

**COUNTRY PROFILE**

**OFF- AND WEAK-GRID  
SOLAR APPLIANCE MARKET  
PAKISTAN**

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**SEPTEMBER 2022**

EFFICIENCY FOR ACCESS COALITION



**This country profile covers market and appliance performance data for off-grid appliances sold in Pakistan, based on Efficiency for Access market survey findings.** The profile explores Pakistan’s overall off-grid appliance market landscape, including the common power type, size, price, and warranty of off-grid appliances sold in retail markets. This publication is relevant for sector stakeholders working in the off-grid solar market in Pakistan, including policymakers, development programmes, mini-grid developers, manufacturers, distributors, and others.

CLASP, Co-Secretariat of the Efficiency for Access Coalition, developed this profile as part of its flagship Low Energy Inclusive Appliances programme. Efficiency for Access is a global coalition working to promote affordable, high performing, and inclusive appliances that enable access to clean energy for the world’s poorest people. It is a catalyst for change, accelerating the growth of off and weak-grid appliance markets to boost incomes, reduce carbon emissions, improve quality of life, and support sustainable development. Current Efficiency for Access Coalition members have programmes and initiatives spanning 54 countries and 26 key technologies. It is co-chaired by UK aid and the IKEA Foundation.

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## INTRODUCTION

### Efficiency for Access Country Profile Series

**Insufficient data about off-grid appropriate appliances<sup>i</sup> makes it difficult for manufacturers, policymakers, distributors, mini-grid operators, investors and other market actors to make informed decisions and identify high quality, efficient products.** To help address this challenge, Efficiency for Access (EforA) has worked to gather data on the availability of off-grid appropriate appliances in key countries.

Since 2018, EforA has conducted market scoping surveys in 11 countries.<sup>ii</sup> The countries have been selected based on the population size, solar home system (SHS) sales volumes,<sup>iii</sup> and market uniqueness.<sup>iv</sup> The survey results inform programme decisions, such as selecting products for testing through [VeraSol](#).<sup>v</sup> To utilise this data and share insights from the surveys more broadly, Efficiency for Access has developed a [series of country profiles](#) that share insights on the off-grid appliance market and contextualise data with supporting research and stakeholder feedback.

Product specifications collected through market surveys may not be accurate. The data cited in this country profile includes claimed values provided by shopkeepers or from consumer-facing materials, such as a product packaging or user manuals. As such, it may differ from data generated through third-party testing, which is available on the [VeraSol Product Database](#). Nevertheless, this data provides preliminary and useful observations about Pakistan's local off-grid appliance market.

### About Pakistan

**Though the overall electrification rate in Pakistan is high, much of the rural population is not grid-connected, and those who are connected experience unstable energy access.** In 2020, 75% of Pakistan's 221 million population were reported to have access to electricity.<sup>1</sup> In urban areas, nearly all residents have grid access,<sup>2</sup> but even those with electricity report frequent power outages.<sup>3</sup> In 2020, only 61% of residents in rural areas had electricity access.<sup>4</sup>

Pakistan has greatly increased its electricity generation capacity in the last several years.<sup>5</sup> However, high electricity demand requires load-shedding to reduce strain on the grid,<sup>6</sup> causing outages and voltage fluctuations that can affect connected appliances. This prompts many consumers to look for backup energy and lighting sources such as fuel-powered generators, solar systems, and torches.<sup>7</sup> Given the frequent power outages for grid-connected households in urban areas and the high

percentage of rural households without access to electricity, off-grid solar energy solutions provide a reliable alternative to meet Pakistan consumers' energy demand.

Pakistan's government has recognised the potential of large-scale and household solar and seeks to codify it through policy and development investment.<sup>8</sup> In 2019, the Pakistani government drafted the Alternative and Renewable Energy (ARE) Policy<sup>9</sup> as a roadmap to harness 30% of grid-supplied energy from renewable sources by 2030. Achieving this requires investment in renewable energy generation projects and facilitating the importation of solar panels.<sup>10</sup> As infrastructure, transmission, and load-shedding issues persist with the national grid,<sup>11</sup> generating consistent power through SHSs will transform the productivity and livelihoods of both rural and urban households.

However, uptake of SHSs has been lower than in other countries surveyed by EforA. GOGLA sales data provides some insight into the market in Pakistan. However, its reach is more limited as few local companies report sales through GOGLA. Between 2018 and 2021, GOGLA affiliates in Pakistan sold between 16,000 and 38,000 solar lighting products annually, though an unusual high of 75,000 units were sold in 2020, due to bulk procurement in the second half of the year.<sup>12,13,14</sup> This indicates that while some consumers have adopted SHSs to provide consistent backup power or to reduce their electricity costs, many retain grid connectivity and other energy sources to power their appliances.

**EforA's survey confirms that the market for off-grid fans in Pakistan is established, while its productive use of renewable energy (PURE) and large appliance sectors are just emerging. Recovery from COVID-19-related impacts and increased local manufacturing and after-sales care of other appliance types and components, while boosting consumer awareness of the benefits of DC appliances, will enable the market's continued growth.** Our survey found that fans are the most widespread and popular appliance, while the market for direct current (DC) televisions is nearly non-existent. As in many countries surveyed by EforA, high costs and a lack of awareness stifle the markets for larger appliances and PURE technologies, such as refrigerators and solar water pumps (SWPs). However, recent policy and program action are beginning to pave the way for the adoption of many more SWPs in Pakistan. In addition, our field consultant highlighted the large market for local manufacturing of fans and evaporative air coolers and the burgeoning market for local manufacturing of SWPs and their motors.

i. In this document, off-grid appropriate appliance refers to appliances that can be powered by distributed energy systems like SHSs and mini-grids or are appropriate to use in weak-grid conditions.

ii. The selected countries are Cote D'Ivoire, Ethiopia, India, Kenya, Myanmar, Nigeria, Pakistan, Senegal, Sierra Leone, Tanzania and Uganda.

iii. Sales volumes of SHS kits can be an indication of off-grid appliance ownership.

iv. Uniqueness of market is used as selection criteria to enable data collection on a larger variety of brands and models, and to have a wider geographical scope.

v. VeraSol tests and generates consistent and comparable performance data to support scalable markets for durable, high-performing, and affordable off-grid appliances and productive use equipment.

## COVID-19 IMPACT

Pakistan's economy has been somewhat resilient to the economic downturn of COVID-19; the GDP rebounded to pre-COVID levels in 2021, but inflation rose to 9.8% in the first half of 2022.<sup>15</sup> In addition, the depreciation of the Pakistani rupee has decreased foreign reserves and restricted imports.<sup>16</sup> These lingering effects are present in the solar sector. The combination of economic strain, market and supply chain uncertainties, inability to travel, and limited business hours are reflected in decreased sales.<sup>17</sup>

The government and development partners have stepped in to alleviate some of the economic issues in the solar sector. As Pakistan's primary consumer financing facility, microfinance institutions (MFIs) offer loans to consumers to purchase solar products and allow them to repay in instalments. To unburden consumers, many MFI participants had their monthly payments deferred for a year. However, this also resulted in delayed payments to underlying companies.<sup>18</sup> More financial assistance to consumers through MFIs came in August 2020. The German Development Bank (KfW) allocated a 15 million-Euro loan to Pakistan's primary wholesale lender to MFIs, the Pakistan Microfinance Investment Company (PMIC), to implement their joint Renewable Energy Initiative through Microfinance (PRIME).<sup>19</sup> Through these investments, consumers have more financial flexibility due to monthly instalments, and the initiative promises to continue offering future loans with funding already secured.

