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Reducing Black Carbon Emissions by Transitioning to Clean and Sustainable Lightning (Nigeria)

United For Efficiency Initiatives (U4E)
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1. **CONTEXT:**

The 2017 Global Tracking Framework from the World Bank estimates that 1.6 billion people live without access to the electric grid, while the International Energy Agency further estimates that another one billion are left with unreliable and unstable connection to the grid. In Africa alone, approximately 600 million people have no access to the grid. This includes an estimated 465 million in rural areas and 121 million in urban areas. The number of people living in areas without access to the electric grid in Africa is expected to rise to about 700 million by 2030. In the meantime, populations without access to grid electricity rely mainly on dangerous sources of lighting such as kerosene lamps, candles, open-fires and battery-powered torches.

Fuel-based lighting is generally of low quality and expensive, impeding learning and economic productivity. Annually, the consumption of kerosene for lighting amounts to more than 25 billion litres. This translates into 270,000 tons of black carbon with a warming effect equivalent to an additional 240 million tons of CO₂, approximately. For isolated populations, fuel-based lighting and candles are the only available sources of light, raising indoor air pollution, and mainly impacting the health of impoverished residents, nurturing significant fire hazards.

2. **PROJECT OBJECTIVES**

The overall objective of the “Reducing black carbon emissions by transitioning to clean and sustainable lighting” initiative, is geared at accelerating increase in the access to clean lighting; by overcoming identified barriers to large scale uptake of alternative lighting technologies, by supporting policy development in Nigeria, and by supporting activities, including a study on kerosene subsidies and deploying an awareness raising campaign. This proposal responds directly to the recommendations from the Scientific Advisory Panel (SAP) in their briefing note on black carbon emissions from kerosene lamps, in which they identified this area as a Global priority.

The purpose of this project lies with implementing the project “Reducing black carbon emissions by transitioning to clean and sustainable lighting” which is part of the Household Initiative Framework of the Climate and Clean Air Coalition (CCAC). The overall objective of this agreement is to support Nigeria to phase out kerosene lamps and promote a market transition to off-grid and energy-efficient lighting products. This

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3 The Advanced DGF Database Information System (ADDIS) project page for Promoting Access to Sustainable OGL (Off Grid Lighting) in West Africa to Achieve SE4ALL Goals http://addis.unep.org/projectdatabases/01353/project_general_info
4 Ibid
5 CCAC, Scientific Advisory Panel briefing on kerosene lamps & SLCPS, 19 September 2014.
project builds on the experiences with the UN Environment-Global Environment Fund (GEF) project “Establishing the Foundations of a Partnership to Accelerate the Global Market Transformation for Efficient Appliances and Equipment” called United for Efficiency (U4E). The U4E initiative aims at enhancing the scope of en.lighten initiative expanded from lighting to appliances and equipment which have been identified as top priority themes by the UN Secretary-General’s Sustainable Energy for All (SE4All) initiative to achieve the goal of doubling the global rate of improvement in energy efficiency.

This project will also build on work conducted by UN Environment in West Africa and Power for All's projects in Nigeria. Power for All is a global decentralized renewable energy (DRE) campaign that supports national stakeholders towards taking action in support of Distributed Renewable Energy (DRE) market growth, and creating awareness and the sector through advocacy and communications. This is in line with the UN Environment Climate Change Sub-Programme of UN Environment Programme of Work 2016-2017 including Expected Accomplishment (b) - “Energy efficiency is improved and the use of renewable energy is increased in partner countries to help reduce Greenhouse Gas Emissions (GHG) and other pollutants as part of their low emission development pathways”; and Output 3, “Tools and approaches designed and piloted in countries to develop mitigation plans, policies, measures, and low emission development strategies, and spur sector investment and innovation within and across selected sectors”. Generating multiple benefits, the proposal will also contribute to the achievement of several Sustainable Development Goals (SDGs), including SDG 3 – Health, SDG 5 – Gender Equality, SDG 7 – Energy, and SDG -13 Climate.

3. PROJECT JUSTIFICATION

Project justification requires examining the current landscape and ongoing initiatives in the Nigerian Off Grid Power Sector, by considering the opportunities and challenges for developers, investors and lenders in becoming involved in the developing the Off-Grid sector specifically the reduction of low carbon emissions through technical assistance in key policy formulation, capacity building, technology transfer, market intelligence and data provision, local content, building an enabling business environment, and developing a system of phasing out fuel based lighting; particularly kerosene lamps and rather encourage the adoption of small solar lanterns. This would involve an examination of kerosene subsidy regime in Nigeria in the past few years and can make the case for fiscal and other socio-economic incentives that would lead to strong policy outputs and policy mechanisms that can promote better lighting and generate a trusted quality assurance program, provide adequate financing available across the supply chain and effective consumer awareness campaigns.6

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4. RESEARCH METHODOLOGY

The methodology adopted for this project comprised of primary and secondary data collection and an analysis of this data. The primary data was collected through interviews with solar energy companies, government agencies and development agencies. The secondary data was collected through review of literature of research summaries, articles and publications by government bodies, development agencies and researchers.

Our methodology for this project was in phases, starting first with the project development stage. This involved developing a work-plan to guide the project life-cycle and a research framework for this project. To ensure the project delivers with specifications and standards we developed a project plan that took into account a needs assessment for the entire project. This involved creating outlines and timelines to guide each phase of the project as well as interview guidelines and codes. Based on these guidelines, broad research questions were formulated as well as two specific sets of questions aimed at obtaining a wide range of views from stakeholders in the sector, specifically from government, industry, the donor community and NGOs, for the project.

The second stage was a comprehensive literature review on all the relevant literature existing on the subject matter of kerosene subsidies; efficient lighting as well as health and risk impacts. This section further delved into research on the historical underpinning of kerosene subsidies in Nigeria. The literature review also included looking at international and regional studies on subsidies existing in other countries and regions and drew some comparative analysis on its impact on the energy equation in those countries. Further study was done on transitioning to efficient lighting and the off-grid market growth of those countries and a further exploration of related fossil fuels (i.e. Diesel) used for lighting and its impact on the status of the Off-Grid market.

There was huge reliance on primary data collection, with over 40 interviews conducted during the course of this project. Most of the interviews were conducted with stakeholders in the decentralized renewable energy sector as well as policy makers both in the electricity sector, the environment sector and the petroleum sector. Most of these interviews were conducted in person, and some were conducted via telephone in cases where a person to person interview was not practicable as a result of time and distance. The interviews were conducted based on the research code and the interview guide developed. Finally, the results of these interviews were collated and analyzed, and data collected used were employed in macro-economic modeling to make economic case for transitioning from kerosene to more efficient lighting products and also for formulating polices and for project funding necessary for catalyzing the efficient lighting market in Nigeria.

5. ENERGY CONSUMPTION IN NIGERIA

5.1 Total Energy Consumption and The Challenge of Energy Access

Nigeria reportedly ranks in the bottom 25 of countries on power consumption per capita. The country’s estimated demand for electricity in 2016 is put in the region of 12,800 MW to 15,730 MW, and projected to reach 30,000MW to 88,282MW by 2020. This huge disparity between the demand for power in Nigeria and available electricity supply mainly from the grid has led to widespread self-generation of electricity in the commercial, industrial and residential sectors and even more so in numerous rural communities many of which remain completely off-grid. About 55% Nigerians are said to lack access to electricity although the Nigerian Association of Energy Economists puts this figure at 75% arguing that regular power supply is restricted to just 25% of the 45% connected to the national grid. This data highlights the difference between Nigerian grid based population and several of those living off-grid.

This means that the use of diesel and kerosene fuel generation as an alternative to grid connected supply, is a widespread practice for many individuals and communities to compensate for the lack of access to supply across the country. Many urban and peri-urban dwellers use diesel as means for alternative energy generation, at a higher cost Nigerian Naira (NGN)62 - 94/kWh than grid-based (NGN 26 - 38/kWh) power.

Several businesses rely on self-generation via diesel-powered generators which has resulted in various health, safety and environmental issues; it has further contributed to the increase in the price of goods and services. Similarly rural dwellers (as well as

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12 Ibid. Advisory Power Team (2015)
13 Ibid. Advisory Power Team (2015)
17 NGN means Nigerian Government Naira – a popular way outside of the ₦ symbol of denominating the Nigerian Naira
18 Advisory Power Team (2015), op cit
19 Adaju Segun (June 2017) – CEO, Consistent Energy – Interview conducted in June 2017 in Abuja – As part of the U4E project.
peri-urban dwellers) in Nigeria get a significant portion of their electricity from kerosene lamps. Recent May 2017 data from the Nigerian Bureau of Statistics shows that the costs of kerosene across the country are prohibitive and volatile.\textsuperscript{20} The Nigeria government’s focus on solving its energy deficit has for many years mainly focused on grid expansion,\textsuperscript{21} and only very recently has there been some evidence of a significant push for renewable energy generation and specifically a push for off-grid renewable energy generation in the country.\textsuperscript{22}

