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END NOTES

[1]France24 (2016)
[2]Quartz Africa (2015)
[3]International Energy Agency (2014)
[4]Nerini and others (2016)
[5]This report considers the full range of solar devices, using terms such as "solar household solutions" or "solar off-grid options", except where it specifically refers to solar lanterns or larger solar home systems
[6]Bazilian and Pielke (2013)
[7]Alstone, Gershenson and Kammen (2015)
[8]As developed by McKinsey and the International Energy Agency (IEA)
[9]Castellano and others (2015a, p36); IEA (2014)
[10]"Branded" pico-solar products include Lighting Global quality-verified products and other branded products
[11]Generic pico-solar products include no-names, copy-cats and counterfeits. Sales figures for these products remain highly speculative given the lack of reporting by distributors
[12]The figures for branded products are from Orlandi, Tyabji and Chase (2016). The figures for generic products are based on the estimated global sales of generic products. They were calculated with the assumption that the ratio between African and Asian sales is the same for both branded and generic products
[13]Grid-connection charges in Africa range from US$2 to US$400 (Harrison, Scott and Hogarth, 2016). In Kenya, Rwanda, Tanzania, Burkina Faso and the Central African Republic, connection fees are more than the average monthly income (Alstone, Gershenson and Kammen, 2015). As a result, the process of connecting homes after a village is electrified tends to occur slowly and regressively, with better-off families gaining access first (Pachauri and others, 2013)
[14]Electricity grids in sub-Saharan Africa typically suffer from over eight power outages per month, each lasting an average of 5.3 hours (Scott and others, 2014). Grid power is unavailable for an average of 540 hours per year (6 per cent of the time), and much longer in Nigeria, Guinea and the Central African Republic (IEA, 2014)
[15]Orlandi, Tyabji and Chase (2016)
[16]Scott and Miller (2016)
[17]ESMAP (2015)
[18]By Alstone, Gershenson and Kammen (2015)
[19]Orlandi, Tyabji and Chase (2016)
[20]Orlandi, Tyabji and Chase (2016)
[21]Orlandi, Tyabji and Chase (2016)
[22]Alstone, Gershenson and Kammen (2015)
[23]Orlandi, Tyabji and Chase (2016)
[24]Harrison, Scott and Hogarth (2016)
[25]Orlandi, Tyabji and Chase (2016)
[26]Orlandi, Tyabji and Chase (2016)
[27]SolarAid found that solar lantern users directed their savings to food (46% of respondents); education costs, including fees, uniforms, books (30%); farming inputs, such as fertilizer, seeds, equipment (8%); and other small-scale businesses (7%) (Harrison, Scott and Hogarth, 2016)
[28]Between 1998 and 2006, about 24,000 fires, resulting in 1,088 deaths, were reported in informal housing in South Africa alone. Candles were thought to have ignited one-third of them (see also UNEP, 2014b, which reports candles accounted for 40% of settlement fires). In Nigeria, kerosene-lamp explosions were responsible for nearly one-third of those admitted to the hospital with burns (Mills, 2015)
[29]The compounds emitted by devices that use kerosene – carbon monoxide (CO), nitric oxides (NOx) and sulphur dioxide (SO2) – exceed World Health Organization guidelines. They impair lung function and increase the risk of infectious illness (including tuberculosis), asthma and cancer (Lam and others, 2012a; Bates and Bruce, not dated)
[30]Replacing kerosene-fueled lighting can also significantly reduce greenhouse-gas emissions (Lam and others, 2012b). In total, kerosene lanterns produce the

equivalent of 240 million tons of CO2 per year – half the annual emissions of the United Kingdom, or 0.5% of the world's total (Orlandi, Tyabji and Chase, 2016)

[31]Kerosene poisoning is common, affecting 80,000 children per year in South Africa alone (Orlandi, Tyabji and Chase, 2016). Common complications include chemically induced pneumonia and damage to pulmonary and central nervous systems. Ingesting as little as 10ml can be fatal (Mills, 2015)

[32]Harrison, Scott and Hogarth (2016)

[33]Orlandi, Tyabji and Chase (2016)

[34]Orlandi, Tyabji and Chase (2016)

[35]Orlandi, Tyabji and Chase (2016)