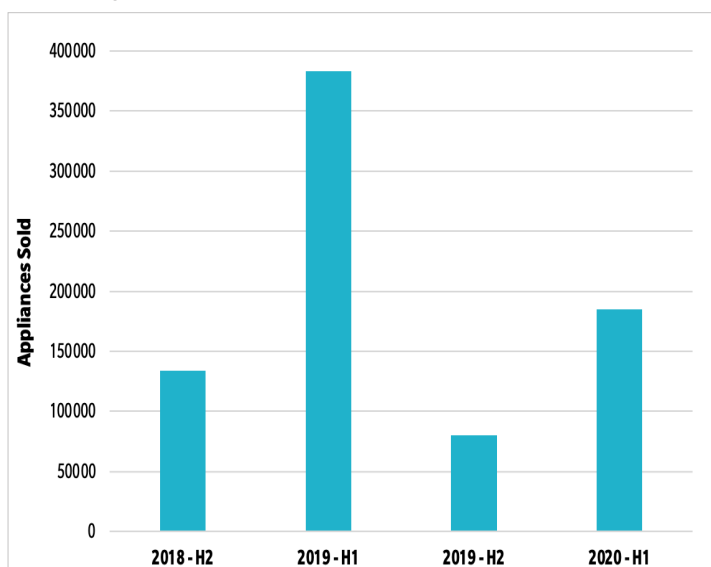
## MARKET LANDSCAPE

### Market Conditions

**Sales of solar appliances in Pakistan reflect a thriving market built primarily on fan sales, although COVID-19 has stifled growth in the last several GOGLA reporting periods.** Based on limited data, GOGLA affiliates reported sales of over 463,000 appliances in Pakistan in 2019 (Figure 1).<sup>20,21</sup> These are the highest recorded appliance sales by any country tracked by GOGLA during a single year since they began reporting appliance sales and are due almost entirely to fan sales sold through financing from development programs. Despite COVID-19 and reduced procurement, Pakistan still sold 185,000 appliances in the first half of 2020.<sup>22</sup> GOGLA-affiliated companies have not logged high enough sales to report numbers since then.

Pakistan faces extreme heat,<sup>23</sup> with an estimated 34 million people at high, potentially fatal, risk of heat-related incidents.<sup>24</sup> Cooling appliances, therefore, are essential in Pakistan and comprise the majority of off-grid appliance sales. In 2019, for example, fans accounted for 99% of appliances sold by GOGLA

**Figure 1: Appliances sold by GOGLA affiliates in Pakistan per half-year reporting period**



affiliates in Pakistan.<sup>25,26</sup> One interviewed stakeholder shared that fans are also a driver for SHS sales when bundled together, further indicating the importance of fans in the market. As highlighted in Figure 1, seasonal fan sales in Pakistan and other South Asian countries are higher in the first part of the year. That is because distributors typically make bulk purchase orders in the first half of the year when climatic conditions drive demand. They sell most of their stock from March through the hot summer months and reorder the next year to replenish their inventory.<sup>27</sup>

The pre-COVID market for appliances in Pakistan shows a strong foundation in cooling technologies, with consumer demand driving the market. Government and development program interest in making PURE products, like SWPs, available indicates a diversification of appliance types in Pakistan. Increased consumer buy-in is needed to grow the market for burgeoning appliance types.

### Government Policy and Programmes

**The government of Pakistan has enacted recent policy changes to stimulate solar energy generation, yet most products are still subject to high taxes and duties.** In June 2022, the prime minister announced plans to exempt solar panels from a 17% sales tax to encourage renewable energy uptake and to increase affordability for developments like solar microgrids.<sup>28</sup> However, this does not exempt related products, as tax and duties of around 22% are levied on imported SHS, with 25% set on imported SWPs. Locally manufactured solar products are still subject to 17-20% tax, as are components commonly used with solar systems and appliances like inverters, charge controllers, and batteries.<sup>29</sup> To increase affordability, especially for households using small amounts of energy, the government plans to offer loans with lenient instalment terms to facilitate SHS purchases.<sup>30</sup>

Pakistan has also taken steps to improve the quality of imported solar energy kits<sup>31</sup> by imposing pre-export verification of conformity (PVoC) requirements and verification to international test methods (IEC TS 62257-9-5).<sup>32</sup> PVoC conditions are also in place for photovoltaic (PV) inverters and SWPs.<sup>33</sup> There are safety, manufacturing, and quality standards



for solar components, but no quality requirements are in place for locally produced and imported SHSs.<sup>34</sup> Strengthening requirements for SHSs, such as adopting the international quality standard (IEC TS 62257-9-8), and enforcing minimum quality requirements for imported and domestically produced appliances will exclude low-quality products from the market and boost consumer confidence in brands they can trust.

Sustainable and efficient cooling is a key focus of the government of Pakistan. It is preparing to draft the National Cooling Action Plan (NCAP) in 2023 to ensure sustainability in the cooling industry by encouraging appliance efficiency to use less electricity, cut carbon emissions, and regulate unsafe refrigerants used in appliances such as refrigerators.<sup>35</sup> Pakistan is also working to promote fan efficiency through the National Energy Efficiency and Conservation Authority (NEECA), which launched a voluntary star labelling program in 2016 to promote highly efficient alternating current (AC) fans. The installation and operation of labelled fans have been highly effective, offering estimated total energy consumption savings of 6-9 Megawatts compared to non-labelled fans.<sup>36</sup> Though DC fans are not subject to this labelling scheme, fan technology innovations that improve efficiency move the sector forward.

PURE appliances like SWPs are gaining interest from governments to increase agricultural productivity through improved irrigation. For example, Pakistan's Punjab Energy Efficiency and Conservation Agency (PEECA) is developing plans to upgrade or replace most of the roughly 1.1 million diesel- and electric grid-powered pumps in the Punjab region with solar-powered versions. This may help alleviate recurring fuel costs and troubles caused by inconsistent grid supply, particularly for smallholder farmers dependent on pumps for their livelihoods.

## Market Development Programmes

**Funding and development projects have been influential in helping grow the off-grid solar sector in Pakistan. However, specific assistance for off-grid appliances has been low.** Key partnerships with funders are increasing electricity access and therefore opening pathways to appliance ownership. For example, the World Bank has committed USD \$100 million through 2023 to developing solar energy generating capacity in the Sindh province and distributing SHSs to households. As part of this Sindh Solar Energy Project (SSEP), USD \$30 million is allocated to subsidise 40% of the cost of a typical SHS packaged with a DC fan, with quality standards adopted by the program to promote good quality products. This is well-timed to alleviate the energy burden and improve electricity access for Pakistan's rural off- and weak-grid populations, particularly as COVID-19 has depressed the economy.<sup>37</sup>

Along with the German Development Bank's partnership with the Pakistan Microfinance Investment Company (PMIC) to offer loans for SHS purchases, they have also invested in solar mini-grid access to electrify off-grid communities<sup>38</sup> and support appliance uptake. Other development partners, such as USAID's Pakistan Agricultural Capacity Enhancement Program (PACE), produce market intelligence, policy analysis,

and skills development for similar projects. PACE works at the provincial government level to promote agricultural innovation and has examined the solarisation of pumping in Pakistan,<sup>39</sup> which is now a priority for several regional governments that are in line to receive state and donor funding for this. This has already translated into projects such as pilot work by the Pilio Group and local consultancy HIMA'verte on community SWPs and other vital areas like clean cooking and cooling.

## Consumer Financing

**The recent depreciation of the Pakistani rupee has hindered affordability in the solar sector, highlighting the importance of consumer financing to unlock access to larger appliances.** Pay-as-you-go (PAYGo) product options can be more flexible and affordable than cash sales but are not common in Pakistan. In the second half of 2018, GOGLA recorded that just 19% of solar appliance sales in Pakistan utilised PAYGo,<sup>40</sup> and our consultant notes that no companies offer this option currently. Mobile money accounts often facilitate PAYGo sales for remote payment, and though access to mobile phone service is high,<sup>41</sup> just 21% of Pakistani adults owned mobile money accounts in 2017.<sup>42</sup> The State Bank of Pakistan and the Pakistan Telecommunications Authority are working to increase mobile money access,<sup>43</sup> which will be essential to opening more consumers up to flexible payment options. Still, for now, cash sales are the predominant method of purchase in Pakistan.