### 5.2 Total kerosene consumption in Nigeria

At least, 30\% of Nigeria’s population depends on kerosene for their energy needs, specifically for cooking and lighting. Consumption of kerosene in Nigeria was \textbf{52,000 barrels/day} in 2013 according to the IEA.\textsuperscript{23} The UNDP estimates approximately 43,000 barrels/day for 2012. Mills estimates that Nigeria is responsible for 5\% of total global kerosene consumption.\textsuperscript{24} More recent data newly released by the Nigerian Bureau of Statistics shows kerosene consumption in Nigeria from January to September 2016, to be a total of 12,655,215,047 litres with a daily average put at 51,865,635 litres.\textsuperscript{25}

Total primary energy consumption in Nigeria was \textbf{1.328 Quad Btu} in 2014.\textsuperscript{26} Kerosene has 5.670 million Btu/bbl.\textsuperscript{27} Thus, consumption of kerosene in 2013 was \textbf{0.108 Quad Btu} or roughly 8\% of total energy consumption in Nigeria. These official consumption statistics may not be reliable, as they fail to take into account illegal diversion of fuels across borders, which results in huge year-to-year swings in kerosene consumption statistics.\textsuperscript{28} For instance, EIA reported kerosene consumption was 18,000 barrels (bbl)/day in 2009 yet 44,000 bbl/day in 2010.\textsuperscript{29}

Domestic production of kerosene in Nigeria was 12,000 bbl/day in 2013.\textsuperscript{30} Assuming that the level of imports is equal to total consumption minus domestic production, there were 40,000 bbl/day of kerosene imported. Thus, imports account for 77\% of total kerosene consumption in Nigeria, and domestic production accounts for 23\% of total

\begin{itemize}
  \item \textsuperscript{20} Nigerian Bureau of Statistics (May 2017 data on costs of Kerosene) =Retrieved on June 13\textsuperscript{th} 2017 and available at http://www.nigerianstat.gov.ng/download/574
  \item \textsuperscript{22} Adaju op cit; Aighblakan G (2017, May) – Interview conducted May 31\textsuperscript{st}, 2017 – U4E Nigeria.
  \item \textsuperscript{23} Source: International Energy Statistics Database, \textit{US EIA}
  \item \textsuperscript{24} Mills (2017). Global Kerosene Subsidies: An Obstacle to Energy Efficiency and Development, p. 5
  \item \textsuperscript{25} There is a newly released statistic by the Nigerian Bureau of Statistics (NBS) showing kerosene consumption in Nigeria from January to September 2016. See document here: https://www.nigerianstat.gov.ng/pdfuploads/2016\%20Petroleum\%20Products\%20Consumption\%20(Jan-Sep)\%20.pdf
  \item \textsuperscript{26} Source: \textit{US EIA}
  \item \textsuperscript{27} Source: \textit{US EIA}
  \item \textsuperscript{28} Mills, E. “Global Kerosene Subsidies: An Obstacle to Energy Efficiency and Development, World Development” (2017), \url{http://dx.doi.org/10.1016/j.worlddev.2017.05.036}, p. 7
  \item \textsuperscript{29} Source: \textit{US EIA}
  \item \textsuperscript{30} Source: \textit{US EIA}
\end{itemize}
kerosene consumption. These estimates are conservative as Mills (2017) notes that reported annual kerosene consumption in Nigeria varies by 40%.31

5.3 Household kerosene consumption

The UNDP report indicates that about 4.0 million households are likely to rely on kerosene for cooking and about 10.8 million households are likely to rely on kerosene for lighting, out of 35 million total households in the country.32 This UNDP report further estimates that Nigerian households use 8.9 L/ Household/month of kerosene and further estimates that, in 2012, 1.647 billion L of kerosene were used for household lighting and 1.450 billion L of kerosene were used for household cooking; thus, about 53% of kerosene use was for household lighting, and 47% of kerosene use was for household cooking.33

6. SITUATIONAL ANALYSIS: THE KEROSENE SUBSIDY IN NIGERIA

6.1 Estimates of National Subsidy Expenditure

Nigeria is listed among the top twenty-five countries subsidizing fuel consumption.34 There are few official statistics for the level of kerosene subsidies and official subsidized prices in Nigeria are often one-third to one-quarter of those observed, even at regulated petrol stations.35 Mills estimates total national kerosene subsidy expenditure in 2016 as $1,545 million USD/year.36

This estimate is confirmed by other sources finding that the Nigerian government spent $1 billion on the kerosene subsidy in 2015.37 In fact, between 2009 and 2013, at least N1 trillion was spent to subsidize kerosene. Another estimate from the African Development Bank reports that in 2011, pre-tax subsidies for fossil fuels (including kerosene) in Nigeria cost $7.5 billion, accounting for up to 6.9% of government revenues.38

However, despite these levels of subsidization, the product is neither available nor sold at the official Nigerian National Petroleum Corporation (NNPC) pump price.39 This was a major motivation for the increase in the national kerosene price in early 2016.

31 Mills (2017) p.7
32 Ibid, p. 46.
33 Ibid, p. 49.
35 Mills, 2017, p.6
37 AllAfrica (2016) “Nigeria: Govt Spent $1 Billion on Kerosene Subsidy in 2015 - Osinbajo.”
Nigerian National Petroleum Corporation attempted to install a price ceiling of 150 Nigerian Naira per litre (NGN150/L) in October 2016, but was quite unsuccessful. We discuss subsidy reform further below.

### 6.2 Subsidy distribution across household income

Though kerosene subsidy is a measure to help low income households, numerous studies find that in Nigeria, the primary beneficiaries of the subsidy are not the Nigerian poor – they are largely the importing companies and local wholesalers, some of whom smuggle the subsidized fuel to neighbouring countries to sell it at a higher price.

Highly subsidized kerosene in Nigeria is diverted to the aviation sector, where it can be sold for a much higher price resulting in large arbitrage profits for intermediaries. Subsidies also encourage black markets and smuggling of fuel. For instance, ESMAP reported in 2009 that 20-30% of petroleum consumption in Niger is smuggled from Nigeria. This means that Kerosene is still evidently a scarce commodity despite the removal of subsidies, where reports suggest that they are neither available for household uses and despite the fact that costs have significantly shot up. Together these leakages mean that even less of the national subsidy is directed to poor households than reported. In fact, the poorest quintile of Nigerian households is only estimated to receive 13% of total kerosene subsidy.

There is actually little variation in kerosene usage across household income groups (as opposed to petrol use, which varies dramatically across income groups). 66% of households use kerosene throughout the country and this includes kerosene for cooking. Soile and Miu (2014) cites a National Bureau of Statistics (NBS) data, where the share of households using kerosene for cooking and lighting is respectively 22.8% and 57.8%. This data is quite at variance with the UNDP statistics that states that 10.8 million out of 35 million households use kerosene for lighting. However household budget spending on kerosene is inversely related to household income – on average the poorest household will spend 8.7% of income on kerosene while a rich household will

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40 Vanguard (2016) “NNPC Fixes Kerosene Price at N150/L.”
41 Siddig (2014). p. 166
42 UNEP, 2014. Lifting the Darkness on the Price of Light: Assessing the Effects of Fuel Subsidies in the Off-Grid Lighting Market, p. 15
46 Soile and Mu (2014). P. 322
47 Soile and Mu (2014). p. 320
48 Ibid
spend 2.9% of income.\textsuperscript{49} This is because rural households generally have higher expenditure shares for energy-intensive goods and services, while urban households directly consume relatively more petroleum products.\textsuperscript{50}

Furthermore, while kerosene prices seem cheap this is only when the cost of supply shortages, transportation costs and the resulting pricing power of last-mile distributors are not taken into account.\textsuperscript{51} However as a Lighting Africa publication reports, these costs are borne by the consumer, mostly at the bottom of the economic pyramid and are not covered by subsidies.\textsuperscript{52} In fact, kerosene subsidies are regressive: the GINI coefficient\textsuperscript{53} for the distribution of kerosene subsidies is \textbf{0.6747}, compared to 0.4283 for the Nigerian economy as a whole, where a higher GINI coefficient represents more unequal distribution.\textsuperscript{54}

7. IMPACTS OF KEROSENE USE ON HOUSEHOLDS

7.1 Household expenditure on kerosene

Across Africa, about 53\% off-grid households use kerosene-based lighting with a total annual expense of $4.4 billion\textsuperscript{55 56}. In some African countries, kerosene costs make up 10-25\% of household monthly budgets – even where the fuel is subsidized\textsuperscript{57}. In East Africa, 15-30\% of household income goes into kerosene purchase.\textsuperscript{58}

According to the International Finance Corporation, Africa’s Base of the Pyramid’s (BoP)\textsuperscript{59} use of kerosene-based lighting accounts for 20 million tons of CO\textsubscript{2} emission annually\textsuperscript{60}. In Tanzania and Kenya, a large percentage of kerosene consumption by households is primarily for lighting, with just 2\% of kerosene used for cooking\textsuperscript{61 62} and 89\% and 94\% of the urban and rural population respectively in Kenya, depend on kerosene for lighting\textsuperscript{63 64}.