[36]Hogarth (2012)

[37]Orlandi, Tyabji and Chase (2016)

[38]Orlandi, Tyabji and Chase (2016)

[39]Orlandi, Tyabji and Chase (2016)

[40]Diecker, Wheeldon, and Scott (2016)

[41]Orlandi, Tyabji and Chase (2016)

[42]Global LEAP (2015)

[43]Global LEAP (2016)

[44]In Kenya, for example, half a million households reported changes to their practices based on a popular television show focused on money management. A Tanzanian drama series highlighting high fertility rates led to wider discussions about family planning (Global LEAP, 2016)

[45]Global LEAP (2016)

[46]Customers generally pay around US$30 upfront for the system, and then regular payments ranging from US$0.20-0.50 per day for smaller systems up to US$2 per day for larger ones. Some PAYG models, including M-KOPA, use "mobile money" payments; others, such as Azuri Technologies, use scratch cards. Some businesses operate on a rent-to-own basis, where the customer eventually owns the solar home systems outright; others operate through perpetual payments (Orlandi, Tyabji and Chase, 2016; Scott and Miller, 2016)

[47]Orlandi, Tyabji and Chase (2016)

[48]IRENA (2015a)

[49]Most cost reductions will result from switching from standard AC appliances to DC ones. DC appliances currently are less common and costlier. However, they are more compatible with solar panels, which produce direct current power. Costs of DC appliances are expected to decline as they become more common (Orlandi, Tyabji and Chase, 2016)

[50]Global LEAP (2016)

[51]In the meantime, the diffusion of energy-efficient refrigerators is more likely to be driven by demand from off-grid businesses, not households

[52]Global LEAP (2016); Orlandi, Tyabji and Chase (2016)

[53]Winiecki and Kumar (2014)

[54]Clients who purchase solar home systems through lease-to-own PAYG models will also gain an asset that could be used as collateral (Orlandi, Tyabji and Chase, 2016)

[55]Orlandi, Tyabji and Chase (2016)

[56]Hogarth and Granoff, 2015

[57]USAID (not dated) calculated that the electricity needs of a larger clinic (with 60 beds) ranged from 5 to 10kWh per day. Practical Action (2013) estimated that the electricity needs for a primary school with approximately 100 students and four classrooms would be similar. Hogarth and Granoff (2015) calculated that over a 20-year period, off-grid technologies – wind, solar or hybrid diesel-solar systems – tend to be more cost-effective than the electricity grid in providing 5kWh per day to rural schools and small clinics that are currently more than 3.2 km from the electricity grid

[58]Practical Action (2014); USAID (not dated)

[59]Practical Action (2013)

[60]Africa Progress Panel (2015)

[61]Practical Action (2014)

[62]Strohmeier (2015)

[63]Scott and others (2014)

[64]CAFOD (2013)

[65]Tortora and Rheault (2012)

[66]In Ghana, for example, a study found the average income of solar-electrified enterprises to be 82% higher than non-electrified enterprises (although the causal direction of this relationship was difficult to untangle) (Obeng and Evers, 2010). In Uganda, micro-enterprises with solar were found to attract more customers per day than non-electrified ones and earn US$4.40 more per month (Harsdorff and Bamanyaki, 2009)

[67]Harrison, Scott and Hogarth (2016); Harsdorff and Bamanyaki (2009); Obeng and Evers (2010)