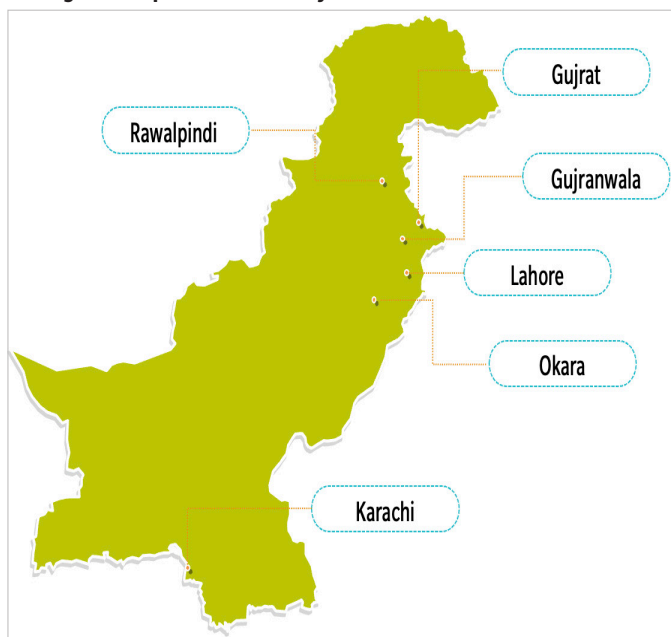
Consumer financing facilities, particularly MFIs and non-governmental organisations (NGOs), have a foothold in Pakistan as SHS and appliance lenders.<sup>44</sup> In addition, these groups partner with solar companies to subsidise the cost of an SHS or appliance for consumers.<sup>45</sup> For example, the Sindh Solar Energy Project and the KfW-PMIC Renewable Energy Initiative through Microfinance (PRIME) are working to enhance the affordability of energy access products for rural communities. Cooperation with third-party finance providers that often act as market stimulators and introducers of new appliance types will continue to grow the market, particularly for high-impact, expensive PURE equipment.



19%

**Of solar appliance sales in Pakistan utilised PAYGo, according to GOGLA sales for the second half of 2018. Cash sales remain the preferred purchase method.**

Figure 2: Map of locations surveyed in Pakistan



## PRODUCT AND TECHNOLOGY

### Methodology and Sample Source

EforA engaged a field-based consultant to survey key off-grid retail markets in Pakistan. The first round of surveys was completed for fans and refrigerators in 2018, and the second round for fans, refrigerators, SWPs, and evaporative air coolers in 2022. The surveys aimed to identify product models sold in the retail markets and any market changes over time.

The field consultant visited over 100 retail shops in Pakistan to collect data on brand, model name/number, appliance size, power input, voltage, warranty, and retail price. This data was pulled from rated claims on the product packaging, user manual or a shopkeeper's knowledge of the product and thus may not be as accurate as tested data. VeraSol has tested several of the surveyed models, and that data is available on the VeraSol Product Database.

In addition to gathering data on product specifications, the field consultant conducted interviews with shop owners to collect qualitative evidence and anecdotes. This anecdotal evidence complements quantitative data and may provide insights into perceived product demand, quality, and performance.

Three key markets were selected for data collection (Figure 2). Karachi, the most populous city in Pakistan, is the main port into the country and serves as the hub of imported products for distribution throughout the country. Lahore is a rural and urban distribution hub in the west and north of Pakistan. Gujrat and Gujranwala, in the Punjab province, compose part of the Golden Triangle of industrial cities in the north of Pakistan. In addition to housing retail shops, wholesale manufacturers and distributors operate from

these cities. Most of the solar product assembly in Pakistan, such as fans and motors for water pumps, occurs here. Two additional markets were visited for product observation. Rawalpindi is a distribution hub in the north of the country, and Okara is located near Lahore and houses retailers of off-grid refrigerators. Our consultant also visited the warehouses of several local manufacturers to gather qualitative feedback.

### Data Analysis on Appliances

The section below analyses off-grid appliances available in Pakistani retail markets in May 2018 and February 2022, focusing primarily on fans, refrigerators, and SWPs. Our consultant also surveyed the growing evaporative air-cooling market in 2022, which is becoming an increasingly popular appliance category in Pakistan. Product information was collected at marketplaces in Pakistan, and the data was analysed based on the following characteristics:

- **Power type:** Are there more alternating current (AC), direct current (DC), or AC/DC appliances available?
- **Size:** What are the most prominent sizes of the products?
- **Price:** What is the range of retail product prices?
- **Warranty:** How many products are covered by a warranty, and how long is the warranty?
- **Energy consumption:** What is the lab-tested energy consumption of appliances sampled from Pakistan, and how do they compare with other markets?

### BOX 1

#### AC vs DC Appliances

Appliances may be specified to be used with only DC power, AC power, or compatible with both AC and DC power. An end-user may have access to the AC grid, DC or AC mini-grids, or DC SHSs. To power the appliance, an end-user has to ensure that the power type (AC or DC) and voltage ranges are compatible with the appliances they are using. When the power supply and appliance are not directly compatible, a power converter – an inverter or a rectifier – is required. An inverter converts DC power to AC power, while a rectifier performs the reverse conversion of AC to DC. The use of a power converter adds additional power consumption, and typically increases the complexity of the system set-up, as well as adding cost and quality considerations.

## TV MARKET INSIGHTS

Although the estimated addressable market<sup>vi</sup> for televisions in Pakistan is large, our survey notes low demand for this off-grid entertainment technology.

Similarly, based on limited data, GOGLA's sales records show zero TVs being sold by affiliates since they began reporting appliance sales in 2018.<sup>46</sup> Our consultant noted that the negligible fraction of DC TVs available in the market were brandless, imported, substandard models and did not sample any TV models in 2018 or 2022. Therefore, we did not analyse this product category in this report.

## FAN MARKET INSIGHTS

Fans are the most popular off-grid appliance in Pakistan due to the hot and humid climate and their ability to cool more efficiently and affordably than air conditioners.<sup>47</sup> In

2013, the total addressable market for off- and weak-grid fans was estimated at 100,000 households and expected to grow to 10.2 million by 2020.<sup>48</sup> Based on knowledge of the market and interviews with member companies of the Pakistan Electric Fan Manufacturers Association (PEFMA), our consultant estimated in 2018 that 2.1 million DC fans were manufactured or imported annually. Now, that estimate is over five million fan units produced annually, with AC/DC types comprising two million and up to 500,000 DC models. This demonstrates a dynamic market responding quickly to consumer preferences for AC/DC models, reflecting the immense growth potential and demand for fans in rural Pakistan.

Our consultant collected data on 144 models of fans from 70 brands in 2018 and 29 models from 12 brands in 2022. This decrease in available fans could be partially due to COVID-19 impacts, which have decreased appliance availability and demand in the marketplace. In 2018 and 2022, most fans sampled were offered as standalone appliances, though in 2018, several were offered bundled with an SHS. Pakistan also has a strong local manufacturing market for fans, with 82% of fans surveyed in both 2018 and 2022 manufactured in Pakistan. Our consultant noted consumers consider locally made metal body fans as higher quality.

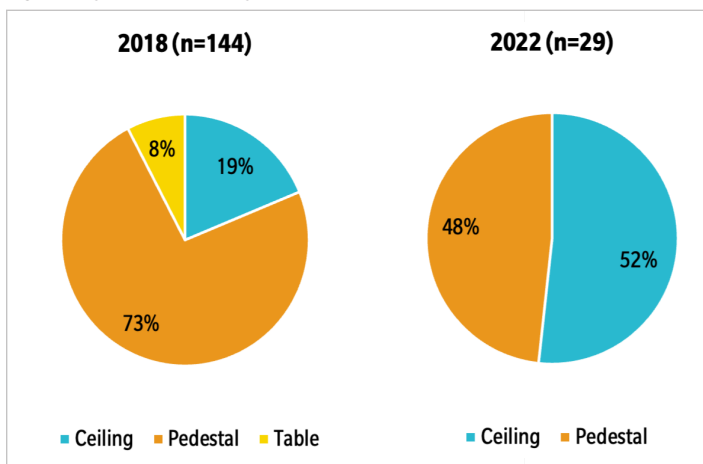
### Power Type

Nearly all fans surveyed in 2018 (100%) and 2022 (90%) are DC or AC/DC. The market has shifted more toward AC/DC since the 2018 data was collected, which would offer more flexibility to meet the needs of both off-grid and grid-connected consumers. Our 2022 survey includes a third power type, accounting for 10% of surveyed fans, referred to as AC/DC inverter. These fans are used with AC power sources but are typically built with brushless DC (BLDC) motors. An accompanying inverter allows the user to control the speed of the motor to satisfy their ventilation needs and prevent the fan from running at full power constantly, with no loss in efficiency. This makes the fan very efficient and provides similar energy-saving and electricity cost reduction benefits to DC-powered models.

vi. Total Addressable Market (TAM) refers to the maximum size of the opportunity for a particular product or solution.



