity demand in rural areas and affordability for the poorest. Allowing continued reliance on kerosene is not a socially or economically responsible option. Kerosene can lead to levels of particulate matter and other pollutants that exceed World Health Organization guidelines. It gives low levels of light, limiting education and income-generating opportunities. And the subsidy cost of kerosene to government can soar when international oil prices rise, as occurred in 2018. Finally, kerosene was responsible for around a quarter of all energy-related residential greenhouse gas emissions in 2013.

Shifting subsidies from kerosene to off-grid solar photovoltaic products is one way to fund the energy transition for marginalized households. Solar products such as lanterns, home systems and mini-grids are currently providing economical connections and backup power in remote regions. However, most households still rely on kerosene as their primary source of lighting (if unelectrified) or as a coping strategy during outages. But this is not by preference. Surveys indicate a strong preference for off-grid solar compared to kerosene, even if this means a reduction in the kerosene subsidy.

Kerosene is used for more than lighting, but this is not a reason to maintain the subsidy. Census data from 2011 indicates that kerosene was used for cooking in 1 per cent of rural households and 11 per cent of urban households. These numbers are likely to have declined significantly with the expansion of clean cooking programs. Kerosene is also used to ignite biomass for cooking, and an estimated 45 per cent is diverted to the black market for use in irrigation or transport. Existing programs for clean cooking and solar-powered pumps should be augmented rather than continuing to incentivize kerosene, a second-best fuel in all cases.

Making the switch to solar would significantly reduce fiscal and household expenditure. A range of off-grid solar products is now cheaper than kerosene over the lifespan of the technology. Table ES1 shows that, once the upfront costs of solar products are spread over two years and government subsidies for kerosene are taken into account, solar products result in savings compared to kerosene lamps. The net cost of the swap is the amount the government could save by switching support to these technologies. In addition, the government would save the losses from fuel diversion and budget blowouts caused by volatile oil prices.

Table ES1. Cost comparison of solar products with subsidized kerosene (INR per month per household)

	Solar Product		
Monthly Cost	**Lantern**	**Home system**	**Microgrid**
Levelized cost of solar product	54	142	146
Average cost of kerosene			
Household expenditure	70	70	70
Government subsidy expenditure	113	113	113
Total cost	183	183	183
Net cost of swap	**-129**	**-41**	**-37**

Note: See Table 1 in the main report for details about products, prices and assumptions.

Due to their high upfront cost, low-income households need assistance to purchase off-grid solar products. This could be achieved in three ways:

1. Subsidy programs for households to help them buy solar products.
2. Subsidy programs for manufacturers to reduce the final price of products for eligible consumers.
3. Subsidy programs for banks and microfinance institutions to make borrowing for solar products more affordable.

This report presents the pros and cons of these options, along with a broad implementation plan. It is not intended to be prescriptive but rather suggests several viable pathways. Information and policy options are presented for each subsidy pathway along with options for funding and administrative arrangements, identifying and targeting beneficiaries and determining eligible products.

The choice of pathway will depend on government preferences and further consultation among decision makers, relevant national departments, state governments, businesses and consumers. The end goal for each pathway is the same: to assist India's transition to clean and reliable power for all.

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Acronyms and Abbreviations

ACCESS	Access to Clean Cooking Energy and Electricity – Survey of States
BPL	below poverty line
CEEW	Council on Energy, Environment and Water
DC	direct current
DISCOM	distribution company (for electricity)
FY	financial year
GSI	Global Subsidies Initiative
GW	gigawatts
IISD	International Institute for Sustainable Development
kW	kilowatts
LED	light-emitting diode
LPG	liquefied petroleum gas
MW	megawatts
MFI	microfinance institutions
MNRE	Ministry of New and Renewable Energy
MoPNG	Ministry of Petroleum and Natural Gas
PAYGO	pay-as-you-go
PDS	Public Distribution System
PMUY	*Pradhan Mantri Ujjwala Yojana*
PV	photovoltaic
REC PDCL	REC (formerly Rural Electrification Corporation) Power Distribution Company Limited
SAUBHAGYA	*Pradhan Mantri Sahaj Bijli Har Ghar Yojana*
SHS	solar home system
SPI	Smart Power India
TERI	The Energy and Resources Institute
UP	Uttar Pradesh

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1.0 Introduction

In July 2018, The Energy and Resources Institute (TERI) and the International Institute for Sustainable Development (IISD) published the report *Kerosene to Solar PV Subsidy Swap: The Business Case for Redirecting Subsidy Expenditure From Kerosene to Off-Grid Solar* (Gill, Shardul, Sharma, & Bridle, 2018). The report found that a swap, as defined in Box 1, is feasible. A range of off-grid solar products is available in the Indian market at various price points from several reputable suppliers. An examination of the business models for solar products revealed potential intervention points for government. Finally, the report identified Odisha and Uttar Pradesh (UP) as states appropriate for further investigation of a swap, given their high reliance on kerosene and the presence of solar suppliers.

This report takes the next step by providing policy options for how a swap could be implemented. It draws on the 2018 business case and new research in three areas:

- Consultations with government officials, businesses and social enterprises at the central level and in Odisha and UP (hereafter referred to as "the consultations").
- A small-scale survey of potential consumers undertaken in November 2018 in two villages in UP as part of this study: Asuder and Kewtli[1] (hereafter called "the village surveys").
- Two proof-of-concept studies of solar technology suppliers Mera Gaon Power (solar microgrids) and Simpa Networks (solar home systems [SHSs]).