[68]Pachauri and others (2013)
[69]GVEP (2011a)
[70]Burney, Naylor and Postel (2013)
[71]Jain (2015)
[72]Hogarth and Granoff (2015)
[73]GIZ (2016)
[74]Global LEAP (2016)
[75]GIZ (2016)
[76]Practical Action (2014)
[77]UNEP (2015a)
[78]IRENA (2013b)
[79]Barber (2014)
[80]Global LEAP (2016)
[81]Africa Progress Panel (2015)
[82]IRENA (2015b)
[83]IEA (2014)
[84]The Economic Community of West African States (ECOWAS) has estimated a potential demand for 156,000 renewable energy mini-grids in West Africa by 2030 (ECREEE, 2012)
[85]In Sub-Saharan Africa, the estimated cost of rural grid connections is around US$2,300, compared with US$1,300 to US$1,900 for mini-grids, according to research by McKinsey (Castellano and others, 2015a)
[86]RECP (2013)
[87]IEA (2014)
[88]RECP (2013)
[89]SE4All (2014)
[90]IRENA (2015b)
[91]This categorization is also used in a status report by the Republic of Kenya (World Bank, 2016b), referring to the categories as Type 1, Type 2 and Type 3
[92]IRENA (2012)
[93]IEA (2014)
[94]IEA (2014)
[95]Based on a levelized cost of energy (LCOE) analysis, i.e. over the lifetime of the scheme
[96]Frankfurt School (2015)
[97]IEA (2011); Szabo and others (2013)
[98]UNDESA (2016)
[99]GVEP (2011b); RECP (2013); SBI (2013)
[100]RECP (2013)
[101]RECP (2013); SBI (2013)
[102]UNEP (2015b)
[103]SolarServer (2016)
[104]GVEP (2011b); RECP (2013); SBI (2013)
[105]Tungu-Kabiri (2016)
[106]RECP (2013)
[107]ESI Africa (2015)
[108]Navigant (2015)
[109]Palit and Chaurey (2011)
[110]This section draws on Tumiwa (2014)
[111]The Philippines has about 375MW of installed capacity in diesel mini-grids. Most are operated by the National Power Cooperation-Small Power Utility Group (NPC-SGUP), which operates mini-grids in 221 areas (IRENA, 2015)
[112]Following paragraphs draw on Palit and Chaurey (2011)
[113]Schnitzer and others (2014)
[114]GTM Research (2014)
[115]GTM Research (2015)
[116]The blackout that affected large swathes of the north-eastern United States in 2003 and hurricanes Katrina (2005) and Sandy (2012) highlighted the importance of resilience in the electricity supply
[117]GTM Research (2015)
[118]In 2015, New York committed US$40 million for micro-grids; Massachusetts allocated US$18 million for 13 projects; and California has allocated US$26.5 million for renewable energy micro-grids (Miret, 2015)
[119]Disrupt Africa (2015)
[120]SharedSolar (not dated)
[121]IEA (2011)
[122]IEA (2014)
[123]This section draws on Energy 4 Impact and Inensus (2016)
[124]UNEP (2015b)
[125]SBI (2013); UNEP (2015b); ENEA (2016)
[126]AREI (2015)
[127]Castellano and others (2015b)
[128]IEA (2014)
[129]IRENA (2015c)
[130]UNECA (2016)
[131]AREI (2015)
[132]KPMG (2016)
[133]KPMG (2016)
[134]AEEP (2016)

[135]ADB (2011)
[136]Bazilian and others (2012a)
[137]UNIDO (2005)
[138]Eberhard and others (2016)
[139]Eberhard and others (2016)
[140]Bazilian and others (2012b)
[141]Sovacool, Bazilian and Toman (2016)
[142]AfDB (2016)
[143]REI4P (2016)
[144]Eberhard and others (2016)
[145]Latham and Watkins (2016)
[146]UNECA (2016)
[147]Traoré (2013)
[148]Bazilian and others (2012a)
[149]Eberhard and others (2016)
[150]Eberhard (2016)
[151]Sources for this section include: Coal International (2016); UNFCCC (2017) contains the Intended Nationally Determined Contribution (INDC) documents for South Africa, Nigeria, Senegal, Egypt and Botswana; OCP Policy Center (2016); World Future Council (2016); EY (2016); IEA (2016)
[152]Statistics South Africa website, http://www.statssa.gov.za/?p=4820
[153]World Future Council (March 2016)
[154]Also known as feed-in tariffs as they are prices at which a power producer sells to the transmission grid
[155]IRENA (2016)
[156]EIU (2016)
[157]BNEF (2016)
[158]REN21 (2016)
[159]IRENA (2012)
[160]IRENA (2015c)
[161]IRENA (2016)
[162]UNECA (2016)
[163]UNECA (2016)
[164]Quitzow and others (2016)
[165]EIU (2016)
[166]Climatescope (2016)
[167]AEEP (2016)
[168]IRENA (2015b)
[169]UNECA (2016)
[170]Davis (2016)
[171]AEEP (2016)
[172]Davis (2016)
[173]AEEP (2016)
[174]AEEP (2016)
[175]GTZ (2007)
[176]Nyeko (2016)
[177]USAID (2015)
[178]Rosen (2015)
[179]Baker (2016)
[180]Quitzow and others (2016)
[181]Climatescope (2016)
[182]EIU (2016)
[183]GTZ (2007)
[184]Quitzow and others (2016)
[185]UNECA (2016)
[186]EIU (2016)
[187]GreenCape (2016)
[188]GreenCape (2016)
[189]UNECA (2016)
[190]IRENA (2015c)
[191]Climatescope (2016)
[192]EIU (2016)
[193]UNECA (2016)
[194]GreenCape (2016)
[195]Montmasson-Clair and Ryan (2014)
[196]Berenbach (2015)
[197]PV Insider (2016)
[198]IRENA (2015c)
[199]UNECA (2016); AEEP (2016)
[200]Another classification distinguishes between transmission losses and distribution losses, according to the stage in the supply chain that they occur in
[201]IEA (2014)
[202]PwC (2016)
[203]KPMG (2015)
[204]Davis (2016)
[205]KPMG (2016)
[206]UNECA(2016)
[207]Cayten and Bazilian (2016)
[208]Bafana (2016)
[209]Del Bello (2016)
[210]Guay (2016)
[211]Dubey (2015)
[212]This section draws on Tallapragada and others (2009); Eberhard and others (2008); Deloitte (2013)