Figure 3: Types of fans surveyed in 2018 and 2022



### Product Size and Type

Pedestal fans are the most common fan type in the market, representing 74% of surveyed fans in 2018 and 48% of surveyed fans in 2022 (Figure 3). The survey also included ceiling and table fans. The availability of ceiling fans has increased since the 2018 survey, accounting for 19% of surveyed samples in 2018 and growing to 52% of surveyed samples in 2022. Our consultant noted anecdotally that ceiling fans are the most demanded fan type. Table fans represented 8% of surveyed models in 2018, but very few models were noted, and none were surveyed in 2022. This may be because table fans are often utilised in urban office settings instead of rural household settings, where their smaller size and lower air circulation do not fit consumer purchasing criteria.

Fan blade diameter comes in a wide range of sizes, between 8-16 inches for table fans and 14-26 inches for pedestal fans. All ceiling fans surveyed were 56 inches. Retailers noted that they typically recommend a fan type and size to a consumer based on their specific air delivery needs.

## Retail Price

Examining retail price per fan blade inch compares fan prices relative to size. On average, table and pedestal fans are more expensive, while ceiling fans are less expensive (Table 1). More specifically, AC/DC inverter fans are the most expensive, followed by AC/DC and then DC fans. AC/DC inverter fans may be more expensive because of their unique technology and additional components. These fans use a highly efficient DC motor with an in-built inverter to be used with AC power and can operate at variable speeds. Between 2018 and 2022, the highest leap in price was pedestal fans, and DC pedestal fans in specific, growing nearly 120% and 150% more expensive per inch in that time, respectively. This is likely due to improved motors and the introduction of a warranty to most models by 2022. More generally, this may be linked to rising inflation and supply chain and shipping costs due to COVID-19.

Though increased efficiency may contribute to higher prices, reducing energy consumption can translate to savings on grid-supplied electricity and reduce the size and power generation requirement, and often the cost, of a SHS. Compared to other countries surveyed, total fan prices are slightly less expensive than in places like Nigeria<sup>49</sup> and Uganda<sup>50</sup> and are comparable to India's prices in 2020.<sup>51</sup>

Though all table fans surveyed in 2018 came from Chinese brands and all AC/DC inverter fans surveyed in 2022 came from Pakistani brands, pedestal and ceiling fan prices can be compared based on their origin in either Pakistan or China. Pedestal fans manufactured in Pakistan are less expensive per fan blade inch on average than those manufactured in and imported from China. In 2018, local pedestal fans were 57% less expensive than Chinese versions for both DC and AC/DC models, and DC models were still found to be 56% less expensive in 2022. This is likely due to local manufacturing of motors and fans, streamlining production, and cutting

importation costs. This highlights that manufacturing locally can translate to real savings for the consumer, unlocking affordability and wider access to these appliances.

Ceiling fan prices are more complex. Prices per inch for Pakistani and Chinese ceiling fans were about the same in 2018, though Chinese ceiling fans are about 11% less expensive than Pakistani models in 2022. Both DC and AC/DC Chinese models are less expensive than their Pakistani counterparts. These Chinese ceiling fans came from established and well-known brands in Pakistan, though none of them offered warranties in 2022, while all Pakistani ceiling fans surveyed then did. Thus, this price difference may partially reflect improved durability and the cost of providing after-sales service to consumers.

## Warranty

Warranties for fans have significantly improved since EforA first surveyed the Pakistan market in 2018. At that time, 97% of fans had no warranty, and 3% offered a one-year warranty (Figure 4). By February 2022, 83% of fans offered a one-year warranty.

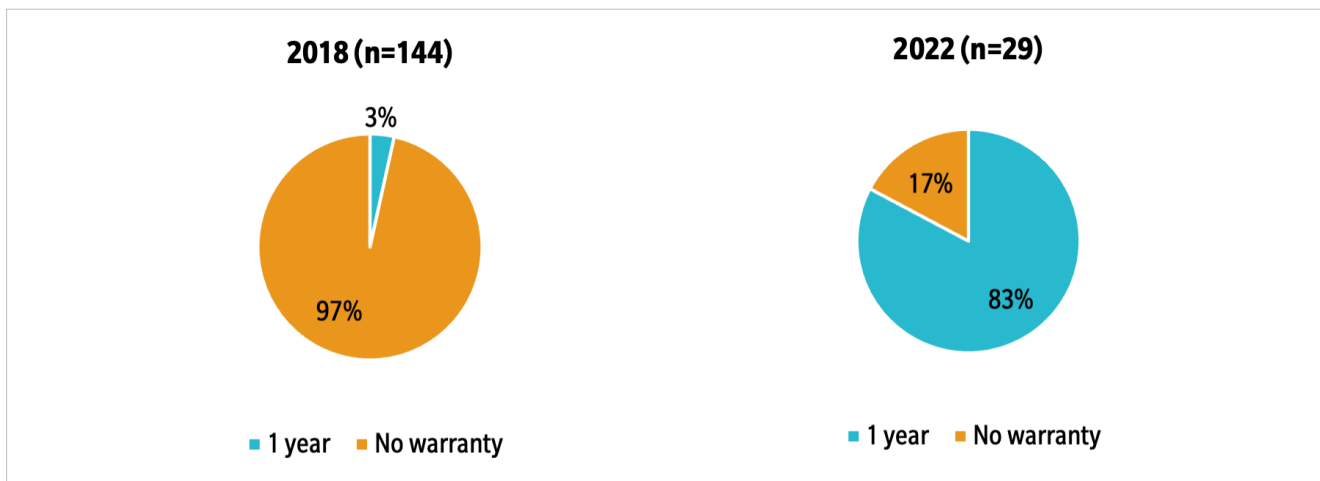
As explored in a fan case study by EforA,<sup>52,53</sup> many manufacturers are now integrating BLDC motors into their fans' design, particularly for ceiling fans. This has resulted in improved warranty periods for these fans for two reasons. Firstly, many of the local manufacturers using brushed motors in their fans in 2018 were sourcing their motors from one company that did not offer any type of warranty. Now, local fan manufacturers can provide warranties for their fans since they are either manufacturing the BLDC motors themselves or importing them from companies that offer a warranty. Secondly, since these motors are typically more durable than brushed motors, manufacturers have more confidence in their products to offer an extended warranty.

**Table 1: Retail price by fan and input power type by year for surveyed fans**

Fan Type	Fan Blade Size (Inches)	Input Power Type	Average Price Per Inch (USD)	
			2018	2022
Table Fan	8-16	All	1.69	N/A
		DC	1.51	N/A
		AC/DC	1.76	N/A
Pedestal Fan	14-26	All	0.83	1.81
		DC	0.69	1.70
		AC/DC	1.82	1.86
		AC/DC Inverter	N/A	2.16
Ceiling Fan	56	All	0.30	0.55
		DC	0.28	0.40
		AC/DC	0.39	0.57
		AC/DC Inverter	N/A	0.63



**Figure 4: Warranty offered by year for surveyed fans for 2018 and 2022**



## Product Performance

EforA sampled 10 fans in 2018 and 10 in 2022 for lab testing. All the fans sampled from Pakistan for testing were either DC or AC/DC. Six of the 10 fans tested in 2022 were AC/DC and were tested in both AC and DC modes. Five fans were also sampled from the Pakistani market in 2020 for follow-up lab testing to the samples surveyed and tested in 2018, so these are included here as additional data points. EforA has previously tested 119 fans, so this global data is used for comparison.