\textsuperscript{49} Soile and Mu (2014). p. 320
\textsuperscript{50} Siddig et al (2014) p. 174
\textsuperscript{51} Spaces4Change (2016) – Policy Brief; Spaces4Changes (2017); Spaces4Change (2016).
\textsuperscript{53} A commonly-used measure of income distribution within a population
\textsuperscript{54} Soile and Mu (2015). Who benefits from fuel subsidies? Evidence from Nigeria, p. 322
\textsuperscript{57} Op cit. Tedsen, E. (2013)
\textsuperscript{60} Lighting Africa (2010) Solar lighting for the base of the pyramid – Overview of an emerging market.
\textsuperscript{63} ibid
7.2 Health Risk Assessment

Kerosene lamps are primarily of three types – flat wick, central draught (tubular round wick), and mantle lamp\(^{65}\). Kerosene lanterns are usually of the flat wick type and are either dead flame, hot blast or cold blast type with the latter working by drawing in fresh air from the top of the globe which is then circulated through the metal side tubes enriching the flame and facilitating brighter burning\(^{66}\). In Nigeria, cold blast lanterns are predominantly used. Flat wick-type kerosene lamps (which are the most commonly used in Nigeria) have the lowest light output in comparison with Center Draft round wick lamps which have three to four times the output of flat wick lamps and pressurized lamps having an even higher output yet of about 8 to 100 lumens\(^{67}\).

Compared to household gas fuels in developed countries and solid fuels in developing countries, there have been few studies of the health and other impacts of household kerosene use\(^{68,69}\). Key documented kerosene hazards are related to poisoning, fires, and explosions\(^{70}\). Less investigated are the risks of exposures to kerosene combustion products\(^{71}\).

7.2.1 Health Impacts

In 2014, 66 countries were assessed by the Solar Energy Foundation Off-Grid Business Indicator (OBIN) on their potential for off-grid business.\(^{72}\) According to the study, the global population using kerosene lamps (glass cover, simple wick) across Africa, Asia and America stood at 627.7 million (306.8 million in Africa, 308.8 million in Asia, and 12.1 million in America)\(^{73}\) with the market potential for the replacement of kerosene lamps valued at US$ 18.8 billion (US$ 9.204 billion in Africa, US$ 9.264 billion on Asia and US$ 363 million in America)\(^{74}\). Globally across America, these countries include Peru, Guatemala, Haiti, Honduras, Bolivia, Nicaragua, Panama and Guyana,\(^{75}\) while across Asia this include 14 countries with India, Bangladesh, Indonesia and Pakistan.


\(^{66}\) ibid

\(^{67}\) ibid


\(^{71}\) ibid


\(^{73}\) ibid

\(^{74}\) ibid

having the largest off-grid population. Colibri a solar PAYG firm focused on the Central American market however reported that unlike East Africa, kerosene is rarely used in Central America and not the main driver for the adoption of solar lighting technologies. According to Colibri, in a survey of 42 off-grid Nicaraguan households administered by Colibri points of sale, none used kerosene for lighting.

Not a lot of research has been done on the health impacts of kerosene lighting across these countries but research available show evidence on the use of kerosene lamps associated with Tuberculosis in Nepal where the odds was nine times greater for women using kerosene lighting than electric lighting. In terms of visual health, studies have shown twice the risk in cataract incidence for households using kerosene lighting than electric lighting; reduced vision for night fishermen in Tanzania; and vision related issues in a study among 472 workers in Thailand that perform visually demanding tasks.

The Lumina Project by Evan Mills in 2012 on the Health Impacts of Fuel-based lighting provides significant insight into the risks and health impacts of kerosene in sub-Saharan Africa. 26% from a survey of 3,315 users of kerosene-based lighting across five sub-Saharan African countries were discovered to have health concerns from the use of kerosene for lighting. In South Africa, over 200,000 people are affected by kerosene related fires annually, 79,750 young children ingest kerosene with 60% of them developing pneumonia as a result.

In Nigeria, for instance, thousands of people are maimed each year by lamp explostions, with a 13% fatality rate. Nigeria is estimated to have 43.6 million glass cover kerosene lamps and 18.1 million simple wick kerosene lamps. Evan Mills (2012) analyzed various reports on kerosene related incidents in various countries including Nigeria which sixteen documented reports on kerosene burns from seven countries, seventeen

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78 ibid
85 ibid
86 ibid
on kerosene explosions from four countries, and twenty-eight on kerosene ingestion from eighteen countries, all including Nigeria. Three multi-year reviews of admission in Nigerian hospitals attribute about 30% of burn cases to kerosene and is underestimated considering the broader population as well as the bulk of unreported cases of kerosene incidents especially from rural inhabitants who result to traditional means for burn treatment. Following the growing incidences of fatalities arising from kerosene in the country, the Federal House of Representatives in March 2017 adopted a motion titled “Need to arrest the resurgence of kerosene explosion with attendant fatalities” and mandated its Committee on Petroleum Resources (Downstream) on finding out the cause of this spike in kerosene explosions.

Some articles have been written on case study fatalities in Nigeria by various researchers, however there is generally little national research on the health and safety impact of kerosene based lighting in the country, with most information on kerosene incidents provided by newspaper articles. Key health and safety risks associated with kerosene based lighting from the bulk of available data and research are discussed below.

### 7.2.2 Indoor Air Pollution

Kerosene use creates indoor air pollution, which kills an estimated 1.5 million individuals annually from respiratory diseases including chronic obstructive pulmonary disease (COPD) and respiratory tract infections, with over 50% of these deaths involving children under the age of five. Reports have highlighted this prevalence especially in Nepal.

In Nigeria, 136,650,000 people are affected by Household Air pollution (HAP) leading to 128,500 deaths annually. Kerosene lanterns emit various indoor pollutants including black carbon, carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen dioxide, formaldehyde, polycyclic aromatic hydrocarbons (PAH), sulphur dioxide, nitrogen oxides and various other VOCS which cause various impairment in ventilator function, rise in blood carboxyhaemoglobin, acute lower respiratory infection and respiratory issues such as asthma and bronchitis. Generally, the key HAP risks resulting from kerosene based lighting include risks of damage to the respiratory and nervous system, kidney damage and blood clots. Various studies have been carried out in different developing countries highlighting the respiratory risks from household air pollution

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90 Ibid
resulting from kerosene-based lighting\textsuperscript{97} 98 99 100 including a research in the Niger-Delta\textsuperscript{101}.

Users of kerosene wick lamps have been found to be exposed to PM2.5 particle concentrations way above World Health Organization (WHO) standards\textsuperscript{102}. Kerosene emits about 2.5 kilograms of carbon-dioxide per liter leading to cases of carbon dioxide poisoning\textsuperscript{103} with increased risks in households that use more than one kerosene lamp. There have also been links between kerosene combustion to higher incidences of tuberculosis and cataracts\textsuperscript{104} 105 106. A review had found that repeated occupational inhalation exposure to kerosene can result in changes to brainstem/cerebellar systems, complex neurobehavioral performance capacity and associated with hematological changes, including reductions in red and white blood cell counts\textsuperscript{107}. Various studies have also highlighted harmful visual effects resulting from kerosene lamps and impact of performance of school children.\textsuperscript{108} 109 110 111

Kerosene lamps may seem fairly mild in causing HAP especially since the fuel is consumed relatively slowly compared to either cooking or heating use. However, with usually prolonged exposure with kerosene based lighting in comparison with cooking for example, serious health issues are bound to occur. For example, since light from a simple wick lamp is only useable over a short distance, a person may be in close proximity to the lamp for several hours at a time such as a child studying. On the other hand, a kerosene based heater may be kept relatively distant from the user, even in the

\textsuperscript{102} Op cit. Mills, E. (2012)
\textsuperscript{103} Op cit. Lighting Africa (2010)
\textsuperscript{109} Solar Aid (2011) The impact of solar on schools and clinics. 9pp
same room while cooking is only for specific duration\textsuperscript{112}. Given the widespread use of kerosene based lighting in Nigeria and its potential for harm and fatality, the health and safety risks of kerosene-based lighting are immense.

### 7.2.3 Household fires

Kerosene-based lighting devices have been responsible for a lot of household fires especially in developing countries primarily from explosions resulting from adulterated kerosene, accidents where kerosene lamps are knocked over, and related accidents.

In Haiti which has the least electrification rate in Latin America and high use of kerosene lighting, over 200,000 deaths and injuries occur annually from house fires, most of which can be traced to the use of kerosene lamps.\textsuperscript{113} Evan Mills highlighted eleven reports across Bangladesh, China, India, Nepal, Philippines and South Africa on the prevalence of house fires from kerosene use for lighting and seventeen reports across India, Nigeria, Papua New Guinea and South Africa on kerosene explosions.\textsuperscript{114} These include a 2009 fire incident affecting 3000 people and killing 16 in the Philippines; destroying 300 homes in India in 2010; and 1,200 to 1,500 homes in a Nepali camp.\textsuperscript{115}

Cultural practices such as keeping kerosene lanterns and candles close to young children to ward off evil spirits\textsuperscript{116} are also a cause to household fires where these kerosene lamps are accidentally knocked over, as well as health issues form prolonged inhalation related to the previous sub-section. Kerosene aerosol or vapor especially from kerosene storage also contribute to household fires even though at a low level\textsuperscript{117}

A research study by Peck M.D. and others; discovered that kerosene-based lighting is often used in confined spaces usually in poor and crowded communities in slums with the homes often made of wood.\textsuperscript{118} The eventuality of these kerosene lamps resulted in their being knocked over, causing spillage and resulting in a rapidly spreading fire. The research also found that locally made kerosene lamps are poorly constructed and leak, which may result in fires. Households primarily in peri-urban areas who use small generators for primarily lighting and kerosene lanterns for secondary lighting can accidentally use the similar containers for kerosene and petrol which results in explosions in the kerosene lamps. Another common cause is the practice of adding kerosene fuel to a device such as the kerosene lamps when it is still lit.