Details are set out on approaches that the government could take to implement a swap across key policy areas:

1. Identify funding sources and mechanisms
2. Identify and target recipients
3. Select eligible solar products
4. Identify mechanisms to deliver an off-grid solar subsidy
5. Leverage existing distribution networks
6. Identify barriers to implementation

Box 1. Defining a clean energy swap

The swap concept is simple. It refers to redirecting government support from fossil fuels to clean energy. This does not need to involve explicit earmarking (or "hypothecation") of funds: savings from fossil fuel subsidies and spending on renewables could happen independently in the government budget. The core concept of a clean energy swap is that it accelerates the replacement of fossil-fuelled energy systems with sustainable energy systems through a shift in government priorities, as expressed through funding or regulatory changes.

The two key elements are that: 1) fossil fuel subsidies are reduced and 2) this happens alongside measures that increase the deployment of sustainable energy.

Therefore, a kerosene to solar swap will reallocate finances away from kerosene, promoting cleaner lighting fuels for unelectrified or underserved consumers.

[1] Asuder is located in the Sitapur district in central UP, and Kewtli is located in Jaunpur district in eastern UP.

2.0 Rationale for a Kerosene to Solar Subsidy Swap

The Government of India has made remarkable progress in electricity access. In April 2018 every village was connected to the grid and by March 2019 *Pradhan Mantri Sahaj Bijli Har Ghar Yojana* (SAUBHAGYA) had almost completed its mission to connect all willing rural households (REC, 2018). The final stage is achieving 24x7 Power for All, for which the government set a target deadline of March 31, 2019.

Achieving high-quality and uninterrupted power for every households is going to be a challenge that will extend well after connections have been made available (Government of India, 2017). In rural areas, supply and service costs are prohibitively high, while demand density is low and fragmented. This is a disincentive for India's state-owned distribution companies (DISCOMs) (Mukherji, 2017). As a result, there are gaps in electricity access that will take years to resolve: one senior policy-maker interviewed for this project stated that backup lighting and power will likely be needed for the next 15 to 20 years.[2]

Redirecting public funding from kerosene to off-grid solar can help fill these gaps, thereby improving energy access, reducing the negative health impacts of kerosene, and saving both households and the government money. These outcomes are discussed below, along with side benefits for energy security, greenhouse gas emission reduction and achieving targets for renewable energy.

2.1 Delivering 24x7 Power for All

While SAUBHAGYA has brought electricity to nearly every household, this has not resolved all of rural India's electricity access problems. A recent survey by Smart Power India (SPI) across four states found that 15 per cent of surveyed households did not have a connection, despite having an electricity pole within 50 metres (Agrawal, Bali, & Urpelainen, 2018). The majority (80 per cent) cited unaffordability as the reason for refusing a connection. Another recent survey across six states (ACCESS by the Council on Energy, Environment and Water [CEEW]) found that 14 per cent of unelectrified households did not want a free electricity connection (Jain et al., 2018).

Grid-connected households suffer ongoing electricity access issues. The ACCESS survey found that over 70 per cent of electricity customers surveyed experienced issues with capacity, duration, quality, reliability, affordability or legal status (Jain et al., 2018).[3] The SPI survey found that 86 per cent of grid-connected households also used at least one other source of electricity or lighting (Agrawal et al., 2018).

Individual locations, particularly in more remote areas, can experience problems that are more severe than population averages. In the village surveys conducted as a part of this project,[4] it was found that the majority of households with a grid connection only received between one to five hours of electricity per day. Over two thirds of these households were not satisfied with their electricity connection and 83 per cent used kerosene on a daily basis.

The draft National Energy Policy recognizes that solar and other off-grid renewable options can play a role in supplementing grid supply, thereby reducing demand during peak times (Government of India, 2017). Off-grid solar technology is already part of the government's strategy for non-grid-connected areas (see Box 2). But these programs do not cover grid-connected households where electricity supply is inadequate for daily needs or poor households that declined a grid connection due to affordability concerns.

[2] Based on meeting with power and regulatory sector experts in UP on November 14, 2018.

[3] Over 70 per cent of all households in these states were found to be in "Tier 0" or "Tier 1."

[4] The TERI survey is representative of the villages, as 51 of the 172 households in Asuder and 52 of the 358 households in Kewtli were included.

Box 2. Current off-grid solar programs

SAUBHAGYA provides funding for standalone solar photovoltaic (PV) systems for households in remote regions where grid extension is not technically feasible or cost-effective (REC, 2018).[5] The scheme covers 0.5 million households (Palit, 2018). As with grid connections, off-grid solar is provided to poor and disadvantaged households free of charge and to other households for a fee of INR 500 payable in 10 instalments (Ministry of Power, 2017). In December 2018 the REC Power Distribution Company Limited (REC PDCL) and several states (Assam, Odisha, Rajasthan and Tripura) issued tenders to install standalone solar power in unelectrified villages funded by SAUBHAGYA (REC PDCL, 2018).

Separately, phase III of the Off-grid and Decentralized Solar PV Applications Programme—part of the Jawaharlal Nehru National Solar Mission—was allocated INR 656 crore in FY 2018/19 over two years (Ministry of New and Renewable Energy [MNRE], 2018). Funding covered the installation of 300,000 solar street lights, 100 megawatt peak (MWp) of solar panels for public buildings that grid power has not reached or for which it is not reliable, and 2.5 million solar study lamps for school children in states with low grid connectivity.

2.2 Social Benefits of Transitioning Away From Kerosene

For households lacking a grid connection or with an unreliable connection, kerosene remains an important source of lighting. The SPI survey found that 91 per cent of non-connected households used kerosene lamps, with as many as 25 per cent of households relying on kerosene as their primary source of light in UP (Agrawal et al., 2018). The SPI survey cited kerosene as the most popular choice for backup lighting in electrified households.[6] Remarkably, approximately 5 per cent of households in Madhya Pradesh, with 100 per cent electrification, relied on kerosene as their *primary* source of lighting (Jain et al., 2018).