A fan's energy efficiency index (EEI) is measured using the air delivery provided over the power consumption, with the higher the EEI value, the better the efficiency. Overall, the EEI for tested fans from the Pakistan market is 19% better than the global average for all other fans tested by EforA (118 fans), demonstrating the high efficiency of fans in the Pakistani marketplace. Ceiling fans performed particularly well, as do many domestic brands.

Input current and motor type may influence efficiency (Table 2). Since fans using AC power typically run on more abundant grid-supplied energy and are less constrained by efficiency needs than those running on limited-generation DC systems, these models often demonstrate lower EEI. However, Pakistani fans tested in AC mode in 2022 show much higher efficiency than the benchmark average, indicating that Pakistan's focus on AC efficiency and labelling may already be reflected in the market.

For DC only fans, the 2018 and 2022 tested fans aligned with the global average of EforA-tested fans. The DC fans tested in 2020 were extremely efficient due to targeted testing to measure efficiency improvements of fans that had updated their products' design to include BLDC motors. This sample set also included two super-efficient ceiling fan models from two Pakistani-based brands, with extremely high EEI values of 5.73 and 7.21. Outside of the DC fans tested in 2020, AC/DC fans from Pakistan were the most efficient. This may be due to efficient brushless motors and models optimised for use with both AC and DC power sources. This suggests that DC and AC/DC fans sold in the Pakistani market already demonstrate extremely high efficiency.

We also compared the EEI of tested fans against NEECA's voluntary star labelling program for AC fans in Pakistan. 94% of the fans tested by EforA met the criteria for three-star fans, the best rating for efficiency. The only two fans that didn't meet the three-star criteria were AC/DC fans tested in AC mode, and they still reported high enough efficiency to meet the two-star rating. These results reflect Pakistan's highly developed fan market and demonstrate the payoff of concentrated efforts to improve fan efficiency.

**Table 2: Energy Efficiency Value for tested fans by year and by power input, with benchmarking**

Input Current Type	Benchmark EEI [m <sup>3</sup> /min/W]	Pakistan Tested Fans EEI [m <sup>3</sup> /min/W]		
		2018	2020	2022
AC	2.2	N/A	N/A	3.4
DC	3.1	3.2	4.4	3.5
AC/DC	3.7	4.1	N/A	N/A

## REFRIGERATOR MARKET INSIGHTS

### The off-grid refrigerator market in Pakistan is nascent, and there is little research to show current penetration rates and sales figures.

Earlier research in 2013 found that the rural penetration of refrigerators in Pakistan was estimated to be 30% of households, much higher than in India (7%) or Nigeria (8%).<sup>54</sup> In addition, between 2015 and 2020, the estimated addressable market of off- and weak-grid households that could purchase and power a refrigerator was expected to grow from 900,000 households to 4.5 million.<sup>55</sup> Based on limited data, sales volumes of refrigerators sold by GOGLA affiliates have also not been high enough to report.

In 2018, EforA's consultant surveyed just four models produced by a single Chinese manufacturer, sampled at one Pakistani retail shop, demonstrating little diversity in the off-grid refrigerator market. However, in early 2022, we captured data on nine models from two brands, as a second DC refrigerator manufacturer gained a footing in the market. Both brands offered a full line of refrigerator types and sizes.

### Power Type

All refrigerator models surveyed were DC, primarily due to our consultant's sampling strategy. However, they noted that the availability of DC refrigerators is extremely limited, and the samples surveyed are some of the only available DC models in the market. Our consultant also highlighted that many retailers were unaware of DC refrigerators. Distributors that offered DC refrigerators noted that high prices and low demand make it a difficult technology to keep in stock and sell.

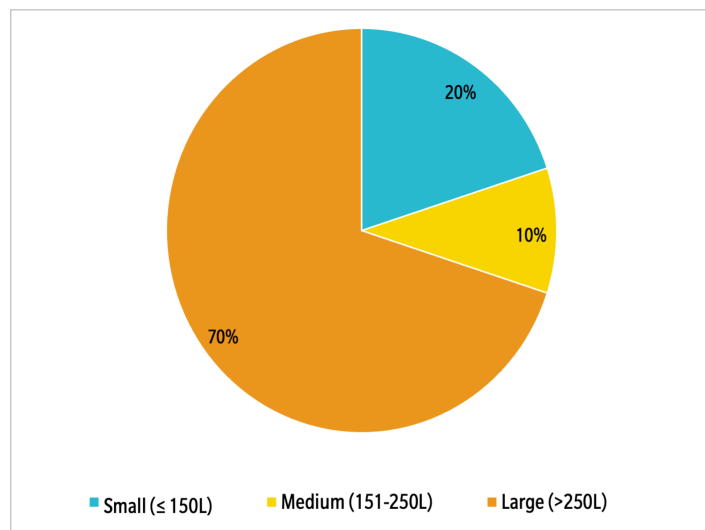
### Product Size and Type

The refrigerator market in Pakistan may be growing, as indicated by a wider selection of product sizes. In 2018, only small refrigerators ranging from 90-150 Litre (L) were surveyed, while our 2022 survey found refrigerators of all size categories ranging from 60-550L. Large refrigerators were the most common product (70%), while small and medium sizes comprised 20% and 10%, respectively (Figure 5). An abundance of size offerings allows consumers more selection based on their needs, and large refrigerators can offer greater opportunities for income-generating productive use. It is unusual, however, to see so many large models available on the market, though EforA found a similar trend for refrigerators sold in India.<sup>56</sup> Our consultant noted that Pakistani households often prefer to purchase large refrigerators, even if smaller models would satisfy their capacity needs.

In 2018, refrigerator-freezers were most commonly available in the market. Only a couple of these were observed in the 2022 survey, however, with multi-temperature cabinets that can be used as either a refrigerator or a freezer are becoming more widely available. Our consultant also noted a market for deep freezers for perishable storage in rural shop settings, surveying a few DC models in 2018 and noting the existence of several large commercial DC deep freezers on the market.

Large commercial models were not included in data collection and analysis due to their size and use case.

Figure 5: Size categories of surveyed refrigerators (n=10)



### Retail Price

Prices for surveyed refrigerators range from USD \$131 to \$360, which is less expensive than other nearby markets surveyed by EforA. In India, for example, nearly half the surveyed models were priced between USD \$400 and \$1,200, despite being comparable in size to those sampled in Pakistan.<sup>57</sup> As may be expected, prices for refrigerators in the Pakistani market increase as the refrigerator size increases (Figure 6). In addition to product size, the retail price may also be correlated to the refrigerator type. Multi-temperature cabinets were the most expensive products on average, with deep freezers as the most affordable type on average (Figure 7), though this category only contained small-sized units.