### 7.2.4 Kerosene Adulteration

\textsuperscript{113} Sunlight if Free (2017). Available from: https://www.sunlightisfree.org/blank
\textsuperscript{114} Op cit. Mills, E. (2012)
\textsuperscript{115} ibid
\textsuperscript{116} ibid
Mixing kerosene with even a small amount of gasoline results in a lower flash point and higher vapour pressure for the fuel, with potentially dangerous consequences. The bulk of reports on kerosene adulteration is particularly prevalent in Nigeria where gasoline or diesel is mixed with kerosene, resulting from lower prices of gasoline due to subsidies\textsuperscript{119} as well as a few reported cases in India.\textsuperscript{120, 121} A particular incident in Nigeria had 2,500 people affected from an explosion resulting from adulterated kerosene which claimed the lives of 368 (14%).\textsuperscript{122} Various newspapers articles report frequently explosions resulting from adulterated kerosene explosions which has killed almost entire families\textsuperscript{123, 124, 125} while a much higher number of similar cases are most likely not reported.\textsuperscript{126}

During period of kerosene scarcity especially, adulterated kerosene with gasoline or diesel becomes frequent with most victims of kerosene explosion resulting from adulteration being women between the age of 18-45, young children and elderly.\textsuperscript{127} This can also be unintentional for example when the same container is mistakenly used for both diesel/petrol and kerosene either from either the local retailers or households who usually use kerosene lamps for secondary lighting. The rising cases of adulteration led the Nigerian National Petroleum Corporation (NNPC) to put out alerts and warning on the practice\textsuperscript{128}.

Below are some key cases kerosene disasters from various reports between 1984 to 2012 in Nigeria as shown in the table below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>People injured/killed [Female:Male]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>Lagos</td>
<td>53/30 [1:9:1]</td>
</tr>
</tbody>
</table>

\textsuperscript{119} Op cit. Mills, E. (2012)
\textsuperscript{120} The Telegraph (2011) One more dies in kerosene blast; Death toll rises to eight, 62 injured. Calcutta, India.
\textsuperscript{122} ibid
7.2.5 Burns

Statistics show that mortality rates related to burns from kerosene lighting are five-times higher in low and middle-income populations in Africa than in high-income countries in Europe, and 8.3 times greater in South-East Asia than in Europe. Global deaths from burns and smoke inhalation were estimated at 322,000 in 2002 and 195,000 in 2008. In Bangladesh, 23% of infant burns are associated with the use of kerosene lamps and in Sri Lanka over 40% burns are associated with kerosene lamps. Sixteen reports across Bangladesh, India, Mozambique, Nepal, Nigeria, South Africa and Sri Lanka highlight the high rate of burns arising from the use of kerosene for lighting.

Burns from kerosene lights are also less reported pose a major risk especially to young children with various studies existing related to burns caused by lamps in Nigeria. Asuquo et al. (2008) further reports that 33.9% of kerosene and candle related burns out of fifty-nine burn patients (twenty patients) out of which nineteen resulted from explosions. Out of another thirty-six burn cases, seven resulted from kerosene explosions in lamps or stoves with a female to male ratio of 1.22:1. Out of sixty-two children admitted for burns in the hospital, 52% of burns resulted from kerosene explosions with 6% to 50% of the body affected. It was also observed 100% mortality rate from kerosene burns affected over 18% of the body.

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132 ibid
133 ibid
7.2.6 Poisoning

Twenty-eight reports on kerosene ingestion across Latin America, Asia and Africa (covering Antigua and Barbuda, Barbados, China, Ghana, India, Iraq, Israel, Jamaica, Jordan, Kenya, Libya, Malawi, Malaysia, Nigeria, Pakistan, South Africa, Sri Lanka, and Zimbabwe) were highlighted in Evan Mill’s report on the Health Impacts of Fuel-based Lighting with up to 78% rate of admission resulting from kerosene ingestion in lower-income areas of South Africa.\footnote{ibid}

Various research has highlighted kerosene as the single most common cause of child poisoning in Africa.\footnote{Bwibo N. O. (1991) Accidents and poisoning. In: Standfield P., Brueton M., Chan M., Parkin M., Wasterston T (eds). Diseases of Children in the Subtropics and Tropics. 4 th edition Great Britain, Butler & Tanner Ltd., Frome and London. Pp.945-46.} \footnote{ibid} \footnote{Lucia (2017) Too many children are drinking kerosene 0 –Emeka Nwolisa. Sabi News. [online]. Available from: https://www.sabinews.com/73667-2/} \footnote{ibid} \footnote{Edelu, B.O., Odetunde, O.I., Eke, C.B., Uwaezuoke, N.A., Oguone, T. (2016) Accidental children poisoning in Enugu, South-East, Nigeria. Annals of Medical & Health Sciences Research, 6, pp.168-171.} \footnote{ibid} \footnote{Tshiamo, W. (2009) Paraffin (kerosene) poisoning in under-five children: a problem of developing countries. International Journal of Nursing Practice, 15(3):140-144.} \footnote{ibid} \footnote{Op cit. Tedsen, E. (2013)} \footnote{Op cit. Tshiamo, W. (2009)} \footnote{Op cit. Mills, E. (2012)} \footnote{Evan Mills (2012). Health Impacts of Fuel-Based Lighting. A Working-Paper-for-presentation-at-the-3rd International Off-Grid Lighting Conference November-13E15,-2012,-Dakar,-Senegal. http://light.lbl.gov/pubs/tr/Lumina-TR10-health-impacts.pdf} In a well summarized in-depth study on kerosene poisoning in children from developing countries, it was discovered that in addition to inadequate storage and packaging of kerosene, risk factors for kerosene ingestion include age, season, poverty, and living in rural areas\footnote{ibid}. Kerosene is usually stored in soda or water bottles especially in peri-urban and rural communities where households can only afford to buy a small amount at a time and provide their own containers for suppliers to fill \footnote{ibid}. Young children have relatively undeveloped senses of taste and smell and may mistake kerosene for familiar drinks, such as water and some sodas especially during hot periods.\footnote{ibid} Mortality rates range from 0-25% from kerosene ingestion \footnote{ibid}. According to Evans (2012)\footnote{ibid}, 1ml of kerosene ingestion can pose complications and fatal at 10ml.\footnote{ibid} Common health issues with ingestion include pneumonia, pulmonary damage, and respiratory effects.\footnote{ibid} A review over seven years found the most occurring vulnerability age of ingestion by young children to be 18 months, with 5.5% mortality rate.\footnote{ibid}

7.2.7 Black Carbon and Global Warming

Almost one-tenth of the fuel burned in kerosene lamps is converted to black carbon particles. A diesel engine in comparison only emits about one-thousandth of the original fuel as particles. According to a Stanford University research, using a kerosene lamp producing 37 lumens will utilize approximately three liters of kerosene per month for four hours of lighting daily. Assuming single kerosene lantern burns for an average of four hours a day, it emits over 100kg of CO₂ annually. A liter of kerosene emits about 2.5 kilograms of carbon dioxide, therefore for an average of three liters a month, a household emits about 7.5 kilograms of carbon dioxide from one kerosene lamp.

A One kilogram of black carbon in comparison produces as much warming in the air in a month as 700 kilograms of carbon dioxide does over 100 years. At least 270,000 tons of black carbon per year is estimated to be emitted from kerosene lamps worldwide with a climate-warming equivalent close to 240 million tons of CO₂. The warming impact of black carbon emissions from kerosene lamps is highest around source regions and reaches 0.5 watts per square meter. The amount of black carbon emitted by a kerosene lamp however depends on a number of factors, most significantly lamp type. Simple wick lamps, using a rope or cloth wick extended from a metal or glass container, emit substantially more black carbon than glass-enclosed hurricane or pressurized mantle lamps. Research recognizing the high level of black carbon emissions from kerosene lamps is still relatively new. 52,680 tons of black carbon can be saved in Nigeria alone from elimination of kerosene use with 2.3 billion liters of kerosene saved annually.

7.3 Risk assessment on the use of dry-cell battery

Disposable, non-rechargeable dry-cell batteries frequently used to power torches cumulatively drain household income over the long term, and are associated with a high risk of contaminating local water and soil resources with toxic heavy metals, while yet generating a poor amount of lighting. They represent a large volume of toxic and hazardous materials, commonly used for lighting in flashlights (torches) in households with different types which can be categorized under carbon zinc, alkaline manganese,
nickel-metal hydride and Lithium-ion dry cell batteries. They constitute household hazardous waste when ‘dead’, or discarded, that is when the components have reached their equilibrium concentrations. The EU directive on batteries and accumulators (91/157/EEC) introduced in 1991 calls for batteries containing more than 25mg of Hg, 0.025% of cadmium (Cd) and 0.4% lead (Pb) by weight be collected separately from household waste for recycling or special disposal. In 1992, a year after the EU directive, manufacturers of alkaline batteries in Europe ceased the addition of mercury (Hg).