The continued reliance on kerosene is also evidenced by 27 states and territories receiving subsidized kerosene allocations in the fourth quarter of FY 2018/19, despite progress with electrification (Ministry of Petroleum and Natural Gas [MoPNG], 2018a).

Allowing continued dependence on subsidized kerosene is not a socially responsible option. Kerosene gives low-quality light (limiting educational and income-generating opportunities) and creates indoor air pollution that causes serious health impacts (Jain & Ramji, 2016). The World Health Organization discourages the further use of kerosene based on evidence that it can lead to levels of particulate matter and other pollutants that exceed its guidelines (World Health Organization, 2014).

In addition, up to 45 per cent of subsidized kerosene is diverted for illegal uses nationally (Gutpa, 2014). The ACCESS survey found that 20 per cent of survey respondents reported on-selling their subsidized kerosene allocation (Jain et al., 2018).

Households want to transition away from kerosene. The ACCESS survey found that, when asked to choose between subsidized kerosene and subsidized solar lanterns, 84 per cent of households were in support of the government providing subsidies on solar lanterns, even if it resulted in a reduction in the subsidies on kerosene. Households that did not support a switch to solar tended to also be unaware of the health dangers of using kerosene (Jain et al., 2018). The SPI survey found that users of microgrids reported satisfaction rates of 80 per cent, compared to 60 per cent for grid electricity (Agrawal et al., 2018).

[5] SAUBHAGYA provides a 200–300 kWp solar panel with battery, five LED lights, one DC fan, one DC power plug and necessary cables and connection, along with the provision of repair and maintenance for five years (REC, 2018).

[6] The percentage of households preferring kerosene was not provided.

The village survey found that the majority of households (70 per cent in Asuder and 96 per cent in Kewtli) were dissatisfied with kerosene as a lighting source. Ten per cent of households in Asuder and 70 per cent in Kewtli said they had experienced health impacts from using kerosene. The disparity between villages may indicate a different level of awareness of the potential health impacts and symptoms of kerosene usage.

Thirteen per cent of households use solar products, among whom 80 per cent and 88 per cent in Kewtli and Asuder, respectively, were very satisfied with it. Those that were dissatisfied mentioned the poor quality of the device or that it only provided a single point of light. All households using solar in Kewtli said it was better than a kerosene lamp. In Asuder, 100 per cent of respondents using solar said that solar lights should be used instead of kerosene wick lamps. All also said they would prefer to have a solar product that produces electricity as well as lighting.

2.3 Off-Grid Solar Is Cheaper

The cost comparison in Table 1 shows that, once the upfront cost of a solar lantern is spread over two years ("levelized monthly cost"), a household could afford an entry-level solar lantern and save money compared to average expenditure on subsidized kerosene.

A combination of average household expenditure on kerosene and reallocation of subsidies—as recommended under a swap—would see a dramatic reduction in the cost of SHSs and microgrids.[7] The net monthly cost of the swap is the amount the government could save by switching support to these technologies.

Not only are these products cheaper than subsidized kerosene in the long term, the electricity could be used for ancillary services such as mobile charging and desk fans. The upfront costs to households could be spread out using consumer financing.

Solar lighting is also significantly brighter than kerosene. Traditional kerosene lamps have a light output that ranges from 7.8 to 67 lumens (Mills, 2003). In comparison, modern light-emitting diode (LED) bulbs are capable of producing 92 lumens per watt (U.S. Department of Energy, 2019). See Mahapatra (2009) for a detailed comparison of various lighting technology options across several parameters.

To provide backup for electricity shortages or address problems with low-quality supply, solar technology options are comfortably cheaper than kerosene, and they can meet a more diverse range of needs.

[7] A "mini grid" is defined as a system having a renewable-based electricity generator with capacity of 10 kW and above. A "microgrid" system has a generating capacity of less than 10 kW. Both generally operate in isolation of the grid but can also interconnect with the grid to exchange power. If connected to a grid, they are called grid-connected mini-/microgrids (MNRE, 2012).

Table 1. Comparison of the cost of subsidized kerosene with common solar products (INR)

	Units	Solar lantern**	Solar home system**	Solar microgrid^
Technical Parameters				
Solar panel capacity	Watts	2.35	10	400
Lighting capability		One 1.1W LED; 100 lumens	Two 2.4W LED; 440 lumens	Two 2.4W LED; 440 lumens
Battery capability		3.7V, 2.2Ah	12V, 7.2Ah	12V, 400Ah
Economic Parameters				
Capital cost of solar product	INR	1,300	3,400	175,500
No. of households served		1	1	50
Life cycle of product	Months	24	24	24
Levelized monthly cost per household	INR	54	142	146
Kerosene average monthly cost per household*	INR	70	70	70
Monthly cost of change per household	INR	-16	71	76
Average monthly govt kerosene subsidy per household*	INR	113	113	113
Net monthly cost of kerosene to solar swap	INR	-129	-41	-37

**Average monthly household kerosene consumption assumed as 2.63 litres based on average value of four sources: National Sample Survey Office, 2014; Jain et al., 2018; Odisha Sun Times Bureau, 2018; Gill et al., 2018. Average household cost and government subsidy is calculated by using market average of retail and Public Distribution System (PDS) kerosene between April and October 2018 (Indian Oil, 2019a, 2019b).*

***The reference prices were based on sample products for solar lantern, Sunking Pro 200 (Greenlight Planet, 2019) and SHSs, Subham Solar SHLS-2 (Subham Solar Solutions, 2019).*

^Solar Microgrid specifications based on specification quoted by five microgrid developers to TERI under the Lighting A Billion Lives Initiative (TERI, 2019).