Figure 6: Price by size for surveyed refrigerators

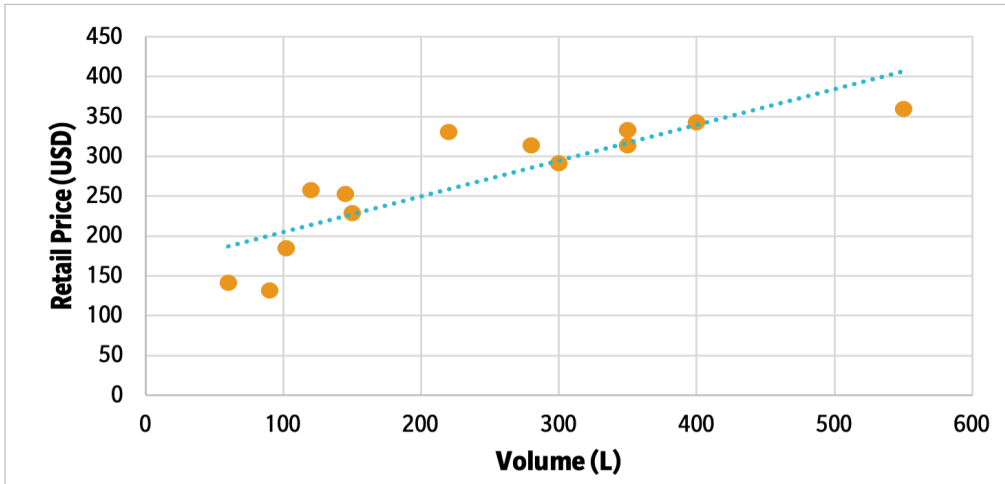
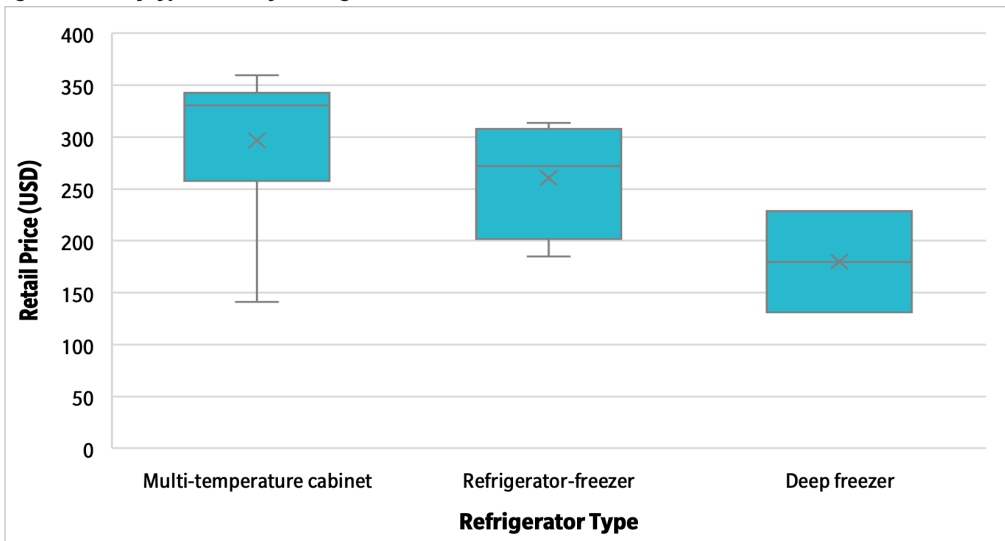


Figure 7: Price by type for surveyed refrigerators



## Warranty

None of the surveyed refrigerators from the Pakistani market had a warranty, which is unusual in countries surveyed by EforA. Warranties and reliable after-sales service are key to building brand loyalty and consumer confidence in the sector, especially for more expensive products like refrigerators. This could be limiting the market and discouraging end-users from buying these refrigerators with no guarantee of support if the product fails.

## Product Performance

EforA selected two models from the 2022 surveyed refrigerators for lab testing. Sample A was a 120 L deep freezer, and Sample B was a 220 L multi-temperature cabinet. These models follow the positive trend among the surveyed refrigerators, where rated power increases as volume does (Figure 8), indicating that larger models use more energy.

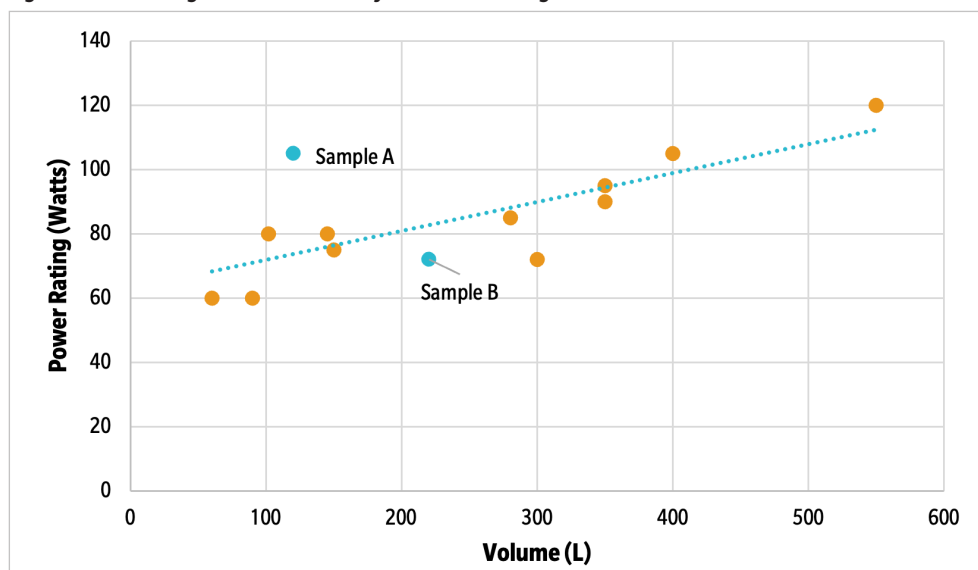
A refrigerator's EEI is defined as square meters of surface area per daily energy consumed in kilowatt-hours,  $m^2/kWh/day$ . The higher the EEI value is, the better the efficiency. When benchmarking these two models' efficiency with others tested

by EforA, Sample A was only compared to freezer settings. Sample B was tested at refrigerator and freezer settings due to its ability to be either.

EforA started testing freezers with the newest version of the [Global LEAP Off-Grid Refrigerator Test Method](#) and has tested five freezers to date, which comprise our global average. Sample A's efficiency was 21.3, making it the lowest tested EEI value for freezers and lower than the global average of 27.2. Sample B's EEI was measured to be 31.4, or the highest measured value of the group. However, this freezer only chilled to -12 degrees Celsius rather than the recommended -18 degrees Celsius achieved by all other tested models. As the maximum and minimum EEI values differ by just 10, and with the small sample size for benchmarking, all tested freezers are quite comparable in terms of efficiency.

The efficiency of 49 refrigerators previously tested by EforA varied more widely, spanning from 11.1 to 192.8. For its refrigerator functionality, Sample B's EEI was 57.8, making it comparable to the global median. Overall, the two sampled models are on par with the global average of other refrigerators and freezers tested by EforA, suggesting there is more room for efficiency improvements.

**Figure 8: Power rating and volume of surveyed and tested refrigerators**



## SOLAR WATER PUMP MARKET INSIGHTS

**Agriculture contributes to over 20% of Pakistan’s GDP and engages about 45% of the nation’s workforce.<sup>58</sup>**

**Pumps are a key PURE technology to increase irrigation and agricultural productivity.**

There is a large market for pumps in Pakistan, with an estimated 800,00 diesel pumps and 300,000 electric pumps in use as of 2015.<sup>59</sup> In addition, anecdotally, many households use water pumps to move pipe-delivered water to rooftop storage tanks, equating to possibly millions more pumps already in use. However, inconsistent grid electricity service and high fuel costs have sparked projects looking to upgrade and replace many of these existing pumps.<sup>60</sup> If affordable and technically acceptable, SWPs could fill this gap and offer consistent, quality water pumping for households and farmers who depend on reliable, sustainable water delivery from surface and submersible sources for their livelihood.

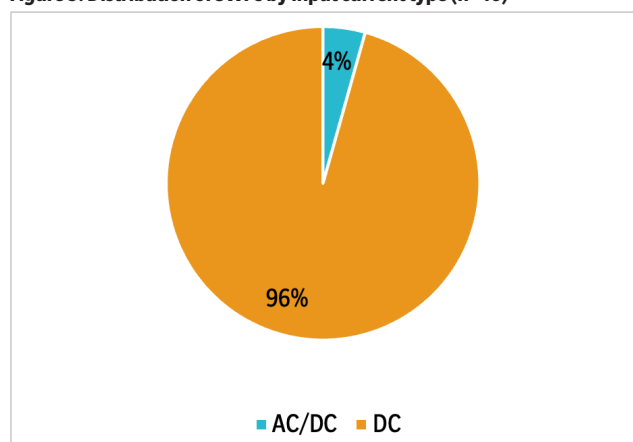
EforA sampled a total of 48 pump models from 7 brands in Pakistan’s marketplaces. The survey indicates great flexibility in purchasing options, with all pumps surveyed available as standalone products or packaged in a solar energy kit. Our consultant noted that local manufacturers produce many cheap, efficient DC pumps with low head to provide low flow for smallholder farms. They also noted that in Gujranwala, Punjab, many manufacturers are producing a low-quality DC surface pump type called mono-block pumps, which can only lift water from 15 meters. Though some DC surface pumps are manufactured in Pakistan, most pumps, including DC submersible pumps, are manufactured in China.