A study carried involving a rural household survey in Benin, Burkina Faso, Mozambique, Rwanda, Senegal, Tanzania and Zambia between 2006 and 2014 showed an increasing shift from kerosene use to the use of dry-cell batteries with implications for environmental pollution due to the lack of proper waste management systems. This assertion is supported by research from Grimm and Peters (2015) highlighting that a key reason for the largely unnoticed shift was because the official census did not include dry-cell battery LED lights as a lighting option. In 2008, the national average monthly consumption figure for kerosene, candles and dry-cell batteries stood for sub-Saharan Africa stood at five to nine litres, three and thirteen candles, and 0.8 to 1.2 batteries respectively, with the exception of Zambia which was almost exclusively candle based. It was discovered that LED usage powered by dry cell batteries were cheaper than kerosene and candles which was a major driver to the shift from kerosene and candles towards dry-cell battery powered LED lighting. According to the research, powering an LED lamp with dry cell batteries for one hour is much lower than for kerosene lamps.

164 ibid
165 ibid
169 ibid
170 ibid
Table 1 Sources of lighting for un-electrified population from some African countries

<table>
<thead>
<tr>
<th></th>
<th>Lighting usage rates among non-electrified households, in %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>candles</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
</tr>
<tr>
<td>Rwanda</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>26</td>
</tr>
<tr>
<td>2013</td>
<td>32</td>
</tr>
<tr>
<td>Senegal 1</td>
<td>2011</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
</tr>
<tr>
<td>Senegal 2</td>
<td>2011</td>
</tr>
<tr>
<td>Tanzania</td>
<td>2014</td>
</tr>
<tr>
<td>Zambia</td>
<td>2011</td>
</tr>
</tbody>
</table>

(Note: Senegal 1 refers to surveys in the Bassin Arachidier and Casamance region, Senegal 2 to surveys in the Thiès region. * refers to surveys that were conducted after an electrification intervention. Numbers reported in this table are based on the control group part of the sample, i.e. households that were not served by the electrification program.)

A large volume of dry cell batteries into Africa and Nigeria are largely imported from Asian countries (especially China) while some are manufactured in Nigeria. Some of these carry caution signs, such as 'Do not incinerate, short-circuit, or disassemble', while others do not. About 11,000 metric ton of dry-cell batteries are imported annually in Nigeria which translates to an average of 275 million batteries annually, excluding batteries smuggled into the country, locally manufactured or packed with items such as cameras, torches etc. There have been instances where the state governments have shut down warehouses discovered to be involved in dumping dry cell batteries in water bodies in their state. While some of these have been reported, a significant number of these are unreported. The increasing level of dry cell battery use with a growing population creates a public health and environmental problem especially in densely populated areas.

7.3.1 Risk Assessment

Common types of dry cell batteries include –

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173 ibid
174 ibid
a. Primary Alkaline which use an alkaline solution (potassium/ sodium hydroxide) instead of the acidic ammonium chloride or zinc chloride electrolyte used in zinc carbon batteries. They have become the dominant battery system in the portable battery market.\textsuperscript{177}

b. Carbon Zinc or zinc carbon or carbon zinc batteries, and sometimes known as “Heavy Duty” or “General Purpose” on their label were more commonly used before the development of alkaline batteries.\textsuperscript{178} The zinc anode of dry cells contain low percentages of cadmium (Cd) and Lead (Pb) for improvement in strength and ductility. Small quantity of Mercury (Hg) is also alloyed with the Zinc (Zn) to control corrosion and provide current carrying capability.\textsuperscript{179}

There is very little information on national risks assessment of dry cell batteries in Nigeria. However, major risks associated with dry cell battery use include,

a. Explosions and Household Fire

While explosions from dry-cell batteries are rare, when they do occur are devastating leading to severe burns that may eventually prove fatal.\textsuperscript{180} These can result from either careless disposal of the dry-cell batteries from households, or storage in hot areas, or use of sub-standard and fake batteries. Children have been known to play with disposed batteries which can lead to explosions. In a case study of a fatal accident from a 1.5 volt dry-cell battery in Lagos, it was observed that majority of the batteries produced in Nigeria do not carry any cautions signs or even labels.\textsuperscript{181} The reported case of a 12 year old boy who sustained extensive oral and facial blast injuries resulting from the explosion for four 1.5 volts dry cell batteries and requiring surgical intervention further highlights how fatal and risky these dry cell batteries can be.\textsuperscript{182}

b. Ingestion and Skin Poisoning

Ingestion and skin poisoning from dry cell batteries are primarily caused by accidents especially with children, improper disposal, ignorance and other reasons. The practice of using dry cell “black mix” (electrolyte + carbon black +graphite rod) for darkening classroom blackboards can expose school children to low doses of heavy metals leading to poisoning.\textsuperscript{183} Studies of prevalence of elevated lead blood (PbB) levels in children 1-6 years old in the country observed high average levels of PbB in children of about 5 years old attributed to the tendency for this age group to play longer in contaminated outdoor environment.\textsuperscript{184} The improper disposal of these dry cell batteries leads to

\textsuperscript{178} Ibid
\textsuperscript{179} Op cit. Osibanjo, O. (2009)
\textsuperscript{181} Ibid
\textsuperscript{183} Op cit. Osibanjo, O. (2009)
\textsuperscript{184} Ibid
environmental problems and subsequently poisoning especially in children resulting from exposure which are usually within their immediate environment. High concentrations of lead are often present in zinc carbon batteries, lesser in alkaline batteries, with high levels affecting kidneys, reproductive and nervous systems particularly for children. Cadmium is also carcinogenic and a toxicant from reproductive system. Mercury is likely to cause brain, kidney and nervous system damage and is still found in some alkaline batteries even though banned in many countries. A relationship was also discovered between lead and cadmium exposure to the alteration on the development in children and increased risk of osteoporosis. Increased exposure to disposed batteries especially children lead to an increased risk of poisoning.

c. Soil, Surface water and Groundwater Pollution

Dry cell batteries are usually disposed together with general household waste and end up in public landfills. Since these batteries are mainly generated at household level where there is often no separation of waste at source, these batteries are therefore discarded with other domestic refuse which end up being disposed of at municipal landfill sites which are often not designed to receive this type of a waste stream. In poorly managed landfills which is the usual case in Nigeria, these batteries have a potential to leach these toxic heavy metals into the surrounding soil, surface and groundwater. In particular, they can cause soil and water pollution and endanger wildlife. For example, cadmium can cause damage to soil micro-organisms and affect the breakdown of organic matter. It can also bio-accumulate in fish, reducing their numbers and making them unfit for human consumption. When consumed unknowingly, this can have adverse health impacts on humans. Table 1 below highlights the mode of battery disposal from studies in Burkina Faso, Rwanda, Senegal and Tanzania.

Bensch, G., Peters, J., Sievert, M. (2015) discovered that a key deciding factor for rural communities in Africa on how they dispose their dry-cell batteries is the population density. With higher population density, there tends to be lesser space for open garbage dumping and most people tend to dispose of these batteries in their latrines, also as a way of protecting their children form the batteries, according to household surveys. This is shown in the Table below

187 ibid
191 ibid
193 ibid
Table 2  Battery disposal of dry-cell batteries\textsuperscript{194}

<table>
<thead>
<tr>
<th>Mode of dry-cell battery disposal, in %</th>
<th>Monthly consumption of batteries among battery users</th>
<th>Household size</th>
<th>Population density in survey areas, in people/km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>nature</td>
<td>garbage</td>
<td>latrines</td>
<td>other</td>
</tr>
<tr>
<td>(non-managed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>2014</td>
<td>61</td>
<td>33</td>
</tr>
<tr>
<td>Rwanda II</td>
<td>2012</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Rwanda III</td>
<td>2013</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Senegal</td>
<td>2014</td>
<td>64</td>
<td>28</td>
</tr>
<tr>
<td>Tanzania</td>
<td>2014</td>
<td>15</td>
<td>69</td>
</tr>
</tbody>
</table>

67 million dry-cell batteries are disposed annually in latrines in Rwanda which is about 2,500 batteries per square kilometre.\textsuperscript{195} These toxic contents of these batteries will mix with the human waste contaminating both the soil and leaching down to the groundwater. Studies by various researchers on groundwater and surface water characteristics in Lagos, Nigeria have discovered high levels of metal and toxic chemicals including lead \textsuperscript{196} \textsuperscript{197} \textsuperscript{198} which could result from the disposal of large quantities of dry cell batteries in addition to other sources.