In some circumstances, off-grid solar is cheaper than grid electricity. Unmetered connections in UP, which accounted for half of all connections, were found to be as high as INR 400 per month (Agrawal et al, 2018). For poor households with few appliances, this represents a waste of resources, and the cost is significantly higher than the solar products in Table 1. A household that uses two 7-W LED bulbs for 12 hours per day would consume only five units of electricity per month. With a metered connection, such a household in UP would pay only INR 65 per month (Agrawal et al., 2018).

Households without a reliable electricity supply must also pay for backup power. Grid-connected households were found to be paying INR 78 per month on kerosene, in addition to their electricity bills, while non-grid-connected households were paying little more at INR 94 per month (Agrawal et al., 2018).

2.4 Supporting Other Government Objectives and Targets

A subsidy swap would help achieve the Government of India's targets for increasing renewable energy and decreasing greenhouse gases, as well as its objective to reduce indoor air pollution. Based on the latest information available on the GHG Platform India, kerosene in 2013 was responsible for around 27 million tonnes of carbon dioxide, equal to around a quarter of all energy-related residential emissions in 2013 (GHG Platform India, 2018). India committed to installing 175 gigawatts (GW) of renewable energy by 2022 as part of India's Intended Nationally Determined Contribution on climate change (Government of India, 2015). The target consists of 100 GW of solar power but, as of November 2018, just 24 GW of solar power was installed (Central Electricity Authority, 2018).

The National Clean Air Programme indicates that the government wants to reduce indoor air pollution but hasn't set specific targets (Ministry for Environment, Forests and Climate Change, 2018). Switching support away from kerosene would help in this objective.

Kerosene also contributes to reliance on imported oil, reducing energy security. In FY 2018/19, 86 per cent of India's oil was imported (MoPNG, 2018b). If kerosene were eliminated, this would avoid 4.4 million tonnes of imported oil.[8] Exposure to world markets also risks increased fiscal burden of fuel subsidies. The Central Government of India has already spent over INR 460 billion in FY 2018/19 on subsidies for cooking gas and kerosene, 84 per cent higher than initially forecast in budget estimates (Jacob & Roychoudhury, 2018). The continuation of the kerosene subsidy risks high and unpredictable costs in periods when oil prices escalate.

[8] This result assumes that all kerosene or oil to produce the kerosene is imported. This is a reasonable assumption given that India imports the vast majority of its oil (imports were 214 million tonnes and production was 36 million tonnes in 2016) (MoPNG, 2018b).

3.0 Policy Options for Implementation of a Subsidy Swap

This section presents policy options for implementation of the swap concept. It is not intended to be prescriptive, but rather suggests several pathways the government could follow in pursuing the objective of a subsidy swap: to improve access to clean energy for the poor and near-poor using funds liberated from kerosene subsidy reforms.

The framework is a broad implementation plan (Figure 1). The first three steps are common to all pathways: (i) establishing funding and administrative arrangements, (ii) identifying and targeting beneficiaries and (iii) determining eligible products. The next steps will depend on subsidy options that the government chooses to use. There are three main options:

1. Subsidy programs for households to help them buy solar products.
2. Subsidy programs for manufacturers to reduce the final price of products for eligible consumers.
3. Subsidy programs for banks and microfinance institutions (MFIs) to make borrowing for solar products more affordable.

The sections below provide further information and policy options for each implementation stage.