### Power Type

Our consultant noted that most pumps sold in the market are AC, but they primarily surveyed DC pumps to show the range of DC models available; therefore, DC SWPs made up most of

the surveyed pumps (Figure 9). This indicates the availability of DC pumps designed for off-grid use in the market, giving smallholder farmers access to technology suited for their irrigation needs. Greater abundance of AC pumps aligns with EforA’s findings in neighbouring India, where 79% of pumps surveyed were AC models.<sup>61</sup> Many retailers and consumers perceive AC motors to have longer lifetimes, presenting a consumer awareness-raising opportunity for educating both groups on the positive aspects of DC pumps.

**Figure 9: Distribution of SWPs by input current type (n=46)**



### Product Type and Size

Most pumps surveyed are submersible (Figure 10). This aligns with EforA’s findings from India, where 74% of sampled pumps were submersible. The surveyed pumps have wide ranges of power ratings, with submersible pumps ranging from 0.25kW to 2.2kW, and surface pumps ranging from 0.18kW to 2.20kW. AC/DC and DC pumps targeted for off-grid use and smaller irrigation projects both had an average rated power of 0.91kW.



## BOX 2

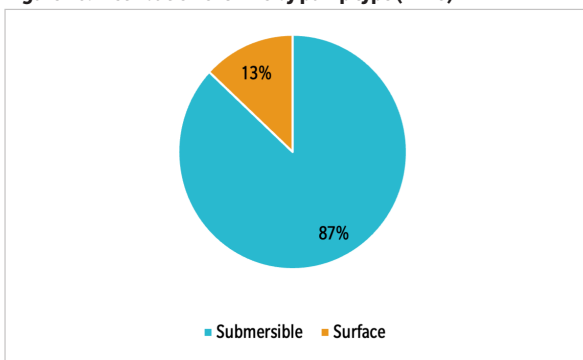
### SUBMERSIBLE PUMPS

These pumps are designed for underwater installation, such as in boreholes and wells. Whilst they are generally less accessible, they do not need to be primed and are not constrained by some of the physical limitations of surface pumps, such as suction lift limits (i.e., the maximum vertical distance the pump can pull water in before pumping it out).

### SURFACE PUMPS

These pumps draw water from surface sources, such as streams and ponds. The pump itself is designed to be situated outside of the water source. The accessibility of surface pumps can present a trade-off between convenience of installation and maintenance and exposure to the elements and potential theft. Some surface pumps are now designed to be mobile to address these concerns.

Figure 10: Distribution of SWPs by pump type (n=46)



### Retail Price

Our field consultant noted that since most DC SWPs in Pakistan are sold with a solar system that is customised based on the use case (e.g., residential, small farming, etc.), many of the shopkeepers quote the price in ranges based on the different options for head size, solar panel capacity, and other variable components such as wiring and piping. All pricing data is analysed for standalone pumps sold without a solar system.

Prices for pumps in Pakistan ranged from USD \$19 to \$350, which is comparatively less expensive than other pumps surveyed by EforA in other countries. For example, in India, EforA's survey found that 91% of pumps surveyed cost over USD \$500,<sup>62</sup> with all Pakistani pumps surveyed costing below USD \$400. The extremely inexpensive models surveyed in Pakistan are low head, low flow, low-power-consuming surface pump models from one imported brand.

There is a strong positive correlation between pump size and price, with higher-power pumps costing more on average (Figure 11). Power type may also influence price, with AC/DC pumps costing about 33% more than DC pumps (Table 3). Surface pumps were also about 14% more expensive than submersible pumps, which is unusual compared to other

markets that EforA has surveyed as submersible technology is typically more complex and, therefore, more expensive. In this case, the surface pumps may have higher prices due to larger power ratings than submersible pumps.

Figure 11: Correlation between pump power and price

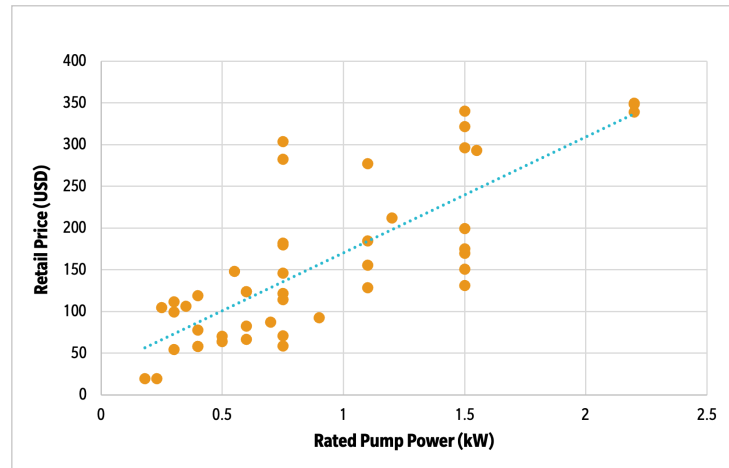


Table 3: Average power rating and retail price for SWPs

Pump Type	Average Power Rating [kW]	Average Retail Price of Standalone Pump [USD]
AC/DC	0.9	230
DC	0.9	154

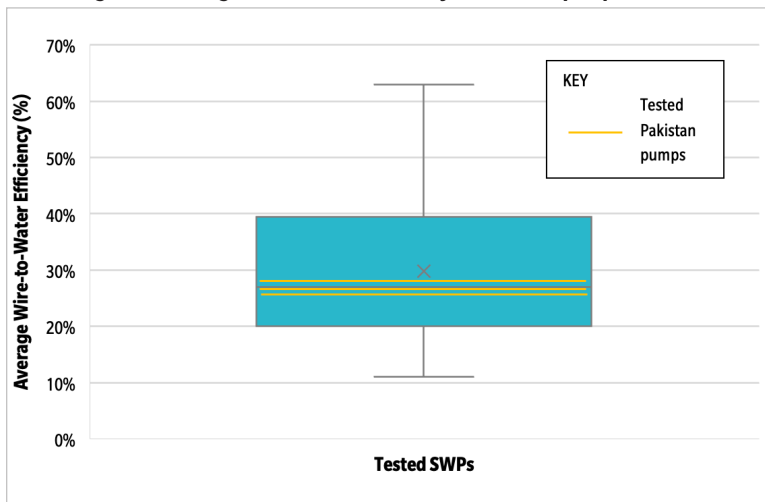
### Warranty

As with refrigerators, none of the surveyed models offer warranties, though one product procured directly from a Pakistani manufacturer did offer a warranty of 6 months. Without the assurance of a warranty, consumers may not be confident in the quality of these products. However, our survey notes that many retailers provide installation services, so they may also move toward offering warranties for pumps. As Pakistan seeks to facilitate the uptake of SWPs to replace diesel pumps, warranties could be improved to build brand loyalty and instil confidence to help consumers make the switch.

### Product Performance

The EforA team sampled three of the surveyed pumps to conduct further performance testing in the laboratory. We measure SWP efficiency by the hydraulic power generated by an electric pump divided by the measured input power. This is called wire-to-water efficiency. Compared to test data from 44 SWPs tested by EforA, all three Pakistani SWPs fell slightly below the benchmark average of 30% wire-to-water efficiency, with values of 26%, 27%, and 29%, respectively (Figure 12). However, most of the pumps included in the existing dataset are winners and finalists from the Global LEAP Awards competition, which typically represents the best-in-class products. Given this, the Pakistan samples are performing in line with higher-quality products sold in the market.