In a Nigerian study of imported dry cell batteries 1980-1998,\textsuperscript{199} the average lead and cadmium content of the dry cells were 1051 mg/kg (range 42-3170 mg/kg) and 107.7 mg/kg (range 4.6-410 mg/kg) respectively. Batteries with labels indicating zero cadmium and lead were found on analysis to contain high concentration of these metals.\textsuperscript{200} About 3400 g/t Pb and 41g/t cadmium is released into the soil through ash and cinder at waste minimization sites with about 1% of these reaching the underground water per annum.\textsuperscript{201} The presence of batteries in household waste also causes problems if that waste is intended for processing to recover the organic component (primarily food and garden waste) as they contaminate compostable materials.\textsuperscript{202}

d. Air Pollution

\textsuperscript{194} ibid
\textsuperscript{195} ibid
\textsuperscript{200} ibid
\textsuperscript{201} ibid
Air pollution from dry cell batteries occur during burning of these public landfills. The open burning of wastes containing municipal and industrial wastes results in the emission of these heavy metals and chemical constituents of dry cell batteries into the atmosphere with fly ash and after fallout, metals in dusts and soils.\textsuperscript{203} Within 1980 to 1988 in Nigeria, an estimated average of 1671 g/t Pb and 475g/t of cadmium was emitted annually into the atmosphere with fly ash particulate at municipal minimization sites.\textsuperscript{204} 33\% and 92\% of lead and cadmium respectively are converted to fly ash upon burning or incineration causing air pollution with resultant health effects if the burning/incineration occurs close to households which is usually the case.\textsuperscript{205}

Limited funding has been attributed as one of the significant impediments to the effective management of toxic and hazardous wastes as well as the lack of development of appropriate technology following the principles of waste minimization and sustainable development.\textsuperscript{206}

In Nigeria, the national laws relating to management include\textsuperscript{207}

- The National Environmental (Sanitation and Waste Control) Regulations S. I 28 of 2009 and the National Environmental (Motor Vehicle & Miscellaneous Assembly sector) Regulations. These regulations and others have specific provisions for Extended Producer Responsibility Programme.

- Regulation 6 Section (2) requires that all damaged and disused components including wires, electronic devices, oil filters, batteries, tyres, airbags, etc, shall be amenable to recovery under the Extended Producer Responsibility (EPR) programme.

However the Extended Producer Responsibility Program under the National Environmental Standards and Regulatory Enforcement Agency (NESREA) is rarely implemented.

**8. OFF GRID LIGHTING MARKET ASSESSMENT**

**8.1 The International Off Grid Lighting Market**

The international off-grid industry landscape is constantly shifting with around 1.2 billion people around the world living without access to the grid and spending about $27 billion annually on lighting and mobile phone charging, the sector still has a lot of...
work to do\textsuperscript{208}. The IEA in a report suggests that about 7.5 billion capital investments would be annually required to reach a “70% electrification rate across Sub-Saharan Africa by 2040.\textsuperscript{209} The Off-Grid population in Sub-Saharan Africa reportedly spent an estimated $14 billion on lighting in 2014 alone compared to $6.6 billion spent by Asia in the same time period.\textsuperscript{210}

Figures reveal that in the first half of 2016, 8.07 million off-grid lighting products were sold globally, bringing the cumulative product sales since July 2010 to 27.20 million. This has supported 1.9 million households and 110 million people have benefited from these products, saving about $4.9 billion globally and $200 on energy-related spending per household.\textsuperscript{211}

The global off-grid solar lighting solutions is currently worth $3 billion and sales of off-grid lighting products in emerging markets is projected to reach $3.1 billion by 2020, and will provide access to improved lighting for 99 million households with no access to electricity grids.\textsuperscript{212} Since 2009, the off-grid lighting market in Africa has grown tremendously, from approximately 300,000 lighting products to 4.4 million units in 2012. There has also been an increase in the sophisticated lighting products being bought by consumers. (SunFunder, 2013)\textsuperscript{213}. In 2016 alone, 1.87 million lighting products were sold in sub-Saharan Africa worth $53.2 million.\textsuperscript{214}

Across Sub-Saharan Africa, the case of Kenya is often cited as model case study for the potential reach and opportunities, present in the off-grid lighting market. This is as a result of several factors, including the fact that the city of Nairobi is an important hub for information technology, finance, and development aid organizations for a large portion of East Africa.\textsuperscript{215} This factor has contributed immensely in conferring Kenya with the distinctive status as an “early adopting” country, and hugely supported by a mature mobile money sector “and a dominant provider—M-Pesa through Safaricom”,

\textsuperscript{212} Available at: \url{https://cleantechnica.com/2016/03/07/lighting-global-powers-off-grid-lighting/}
which has contributed to significant growth and robust investment returns for off-grid solar market.\textsuperscript{216}

### 8.2 Savings potential from transition to distributed, renewable lighting technologies in Nigeria

UNEP research shows that the level of subsidy awarded to the fuel burned by a single lamp in a year is almost equal to the price of purchasing a replacement solar lantern, which is available at $20 or less.\textsuperscript{217} In fact, for every one million dollars of kerosene subsidy reduction, tariffs for 250,000 solar lanterns could be offset.\textsuperscript{218} Additionally, the average payback time for an off-grid lighting system is 14 months.\textsuperscript{219}

As of 2011, a median solar lantern costs around US $20, compared to the $65-85 annual cost for kerosene lighting and phone charging, thus resulting in annual savings of US $45-65.\textsuperscript{220} In 2015, a Pico-solar lantern cost US $4.4, down from US $19.7 in 2010. Costs are expected to fall further to US $3.1 per unit by 2020.\textsuperscript{221} Solar home systems can range in size from 15W to 5 kW. The costs can range from N20,000 for a 15-20W system, to an average of N600,000 for a 2 kW system (prices for 2 kW systems range from N343,000 to N807,000), to N3,000,000 for a 5 kW system.\textsuperscript{222}

The first only document that mentioned energy efficiency was the National Energy Policy (NEP) 2003.\textsuperscript{223} In 2008, the Federal Government in partnership with the Economic Community of West Africa States (ECOWAS) and the government of the Federal Republic of Cuba began an energy data collection program from household energy consumption in Abuja, the Federal Capital City.\textsuperscript{224} In 2009, following this data collection, one million households were retrofitted to promote energy efficiency by replacing incandescent bulbs with compact fluorescent bulbs (CFLs) around the country leading to monthly electricity savings of 3197MWh during the entire programme and finance savings of $674,543.\textsuperscript{225} In 2009, Community Research and Development Centre carried out an energy efficiency survey in Nigeria aimed at preparing a guidance document for the Nigerian government for developing policies and legislation due to the

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{216} Ibid – Lighting Global Report – (2015) Alstone Et al.
\item \textsuperscript{218} Ibid
\item \textsuperscript{219} UNEP and en.lighthen (2013) Off-Grid Lighting Assessment: Nigeria.
\item \textsuperscript{220} Dalberg (2017) Nigeria: Energy Needs Assessment and Value Chain Analysis, p. 21.
\item \textsuperscript{222} Dalberg (2017) Nigeria: Energy Needs Assessment and Value Chain Analysis, p. 23.
\item \textsuperscript{224} Ibid
\item \textsuperscript{225} Ibid
\end{itemize}
\end{footnotesize}
policy gaps on energy efficiency in Nigeria. In January 2014, the Federal Government launched the ‘Operation Light Up Rural Nigeria’, a rural off-grid electrification project focusing on using renewable energy to provide lighting for off-grid communities. However this program reportedly failed due to the perception of it as a social project by these communities rather than a service to be paid for. In 2014, Lighting Africa published a report on its pilot project in the Nigerian Healthcare Sector where thirty-six Primary Healthcare Centers in three states were provided solar lanterns aimed at creating awareness and boosting confidence in solar solutions in rural communities. Findings from the project showed an increase in working hours for midwives by 30% with the replacement of kerosene lanterns, candles and flashlights.

In 2015, the Federal Executive Council approved the Renewable Energy and Energy Efficiency Policy (NREEP) developed by the Federal Ministry of Power developed in line with the objectives of the National Energy Policy, Rural Electrification Strategy and Plan, Millennium Development Goals and National Economic and Development Strategy. This was the first National Policy on Energy and Energy Efficiency in the country. Furthermore, in July 2016, the National Council of Power approved the National Energy Efficiency Action Plans (2015 – 2030) developed through a joint effort by the over twenty Ministries, Departments and Agencies of the Federal Government, Private Sector, NGOs, Civil Society, Academia and Development Partners including the ECOWAS Centre Renewable Energy and Energy Efficiency (ECREEE), SE4All, Africa Hub-AfdB, and GIZ-UNEP. The Plan aims to drive the shift towards energy efficiency for lighting, standard & label, buildings and industries by 2030.

In 2016, the Energy Commission of Nigeria (ECN), Federal Ministry of Environment and the United Nations Development Programme (UNDP) with the support of other key stakeholders proposed the “Energy Efficiency Label” for Nigeria under the Global Environment Facility (GEF) project – Promoting Energy Efficiency in Residential and

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230 ibid
232 ibid
234 ibid
Public Sector, which had established the Minimum Energy Performance Standards (MEPS) and labels for electrical appliances and equipment in the country.\textsuperscript{235} These emerging policy framework in Nigeria, are shaping the market for a robust off-grid solar industry and ensuring that more efficient lighting is a product is more easily adopted due to fiscal and policy incentives. However, a 2017 assessment of the Governance System regarding the adoption of Energy Efficient Appliances by Households in Nigeria showed that weakly developed system based on these policy frameworks have some way to go as issues such as the overlapping of government agencies, lack of resources, and lack of household inclusion in the process hinders any significant progress that can be made towards the adoption of household solar.\textsuperscript{236}

It is important to note that many companies are offering pay-as-you-go systems to increase affordability of solar home systems for households.\textsuperscript{237} For instance, Lumos Global offers a solar kit including an 80W solar panel, mobile charging accessories, and 2 LED bulbs, and allows customers to pay using their mobile phones.