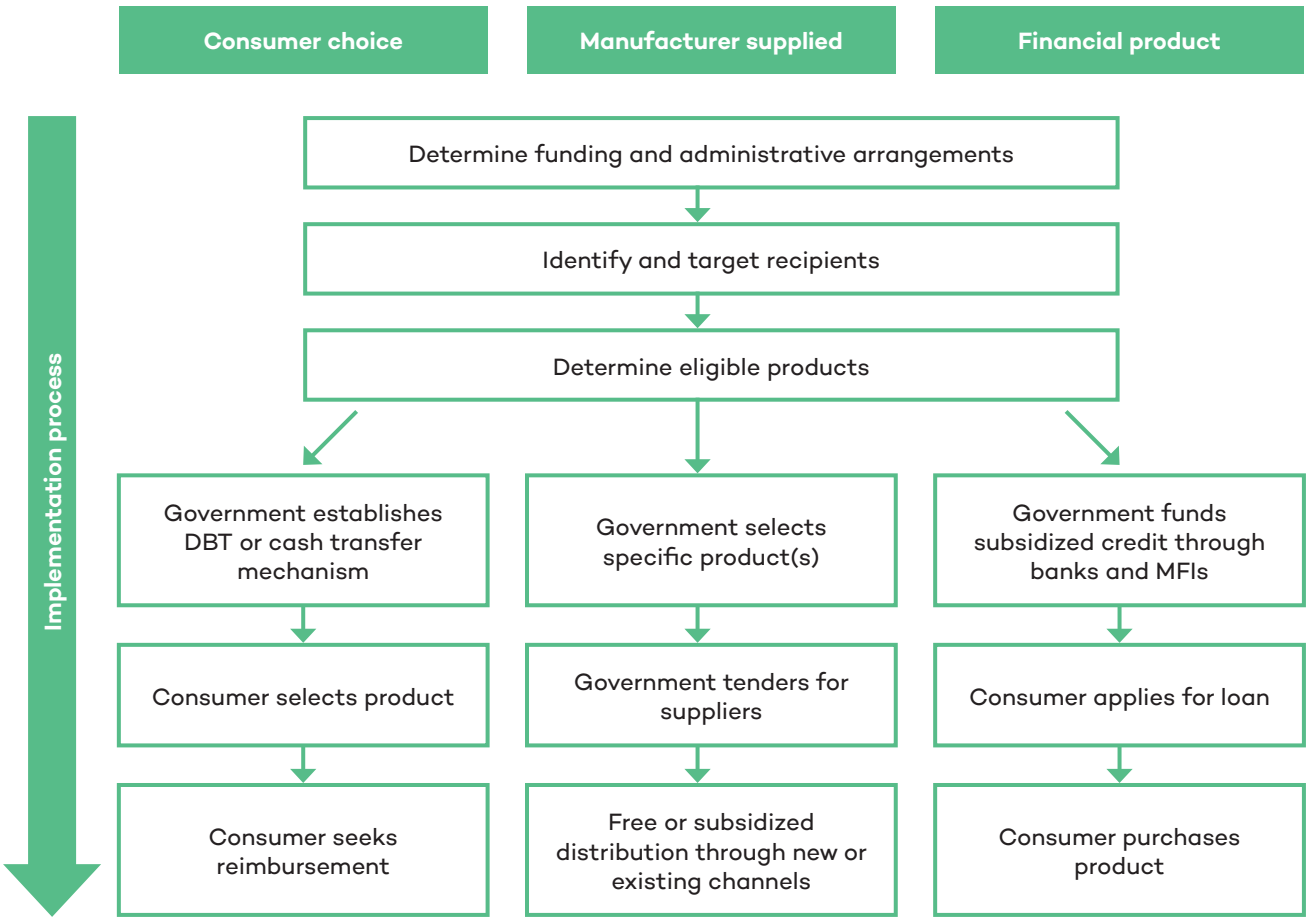

Figure 1. Implementation options for a kerosene to solar subsidy swap

3.1 Administration and Funding

The Central Government provides kerosene subsidies, making it the primary stakeholder and natural lead in a subsidy swap. The key central agencies would be the MoPNG and the MNRE. Other relevant departments include the ministries of finance, power and social justice.

The states are also key stakeholders, given their joint responsibility with the Central Government for electricity supply and their role in promoting solar uptake. States would need to nominate one lead agency and identify other relevant agencies. Consultations in Odisha indicated that the coordinating government stakeholders would be the Department of Energy, the Odisha Renewable Energy Development Agency and the Integrated Tribal Development Agency.

Once administrative responsibilities and coordination mechanisms have been established, such as through a taskforce or steering committee, policy development can proceed.

3.1.1 Funding

The Central Government has gradually reduced subsidized kerosene allocations to the state-based PDS and increased its price. In the past decade, kerosene consumption has more than halved, from 9.4 million metric tonnes in FY 2007/08 to 3.8 million metric tonnes in FY 2017/18 (Petroleum Planning and Analysis Cell, 2018). Also, the price of subsidized kerosene has gone up by 84 per cent since 2015.

Expenditure by the Central Government on kerosene subsidies has fallen to one sixth of pre-2014 levels, creating savings of INR 86,560 crore over the past four years (Figure 2). These savings reflect a reduction in the international oil prices since 2014 as well as changes in government policies. More savings are expected as the reforms continue.

The swap concept suggests that, recognizing these savings, it should be possible to identify fiscal space to increase support for off-grid solar. It does not require an explicit hypothecation of kerosene subsidy savings, such as through a trust fund or similarly complex financial arrangements.

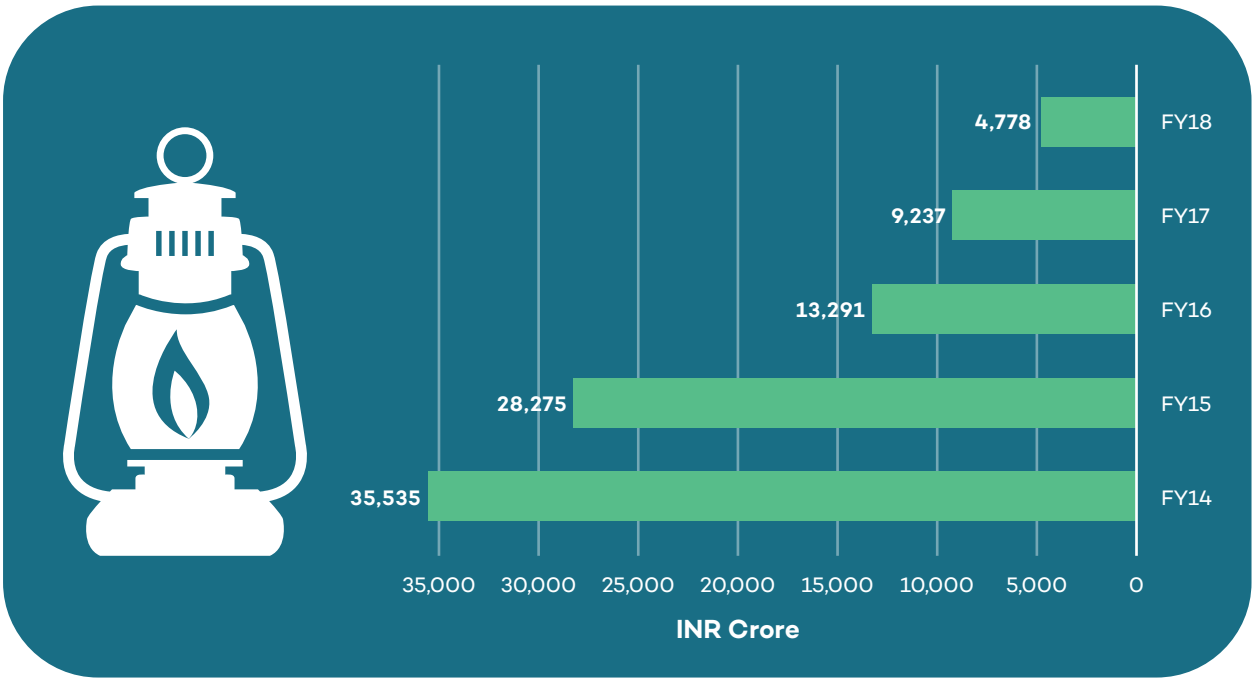

Figure 2. Kerosene subsidy expenditure is decreasing

Source: Soman et al., 2018.