Figure 12: Average wire-to-water efficiency for all tested pumps



For lab-tested pumps, we also examined the cost index, which is the total cost of the pump (pump and actual or estimated price of PV system) over the amount of hydraulic energy per day in watt-hours (Wh) delivered during testing. The Pakistan pumps had an average of USD \$1.11 per Wh compared to an average of USD \$3.52 per Wh for other pumps tested by EforA, with one pump having the second lowest cost index of all tested pumps. This means that the sampled pumps from Pakistan are delivering the same energy services for lower costs.

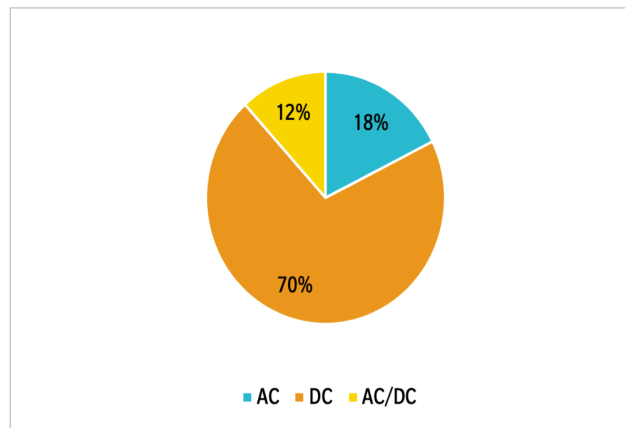
## EVAPORATIVE AIR COOLER MARKET INSIGHTS

Evaporative air coolers, like fans, offer a more affordable and efficient option than air conditioners. They work well in environments with low humidity and are particularly favoured in the dry early summer months of March to June. They use hot ambient air to evaporate water, which absorbs the air’s heat, and this chilled air is pumped out to cool the space around it by 15 to 40 degrees Fahrenheit.<sup>63</sup> Due to Pakistan’s established market for cooling appliances such as fans, evaporative coolers are a logical market expansion. This survey offers an early look into this emerging appliance type. EforA’s field consultant surveyed 17 evaporative air cooler models from five brands. All of these came from Pakistani manufacturers and were sold as standalone products. According to our field consultant, the demand for DC evaporative air coolers is driven by rising electricity tariffs, scheduled and un-scheduled grid power interruptions, and a growing market for solar energy solutions such as SHSs.

### Power Type

The majority (70%) of evaporative air coolers surveyed were DC models, with AC/DC models (18%) and AC models (12%) less commonly found (Figure 13). Our consultant noted that most coolers available in the market are DC and produced locally, though many consumers and distributors believe that AC versions deliver better performance.

Figure 13: Distribution of evaporative air coolers by input current type (n=17)



## Product Size and Performance

Since consumers must add water to the evaporative air cooler, product size depends on a cooler’s capacity in gallons of water. The surveyed models have a capacity from 9.2 to 23.7 gallons of water, with an average of 15.6 gallons. The performance of these coolers is measured in their air delivery to a space over time. All surveyed coolers had similarly rated air delivery ranges, between 350-390 m<sup>3</sup> per minute. This indicates a very consistent market, with some variety in size for consumers to select a model that fits their cooling needs.

## Retail Price

Evaporative air coolers surveyed ranged between USD \$53 and \$89. There is a weak positive correlation between product size and price. Retail prices were also not heavily influenced by air delivery. This comparable pricing may be due to the models’ similarities and that all units are manufactured locally, meaning that these manufacturers do not have to compete with coolers manufactured elsewhere. There is some pricing variation with the input current type, with AC coolers being the least expensive at an average of USD \$67 and more adaptable AC/DC coolers being the most expensive at an average of USD \$83 (Table 4).

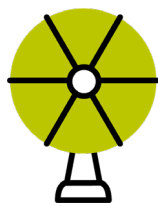
Table 4: Retail price by input current type

Input Current Type	Average Retail Price of Standalone Evaporative Air Cooler (USD)
AC	67
DC	75
AC/DC	83

## Warranty

All evaporative air coolers surveyed by EforA’s consultant offered a warranty. Two models from the same brand offered three-month warranties, while all other models surveyed were protected by a one-year warranty. Like SWPs, our consultant noted that motors for evaporative air coolers are often imported, so manufacturers may be less confident in their quality and therefore offer shorter warranty periods. Since this product type is relatively new, continuing to offer quality products with warranties and after-sales service will be crucial to growing the market.

## CONCLUSIONS AND TAKEAWAYS



**Efficiency wins in the local fan market could translate to other product categories.** After sampling and testing 25 DC and AC/DC fans from the market in Pakistan, we found that Pakistani fans are 19% more efficient on average than the global average for fans tested by EforA. We also benchmarked the performance of tested fans against

NEECA's voluntary star labelling program for AC fans. The analysis showed that 94% of the off- and weak-grid appropriate fans tested by EforA were classified as three-star, the highest efficiency rating. The high efficiency of DC fans may be partly due to most of these local manufacturers using BLDC motors in their fan design, which are highly efficient compared to brushed motors. As Pakistan builds out its local manufacturing for other product categories, including SWPs and evaporative air coolers, it can prioritise the use of efficient motors and components to continue to lead the way in efficiency, ultimately better serving customers and reducing environmental impact.



**Low prices are linked to the local manufacturing sector in Pakistan, which continues to expand.** Our consultant noted a strong local manufacturing market for fans, SWPs, evaporative air coolers, and the motors

used to run some of these appliances. Manufacturing locally cuts importation and distribution costs that are usually passed to consumers, translating to real savings for end-users. This survey found that locally made fans can be 16% to 46% less expensive on average than imported alternatives. Local manufacturing can also be a gateway to better warranty coverage. Local technicians are more familiar with the technology and can better fix issues while being more conveniently located. This has not yet equated to strong warranties for large and PURE technologies, like SWPs and fridges, but consumers of fans and evaporative air coolers are being protected by warranties. However, we cannot verify that these warranties are being honoured.



**Building awareness of the benefits of DC appliances for off-grid users and improving after-sales care will be key to uptake.** Interviews with local stakeholders found that AC appliances are often preferred by off-grid users because they are viewed as higher quality than DC products. This means that many off-grid consumers may be using their AC appliances with an inverter powered

by a SHS. However, our test results demonstrated that DC fans from Pakistan performed extremely well and DC refrigerators

and SWPs performed in-line in terms of efficiency compared to other products tested by EforA. While warranties are improving for products like fans, none of the surveyed DC refrigerators or SWPs offered warranties, which may be contributing to consumers' views of DC appliances as lower quality. Now that DC versions of fans, SWPs, and evaporative air coolers are more widely available due to local manufacturing, education about the benefits of DC appliances for use by off- and weak-grid consumers, coupled with improved after-sales care, will be essential to the growth of the DC appliance market.



**The burgeoning PURE market in Pakistan brings these themes together.** With agriculture as a primary sector and millions of rural smallholder farmers, irrigation is vital to the economy and the livelihoods of Pakistani households. With new projects dedicated to

replacing expensive and unreliable fuel and grid-powered pumps with SWPs, dedicated funding for this through the Sindh Solar Energy Project and work by PEECA will support the SWP market in the next several years. Local pump manufacturing is present for DC surface pumps, providing options for consumers needing low pumping power. Going forward, this may grow local expertise and technology efficiency innovations and can offer more affordability, longer warranties, and comprehensive after-sales service, following the pattern of domestic fan manufacturing. As it stands, SWPs surveyed by EforA were all priced below USD \$400, and their tested wire-to-water efficiency was comparable to other best-in-class products. This indicates that affordability and quality are already being addressed in the market and will help this sector continue to grow. Other up-and-coming technology types, like evaporative air coolers, help address the main market need – cooling – and diversify appliance sales to make the sector more resilient and meet end-users' needs.

If you have any insights about the appliance market in Pakistan or questions about how these surveys were conducted, which shops were visited, or which models were surveyed, please contact [info@efficiencyforaccess.org](mailto:info@efficiencyforaccess.org).

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