However, the number of households with pico-solar powered lighting devices makes up only 4\% of total off-grid households in Africa. This implies that 100-110 million households in Africa still rely on poor quality options like kerosene lamps, candles, and batteries as their primary lighting source.\textsuperscript{238}

A Lighting Africa report states that despite Nigeria potentially being the largest market for off-grid lighting in Africa, there is a low consumer awareness of lighting products and a challenging regulatory environment – especially with regard to taxes, tariffs and entrepreneurialism.\textsuperscript{239}

According to the United Nations Environment Programme (UNEP), Nigeria could save over $1.4 billion and the equivalent of 17.3 million barrels of oil annually if it used modern off-grid lighting solutions and replaced kerosene, candles and batteries currently used for off-grid lighting.\textsuperscript{240}

The off-grid lighting market in Nigeria also holds a lot of potential for employment: As at 2013, 15,000 people in Sub-Saharan Africa were already employed in the sector. However, the employment has been highly concentrated in a few countries such as


\textsuperscript{237} Azuri Technologies, Lumos Global are two examples of PAYG systems in Nigeria.


\textsuperscript{239} Lighting Africa (2013) \textit{Lighting Africa Market Trends 2012: Overview of the Off-Grid Lighting Market in Africa} p.30

Kenya and focused on the sales and distribution end of the value chain because most solar products continue to be imported.

The Economic Community of West African States (ECOWAS) has established a policy framework for off-grid lighting in the region. The ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) developed the ECOWAS Regional Efficient Lighting Strategy, RELS, with technical and financial support from the UNEP-GEF en.lighten initiative in response to the ECOWAS Energy Efficiency Policy. RELS includes a roadmap for transiting to energy efficient lighting in the region by 2020. ECOWAS had also set a target to light up 22% of the rural population in the region with mini-grids and standalone systems by 2020, and 25% in 2030. Throughout ECOWAS, the kerosene distribution market accounts for about 20,000 full-time jobs which comes to one full-time kerosene retailer per 10,000 people living off-grid. However, the transition to energy efficient lighting has led to the creation of 15,000 new jobs already in sub-Saharan Africa with a potential job-to-population ratio of 30 jobs per 10,000 people living off-grid and about 500,000 new jobs through efficient lighting in the region. It is estimated that the market in the ECOWAS region can create about 30 times more jobs than fuel based lighting.

The ACP (Africa, Caribbean and Pacific)-EU Energy Facility of the European Union developed the SEEA-WA project (Supporting Energy Efficiency Access in West Africa) which is implemented by ECREEE in partnership with the Austrian Energy Agency, AERE, ENERGIA, the European Copper Alliance and ENDA. The objective of SEEA-WA is the support the creation of a regional programme on governance for energy efficiency and access thereby boosting the conditions for access to energy services in the region. The project has seen the development of several energy efficiency initiatives including the ECOWAS initiative on energy efficient lighting. Another key initiative driving the transition to efficient off-grid lighting in the ECOWAS region is the Lighting Africa Program which aims to increase energy access to 350 million people by 2030.

242 ibid
243 ibid
244 ibid
246 ibid
247 ibid
248 ibid
249 ibid
250 ibid
251 ibid
Various countries in the West African region are developing different types and levels of activities in their national initiatives of energy lighting while also requiring support towards implementing these programs including adopting an integrated policy approach.  

9. SUBSIDY REFORM OPPORTUNITIES

Despite policy pronouncements in 2009, heralding the removal of kerosene subsidy removal by the government of Nigeria, it is clear kerosene subsidy has in many ways, continued by successive governments since 2009. This is because policy and regulatory uncertainties, as well as deliberate mismanagement of the removal process foiled official attempts to remove the kerosene subsidy and as a result Nigeria’s payment of these subsidies continued to rise over the year. As Spaces4Change a social advocacy group which has done significant work on the issue of kerosene subsidies reports, there is a price modulation in place that gives the government some leeway to adjust domestic product prices to reflect minute changes occurring in the international oil price market. This is coupled with the fact that despite a policy shift in 2009, removing subsidies on Kerosene, it is clear that subsidy payments continued at least up until 2015. Spaces4Change reports a statement made by the Nigerian Senate on the amount paid for kerosene subsidy to be “more than double of the aggregate annual budget for education, health, roads, security and agricultural sectors” and only less “than 10 per cent of Nigerians benefit from this heartless massive scheme that drains the nation’s treasury.”

It is also evident from the conundrum surrounding the issue of kerosene subsidy, that the lack of complementary policies remains insufficient to address the issues of productive use of the product, particularly for lighting. The kerosene subsidy regime in place in Nigeria neither lead to lower prices, nor made the product easily available, therefore, taking the benefits the subsidies farther beyond the reach of the poor it intended to target. Women were most impacted by this trend of cost and unavailability and the subsidies itself created a whole new layer of problems centered diversion and product adulteration.

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252 ibid
253 The Punch Newspapers: Editorial: Stop Kerosene Subsidy Scam, December 12, 2016
256 Punch Newspapers: $1bn spent on kerosene subsidy in 2015 - Osinbajo, November 30, 2016
The potential for off-grid solar lighting in Nigeria is quite high and small pico solar has an immense potential for scale particularly in rural and peri-urban communities. The Federal Government launched its energy mix prospectus which targets 18% renewable energy generation by 2018 and 20% by 2020. This has also been approved and provides a holistic plan for off-grid electrification in underserved communities in the country.

Nigeria has a set of policy tools at its disposal to accelerate the adoption of off-grid lighting: taxes and tariffs incentives, subsidy on alternatives, quality control and technical assistance. The most important of these tools is removing subsidy on alternatives such as kerosene which will offset the effect of implementing tariffs and tax incentives as well as provide financing for technical assistance.

Several studies and reports support the findings that the reduction or elimination of import duties will enable companies import solar products as individual components and assemble in-country, lowering labor and transportation costs and ultimately, price. This will allow Nigeria as the potentially the largest off-grid lighting market in Africa to take a chunk of the 1.8 million jobs the full-penetration of these technologies in sub-Saharan Africa is projected to create, or about 30 jobs per 10,000 people living off-grid, according to an estimate from UNEP.

9.1 Previous subsidy reform attempts in Nigeria and why they failed

Fuel subsidies were introduced in Nigeria in 1973 to provide uniform pricing for fuel products across the country irrespective of associated transportation and cost differences. The first subsidy was provided at 35.7% which was then reduced to 2% in 1978 as the international price of crude oil rose from $3/bbl to $14.10 per barrel. The price of fuel products has undergone numerous increases and reductions as the...
international price of crude oil has also risen. The price of kerosene rose from $0.01/litre in 1990 to $0.32/litre in 2012; that of petrol from $0.05/litre to $0.62/litre in the same time period while that of diesel from $0.05/litre to $0.80/litre in the same time period (Soile & Mu, 2015). In 2008, subsidy on diesel was removed while those on petrol and kerosene were maintained. In 2012, attempts to remove the subsidy on petrol were fiercely resisted by massive nationwide protests. This resulted in an increase in price for petrol (or reduction in subsidy) while kerosene was more heavily subsidized. The attempt at removing subsidy failed mainly because there was a lack of trust in government to invest the savings, a lack of communication with citizens and the absence of palliatives to cushion the effect of the removal of the subsidy.

9.2 Case studies of subsidies in other countries – Subsidy reform and elimination vs. recommendations.

Numerous countries in the past few years have deregulated their fuel markets by eliminating or reducing subsidies and allowing for free market pricing, taking advantage of the recent low international crude oil prices. Indonesia in 2005 launched a cash transfer scheme to compensate for raising product prices by an average of 114%, even though new levels were below international market prices. Senegal encouraged a shift to cleaner fuels using cash transfers through existing structures such as retirement homes, hospitals and schools to distribute transfers via payments through banks, post offices or private companies. Malaysia introduced a smart card system for public transport vehicles and fishing boats. Iran in 2010 used a coherent reform policy of defining objectives, legislation, reducing inflation, setting up a cash transfer system (which involved identifying beneficiaries and arranging physical distribution), a public relations campaign and addressing various industry concerns. This allowed them to increase energy prices up to 20 times.

Ghana implemented a massive public relations campaign to inform and educate the citizens on how low their fuel prices were in the West African sub-region. This was coupled with the immediate elimination of fees at government-run primary and junior

secondary schools and a programme to improve public transport and convinced the public to accept fuel price increases. Brazil used a phased approach to remove subsidies in order to minimize opposition from interest groups. It started with the removal of petroleum products used by few consumers (e.g. asphalt, lubricants) and moved progressively to more widely used products (e.g. gasoline, diesel, fuel oil and LPG). The first products to lose subsidies were generally used by politically weak stakeholders, while the politically more difficult subsidies were removed later. Subsidies for the supply of fuels to the thermal power plants of Amazonia, a politically sensitive issue regionally, were maintained for a period of ten years.

10. CONCLUSION

Kerosene is the most subsidized petroleum product and is mostly used for lighting by low-income earners (poor) in Nigeria. This product is in turn associated with a lot of health and safety risks and the quality of light produced through its usage is generally of low quality and expensive. This study has shown that there is a growing consensus on the inefficiencies and adverse impacts of kerosene subsidies around the world. Nigeria’s kerosene subsidy is laden with controversies due to a lack of transparency in the open market price of kerosene which is as a result of inefficiency, leakages, waste and massive corruption.