3.1.2 Funding Channels

One complication is that the Central Government provides kerosene subsidies while the states generally deliver renewable energy programs. This is not an impediment because numerous precedents provide viable funding pathways on electricity projects.

As mentioned in Box 2, the REC PDCL, a national state-owned company, has issued contracts directly for the supply of standalone SHSs in grid-inaccessible villages in various states (REC PDCL, 2018). In several cases, including Assam and Odisha, the state agencies have issued the tenders (Assam Power Distribution Company, 2018; Odisha Renewable Energy Distribution Agency, 2018). This is a mechanism by which the Central Government could directly fund standalone SHSs or transfer funding to states for this purpose.

In addition, there is currently an incentive for states that voluntarily reduce their kerosene allocation. Under the direct transfer scheme, states receive a cash incentive of 75 per cent of the subsidy savings during the first two years, 50 per cent in the third year and 25 per cent in the fourth year, taking 90 per cent of the FY 2015/16 allocation as the baseline (Kumar, 2018). States participating in the scheme include Karnataka, Telangana and Haryana. Additionally, Gujarat, Rajasthan, Jharkhand and Chhattisgarh have already taken voluntary cuts (Indian Express, 2016; Kumar, 2018; MoPNG, 2018a). Some states have launched their own direct cash transfer system as a replacement for kerosene subsidies (Indian Express, 2016).

Policy options

1. Identify a lead agency, potentially MoPNG or MNRE, to coordinate policy development and consultation—within the government and with states—on development of a swap policy.
2. Commit to using a proportion of previous or future kerosene savings to fund off-grid solar products.

Funding pathways:

1. Direct provision of an off-grid solar subsidy by the Central Government.
2. Transfer of funds for a solar subsidy from the central to state governments.
3. Require that future states joining the direct transfer scheme for kerosene allocate funds to subsidies for off-grid solar products.

3.2 Potential Eligible Population and Targeting

As for all subsidies, an off-grid solar subsidy would need to be aimed at those most in need. There are existing mechanisms for determining eligibility for energy subsidies:[9]

- Below poverty line (BPL) card holders for eligibility under PDS
- BPL families identified under categories such as: i) *Antoyodaya Anna Yoyana* (AAY), ii) *Pradhan Mantri Awas Yojana* (Gramin), iii) scheduled caste and scheduled tribe households, iv) forest dwellers, v) most Backward classes; vi) Tea- & Ex-Tea-Tribes; vii) people residing on islands and river islands (MoPNG, 2018c)
- Families identified through previous mechanisms such as *Pradhan Mantri Ujjwala Yojana* (PMUY)
- Households identified as part of the Social-Economic Caste Census 2011

In addition to income data, energy access data would be needed to target districts with unconnected households or unreliable electricity supply. Under the SAUBHAGYA off-grid solar scheme, households and villages were

[9] It is beyond the scope of this paper to determine an appropriate poverty line. The paper only notes that subsidies should be targeted to the poor and near-poor. Governments would determine eligibility.

identified based on agreed criteria and surveys conducted by DISCOMs (REC, 2018; Rajasthan Renewable Energy Corporation, 2018). DISCOMs hold—and do not make publicly available—the necessary data on blackout days and hours of electricity supply. Survey results such as from ACCESS or the SPI survey also provide useful data on districts to target in energy-deprived states.

Targeting households based on current PDS kerosene usage is problematic because approximately 45 per cent is diverted to other uses (Gutpa, 2014). For example, an estimated 19 million households in UP and 6 million households in Odisha relied on PDS kerosene during FY 2017/18.[10] However, much of the kerosene may not have been used for lighting purposes.

Policy options

- Target recipients through a combination of means testing and electricity supply data, confirmed through surveys.
- Establish a 24x7 dashboard, similar to the SAUBHAGYA dashboard, that monitors duration and reliability of electricity supply.
- Undertake regular monitoring like the CEEW ACCESS survey to monitor in detail electricity access in poorly supplied regions.

3.3 Technologies Eligible for Support

Even a subsidy that allows consumers to select products would require the government to determine which would be eligible. Solar lanterns, mini-grids, microgrids and SHSs are offered in India and provide different solutions to household or regionally specific energy issues (Box 3) (Gill et al., 2018).

Box 3. Insights from consultations and case studies on microgrids, mini-grids and SHSs

The case study with Mera Gaon Power revealed that microgrids (<10 kW) can be a cost-effective solution for the very poor remote villages, which can share the cost of solar panels and batteries among many households. Their usage is low: one to two lights and a charging point per household.

Simpa Networks said that SHSs offer a flexible solution, with each household being able to select the number of panels and storage capacity they need and can afford. The payback period is between six months and three years. They can be deployed to individual households, without the need for a village network.

Mini-grids were not examined as a case study, but one interviewee expressed an opinion that mini-grids (>10kW) can be problematic to administer:

- They require village-level cooperation and many customers to make them economical.
- Differentiated electricity pricing and capital funding mechanisms have to be used due to the difference in demand among the households.
- The upfront costs of setting up the network is large, leading to a long payback time.
- They suffer distribution losses.