[213]This does not include the theft of overhead wires, transformer components and other materials. Although this kind of theft also causes electricity losses, strictly speaking, it is not the theft of electricity. The theft of materials is a significant problem in some countries.
[214]PRNewswire (2014)
[215]Smith (2004)
[216]Tallapragada and others (2009)
[217]Eberhard and others (2011)
[218]Eberhard and others (2011)
[219]Bundock (2014)
[220]Okafor (2016)
[221]Never (2015); Winther (2012)
[222]Smith (2004)
[223]Never (2015)
[224]Malama and others (2014)
[225]NERC (2015)
[226]Malama and others (2014)
[227]Eberhard and others (2011)
[228]Eberhard and others (2011)
[229]World Bank (2015a)
[230]Eberhard and others (2011)
[231]Eskom (2016)
[232]Smith (2004)
[233]Sources for this section include International Energy Agency (IEA) (2016)
[234]Hill, Matthew and Thomas Wilson (2016)
[235]World Bank (2016a); Wilson, Thomas (2016)
[236]IEA (2014)
[237]Poggiolini (2016)
[238]AEEP (2016)
[239]IRENA (2013a)
[240]AfDB (2016)
[241]UNECA (2016)
[242]IRENA (2013a)
[243]IEA (2014)
[244]IEA (2014)
[245]IRENA (2013a)
[246]IRENA (2015c)
[247]IRENA (2013a)
[248]AEEP (2016)
[249]Poggiolini (2016)
[250]IRENA (2012)
[251]IRENA (2012)
[252]Tsiko (2016)
[253]Creamer (2016)
[254]Senelwa (2015)
[255]East African (2016)
[256]SARDC (2016)
[257]Standard Bank (2016)
[258]Tsiko (2015)
[259]Ford (2016)
[260]IEA (2014)
[261]ESI Africa (2016)
[262]Ligami (2016a)
[263]IEA (2014)
[264]Demierre and others (2014)
[265]Ligami (2016b)
[266]Demierre and others (2014)
[267]Poudineh and Rubino (2016)
[268]Nerini and others (2016)
[269]Kojima and others (2016). They cite the Global Tracking Framework report (World Bank, 2015b) that about 35% of African households lived without access to electricity in 2012, compared to 21% in the second worst region, South Asia. Access to electricity was 69% of urban residents and 15% of rural residents, compared to 70% of rural residents in South Asia
[270]Briceño-Garmendia and Shkaratan (2011)
[271]Africa Progress Panel (2015), and Sy and Copley (2016)
[272]Sy and Copley (2016)
[273]IMF (2015)
[274]Sy and Copley (2016)
[275]ICA (2013)
[276]Antony Karembu, quoted in Sy and Copley (2016)
[277]International Energy Agency (2014)
[278]Cayten and Bazilian (2016)

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