Data obtained during the course of this research shows that about 20% of the population typically receives only about one-third of the total subsidy available for kerosene. This amplifies the very economic inequalities that the subsidy is intended to reduce. As demonstrated in this study, there have also been reports of smuggling or other efforts to obtain and resell the subsidized kerosene at elevated prices, often resulting in diversion of the kerosene and sold as jet fuel. Research has also shown that there are more efficient and fiscally sustainable alternatives to conventional kerosene subsidy which the Nigerian government must consider in reforming its kerosene subsidy. Apart from these issues associated with kerosene usage, there is also the issue of reducing carbon emissions which can only be achieved by transitioning to clean and sustainable lighting.

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## ANNEXURES

### ANNEX 1. SUMMARY OF COUNTRY FOSSIL FUEL SUBSIDY REFORMS

<table>
<thead>
<tr>
<th>Country</th>
<th>Away From</th>
<th>Swap Toward</th>
<th>Reform Strategies</th>
<th>Reform Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>Kerosene subsidies and lighting</td>
<td>Solar lighting systems</td>
<td>Gradual/Phase out Approach</td>
<td>Removal of all fossil fuel subsidies (3.4% in 2012) found emissions reductions of 3.2% by 2020 or improving to a 5.94% reduction with a SWAP</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Diesel subsidies and diesel pumps gas subsidies</td>
<td>Solar pumps Energy efficiency in the garment sector Safety nets</td>
<td>The Government of Bangladesh increased gas exploration and established a gas allocation policy; which includes setting up a coal import facility; and promoting the use of LPG in the domestic sector.</td>
<td>Total diesel sales to the agriculture sector in 2015–16 amounted to (approximately) USD 761 million. Removal of all fossil fuel subsidies (4.6% of GDP in 2013) found an 8.6% emissions reduction, reaching a 13.5% reduction with a swap.</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Kerosene Subsidies LPG subsidies Coal production subsidies</td>
<td>Social safety nets Renewable electricity generation</td>
<td>The government introduced a conversion program to encourage the shift from kerosene to cleaner burning LPG (the “Zero Kero Program”) Universal subsidies for 3 kg LPG canisters (5,000 IDR). This led to total subsidies for LPG climbing from 14.85 trillion IDR to electricity over USD 600 million in in 2015, compared to USD 130 million to renewables. Removal of all fossil fuel subsidies (7.3% of GDP) found emissions reductions of 3.2% by 2020 or improving to a 5.94% reduction with a SWAP.</td>
<td></td>
</tr>
</tbody>
</table>

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(USD 1.63 billion) in 2010 to 48.97 trillion IDR (USD 3.91 billion) in 2014. GDP in 2012) gave a 7% emissions reduction, reaching a 12% reduction with a swap.

Morocco

Butane subsidies and agriculture pumps

Solar pumps

The government removed subsidies to gasoline and industrial fuels and reduced subsidies to diesel according to a predefined timeline. In 2014, the total allocation was 41.65 billion DH of which 36.65 billion (USD 3.843 billion) was allocated to petroleum products. By December 2015, the liberalization of all fuel prices was completed.

Research shows that current subsidies stand at USD 1.13 billion in 2016, down from a high of USD 5.79 billion in 2012. The subsidy reforms already completed would bring about GHG emission reductions of 6.6% annually on average between 2012 and 2030. The hypothetical phase-out of both butane and electricity subsidies by 2020 would result in an additional 0.9% in average annual reductions (approximately 2.8 Mt CO2e), for a total of annual average reductions of 7.5% between 2012 and 2030.

Ghana

Fuel subsidies

LPG

Ghana implemented a massive public relations campaign to inform and educate the citizens on how low their fuel prices were in the West African sub-region. This was coupled with the immediate elimination of fees at government-run primary and junior secondary schools and a 50% fuel price increase on average.
<table>
<thead>
<tr>
<th>Country</th>
<th>Type of Subsidy</th>
<th>Subsidy</th>
<th>Description</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>Fuel subsidies</td>
<td>LPG</td>
<td>Iran in 2010 used a coherent reform policy of defining objectives, legislation; reducing inflation, by setting up cash transfer system (which involved identifying beneficiaries and arranging physical distribution), and a public relations campaign addressing various industry concerns.</td>
<td>Growth in the consumption of petroleum products initially stabilized.</td>
</tr>
<tr>
<td>Brazil</td>
<td>Diesel, Gasoline, Ethanol subsidies</td>
<td></td>
<td>Brazil used a phased approach to remove subsidies in order to minimize opposition from interest groups. It started with the removal petroleum products used by few consumers (e.g. asphalt, lubricants) and moving progressively to widely used products (e.g. gasoline, diesel, fuel oil and LPG). The first products to lose subsidies were generally used by politically weak stakeholders, while the politically more difficult subsidies were removed later.</td>
<td>Liberalization of official price for all fuel products.</td>
</tr>
<tr>
<td>Malaysia</td>
<td>Fuel subsidies</td>
<td></td>
<td>Malaysia introduced a smart card system for public transport vehicles and fishing boats</td>
<td>Malaysia to save an estimated 20 bln rgt a year. Fiscal deficit of GDP seen falling to 1 pct in 2015.</td>
</tr>
<tr>
<td>Senegal</td>
<td>Charcoal, Wood, fuel subsidies</td>
<td>LPG</td>
<td>Shift to cleaner fuels using cash transfers through such as retirement homes, hospitals and schools to distribute transfers via</td>
<td>70% of urban households in Senegal and nearly 90% of households in</td>
</tr>
</tbody>
</table>
payments through banks, post offices or private companies. Dakar using LPG as primary cooking fuel. The Senegal Ministry of Energy estimated the annual saving of firewood and charcoal to be 70,000 tons and 90,000 tons.
ANNEX 2. NIGERIA KEROSENE BLACK CARBON FACTS

- In Nigeria, flat-wick, cold-blast lanterns are the most commonly used kerosene lamps.\textsuperscript{282}
- 136.65 million people are affected by Household Air Pollution yearly, leading to 128,500 deaths annually.\textsuperscript{283}
- Kerosene lamps emit black carbon, carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen dioxide, formaldehyde, polycyclic aromatic hydrocarbons (PAH), sulphur dioxide, nitrogen oxides and various other volatile organic compounds (VOCs).\textsuperscript{284}
- Kerosene emits 2.5kg of CO\textsubscript{2}/litre\textsuperscript{285}
- Between January and September 2016, Nigeria consumed about 3.6m litres of kerosene daily. This means the equivalent of 9 kilotons of CO\textsubscript{2} is emitted daily.\textsuperscript{286}
- It is estimated that 53% of kerosene use in 2012 was for lighting – an equivalent of 696.42 million litres.\textsuperscript{287}
- This means that about 174,105 tons of CO\textsubscript{2} are emitted annually from kerosene lighting – or 477 tons of CO\textsubscript{2} daily.
- Users of kerosene wick lamps have been found to be exposed to Particulate Matter concentrations (PM) 2.5 particle concentrations way above World Health Organization (WHO) standards\textsuperscript{288}
- Black carbon is the most solar energy-absorbing component of particulate matter and can absorb one million times more energy than CO\textsubscript{2}.\textsuperscript{289} This makes it the second largest contributor to climate change after CO\textsubscript{2}.
- Developing countries, in Asia, Africa and Latin America emit more than 75 percent of global black carbon emissions, mainly from cookstoves and the burning of solid fuels like coal and wood for heating, which especially affects the health of women and girls.\textsuperscript{290}
- Black carbon also contributes heavily affected by Household Air pollution (HAP) to 136,650,000 people, leading to 128,500 deaths annually.\textsuperscript{291}

\textsuperscript{288} Op cit. Mills, E (2012)
\textsuperscript{290} Ibid.
- 52,680 tons of black carbon can be saved in Nigeria alone from elimination of kerosene use with 2.3 billion litres of kerosene saved annually.²⁹²

- Nigeria uses the World Health Organization standards for gaseous emissions against which air quality parameters are monitored and compared in order to ascertain its cleanliness.

- Nigeria Air Ambient Quality Standards²⁹³

<table>
<thead>
<tr>
<th>Air Pollutants</th>
<th>Emission Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulates</td>
<td>250 (µg/m³)</td>
</tr>
<tr>
<td>SO₂</td>
<td>0.1 (ppm)</td>
</tr>
<tr>
<td>Non-methane Hydrocarbon</td>
<td>160 (µg/m³)</td>
</tr>
<tr>
<td>CO</td>
<td>11-4 (µg/m³) or 10 (ppm)</td>
</tr>
<tr>
<td>NOₓ</td>
<td>0.04-0.06 (ppm)</td>
</tr>
<tr>
<td>Photochemical Oxidant</td>
<td>0.06 (ppm)</td>
</tr>
</tbody>
</table>

- The level of fuel subsidy awarded to fuel burned by a single lamp in a year is almost equal to the price of purchasing a replacement solar lantern, which is available at $20 or less.²⁹⁴

- For every one million dollars of kerosene subsidy reduction, tariffs for 250,000 solar lanterns could be offset.²⁹⁵

- A median solar lantern in 2011 costs around US $20, compared to the $65-85 annual cost for kerosene lighting and phone charging.²⁹⁶

- By 2015, a pico-solar lantern cost $4.4. If kerosene lighting and phone charging costs remain constant, that is now a cost savings of $61-81. Costs are expected to fall further to US $3.1 per unit by 2020.²⁹⁷

²⁹⁵ Ibid