[10] Authors' estimation is based on family size of 6 and 4.3 in UP and Odisha, respectively, per capita allocation of PDS kerosene as 7.8 litres and 9.28 litres in in UP and Odisha, respectively, and sales of 901,300 kilolitres and 244,300 kilolitres of PDS kerosene during FY 2017/18.

Policy options:

- Develop criteria and guidelines to support the selection of solar products depending on local circumstances and objectives.

3.4 Subsidy Pathways

As noted above, households could receive assistance to buy solar technologies through three main mechanisms: direct payments, through manufacturers or through finance institutions. The pros and cons of each approach are summarized in Table 2 and discussed in the sections below.

Table 2. Pros and cons of subsidy pathways for a kerosene to solar subsidy swap

Subsidy mechanism	Pros	Cons
Households	• Maximizes consumer choice • Promotes competition in solar market	• Administratively expensive • Less control over product selection • Cannot use bulk buying to reduce prices
Manufacturers	• Relatively simple to administer • High control over product selection • Use bulk buying to achieve discounts • Distributes through existing channels	• Potential to distort market and undercut other suppliers • No consumer choice
Finance	• Maximizes consumer choice • Could be used alongside household or manufacturer-supplied subsidy • Encourages entrance to financial system	• Administratively expensive • May discriminate against the very poor and migrant classes

3.4.1 Households

Consultations with government demonstrated a strong preference for a subsidy to be delivered to households rather than manufacturers. The primary reason for this was to maximize consumer choice and allow the market to operate competitively, and thus avoid "picking winners" or creating market distortions.

A consumer-oriented subsidy would need to be delivered as a direct benefit transfer or cash payment, linked to the purchase of a solar product as for the direct benefits transfer for liquefied petroleum gas (LPG). The village surveys revealed that 50 per cent of households would prefer a subsidy payment for solar products to be delivered to their bank accounts and 50 would prefer a cash payment. While consultations with senior officials at MNRE and MoPNG suggested any consumer-oriented subsidy such as a direct benefits transfer may be prohibitively expensive to administer, it is supported by a range of other stakeholders.

Several interviewees from solar product manufacturers recommended pay-as-you-go systems for poor consumers with regular (such as weekly) repayments. Large bills are difficult for poor households to manage. Electronic means, including apps-based technologies, were generally supported as the most convenient for customers and administratively simple for companies.

One interviewee noted that the primary barrier to uptake is household awareness. Assistance with education and marketing of solar products could assist the switch from kerosene.

Policy options:

- Provide subsidy directly to consumers as cash or a direct benefits transfer.
- Work with manufacturers and social enterprises to improve household understanding of the availability and benefits of solar products.

3.4.2 Manufacturers

Several respondents recommended distributing solar products through existing avenues, such as ration shops, LPG distributors, petrol pumps and self-help groups (discussed in the finance section below). This would require the government to select and subsidize certain products and brands.

Subsidizing manufacturers to supply cheaper solar products would reduce administrative requirements and costs, as there would be far fewer subsidy recipients. It would also ensure that all solar technologies meet government quality and safety standards. Plus, through bulk purchases the government is in a strong position to negotiate lower prices.

The downside is that interventions such as these risk undercutting the free market for solar products, putting otherwise viable suppliers out of business. There is also risk of graft and corruption in the issuing of government contracts.

One option is to use market mechanisms to select solar products for supply to households. The REC PDCL used reverse auctions when issuing tenders for the supply of off-grid solar products (REC PDCL, 2018). Running reverse auctions at regular intervals would ensure competitive processes and pricing in government procurement. The products could then be distributed through existing avenues such as ration shops or LPG distributors.

In terms of delivery, the village surveys found that 58 per cent of respondents would like to get solar products delivered to their home, 28 per cent would like to receive them through distribution centres in their village, 12 per cent would like to get them through the *Gram Pradhan* (village council) and the remaining would like to directly buy them from a local shop.

Policy options:

- Work with state governments and consumers to identify suitable off-grid solar products for subsidization.
- Issue competitive and transparent tenders for the supply of solar products based on local requirements.

3.4.3 Finance Institutions

One industry respondent said that the biggest challenge to uptake of off-grid solar products is financing. Three reasons were cited for this:

1. The administrative costs of financing small loans for domestic solar products are too high for banks.
2. Solar technologies for domestic use do not necessarily generate additional income, an impediment to lending and potentially repayment.
3. Many of those seeking a loan for solar products do not have a regular income or credit history but may be credit worthy.

Consultations indicated that microfinance institutions (MFIs) were better suited to this type of lending. MFIs, however, only provide loans for uses that are classified as productive in order to mitigate risk. Solar products for domestic use do not fall under this category, although they can lead to income-generating opportunities such as sewing or bread-making machines.

Several interviewees suggested financing through self-help groups, such as Bihar Rural Livelihoods Promotion Society (BRLPS). JEEViKA, as it is locally known, facilitated women-led groups to access discounted financing for a range of products, including lighting (World Bank, 2017).

Greater direct financing through the solar supplier could be facilitated by regulatory change to allow solar companies to do credit bureau checks on customers, use mobile payments and Unified Payment Interface transactions. App-based payment mechanisms greatly reduce the transaction and operation costs. Direct financing would also increase the uptake of pay-as-you-go (PAYGO) financing models where there is greater flexibility for the customer.

A microfinance institution commented that the government should be careful not to intervene in the financial system, such as through zero-interest loans, in ways that would break the "culture of loans." Such an approach could undermine other areas where MFIs operate.

The government could consider a scheme that uses a subsidy together with credit. The *Kisan Urja Suraksha Utthan Mahaabhiyan* (KUSUM Yojana) program provides solar pumps to farmers. The Central Government provides 60 per cent of the cost as a subsidy, the banks provide 30 per cent as credit and the farmer pays 10 per cent of the cost (Government of India, 2018).

Policy options:

- Work with financial institutions to allow lending for solar products where there is no proof of income-generating activities, on the proviso that repayments are within the household's means. Potentially act as guarantor to lenders for these loans.
- Work with banks and MFIs to build institutional capacity for managing micro loans for solar products and a suitable package of lending facilities. The product needs to be easily accessible and rolled out (similar to finance packages available for cars).
- Consult banks and MFIs about mechanisms to finance zero-interest loans in ways that do not undermine existing practices.

3.5 Leverage Existing Distribution Networks

Government selection and subsidization of products would enable the use of existing channels for distribution. India has several programs and institutions that deliver energy services to the poor. A consistent theme in consultations was that these should be considered a potential avenue for providing subsidized off-grid solar lighting, or at least consulted during the development of implementation strategies. The avenues mentioned were:

- DISCOMs – responsible for last-mile electricity delivery, therefore off-grid solar will reduce their grid-connection costs.
- PMUY – already targeting poor women for the cooking gas connections, it makes sense to use the same targeting criteria, with added filters, and distribution networks.
- PDS – supplies kerosene to the poor through Fair Price Shops, thus there is potential to sell discounted off-grid solar products in ration shops.
- LPG retail outlets – consumers come to these locations to fill cooking gas cylinders.

Policy options:

- Review existing programs for energy access at the policy development phase to incorporate lessons and potentially utilize existing social, financial or physical infrastructure.

3.6 Risks, Opportunities and Barriers to Uptake

Identification and mitigation of risks ensures a more robust policy strategy. Consultations revealed three key risks: the impacts of eliminating kerosene subsidies on poor and remote households, the adequacy of after-sales service and corruption. Corruption is a risk in any public program or government tender and can be managed through transparency, competitive tendering and good governance. The other two potential barriers are unique to a kerosene to solar subsidy swap and are discussed below.

3.6.1 Difficulty in Removing Kerosene Subsidies

Consultations revealed that many interviewees considered that further reforms to PDS kerosene are unrealistic and inadvisable due to its importance to the poor and the difficulty in providing solar products, in particular after-sale services, in remote areas. In addition to lighting, kerosene is used by the poor in cooking stoves, to ignite biomass for cooking, as an irrigation pump or transport fuel and to supplement income by sale on the black market.

Based on the 2011 census, kerosene was used for cooking in 1 per cent of rural households and 11 per cent of urban households (Government of India, 2011). Since that time, LPG access schemes such as PMUY have replaced kerosene in many urban areas and could be further expanded to target areas reliant on kerosene for cooking.

The village and ACCESS surveys both indicated a strong preference for solar lighting and electricity, even if this means a reduction in kerosene subsidies. Inhabitants in remote villages already travel to access PDS kerosene and therefore once-off travel to access a solar product may not be a barrier to uptake (although after-sales services in a remote area could be problematic—see below).

3.6.2 After-Sales Service

After-sales service was mentioned as a major concern by policy-makers but not by villagers (but this may have been due to lack of familiarity with solar products). One policy-maker said it is vital to inform consumers about the potential after-sales issues that could emerge and that solar technology should not be promoted to the poor unless it is fail-proof and after-sales service is effective. Another reported that confidence among end-users about the technology and after-sales service is more important than affordability. If consumers are confident, they will pay for the product.

The SPI survey reported that 80 per cent of mini-grid customers were satisfied or very satisfied with their connection, although affordability was cited as a concern. The survey also found 93 per cent satisfaction with redress services for having faults repaired.

After-sales-service can be addressed, at least partially, by promoting branded and certified products, establishment of service centres in rural areas and, as done in Odisha, setting a mechanism for tracking of after-sales service by institutionalizing a toll-free number.

After-sales service can also be bundled into households' equalized monthly instalments. The government can set and enforce minimum standards for after-sales service (such as time periods for response to calls and repair or replacement of faulty products). Mechanisms like PAYGO can ensure that the manufacturers are providing efficient after-sales service. Otherwise consumers stop paying the instalments.

4.0 Conclusions

The Government of India has already shifted public expenditure from fossil fuel subsidies to renewables: expenditure on kerosene subsidies has fallen while spending on off-grid solar has increased under SAUBHAGYA. But more remains to be done. Continued dependence on kerosene is evidenced by states' continuing to draw on their entitlement for subsidized kerosene from the Central Government. Surveys also show that households that cannot afford electricity or have an unreliable electricity supply are using kerosene as a primary or secondary source of lighting.

Improvements to electricity distribution and supply will gradually reduce the need for coping strategies and energy stacking, but consultations suggest this could take 15–20 years. In the meantime, the most marginalized citizens are being disadvantaged in three ways: ongoing exposure to harmful indoor air pollution, rising kerosene prices, and lack of reliable access to high-quality light and electricity. Households have made it clear that they prefer solar electricity and lighting to kerosene.

Switching subsidies from kerosene to solar would result in fiscal savings for the Central Government and help achieve 24x7 Power for All. Around half of subsidized kerosene is diverted to the black market. Eliminating the subsidy would immediately halt this leakage. And analysis presented in this report demonstrates that off-grid solar products are cheaper over the life of the technology. The government can work with the private sector—solar suppliers and financial institutions—to help eligible households manage the upfront cost. The implementation framework and policy options presented here can serve as a guide in achieving this goal.

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