# CLUSTER PROFILE
# RENEWABLE SOLAR ENERGY SECTOR OF BALOCHISTAN

## Small and Medium Enterprise Development Authority
### Government of Pakistan

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# 1 DESCRIPTION OF CLUSTER

## 1.1 Introduction, History & Background of Solar Energy Sector.

Though solar energy has found a dynamic and established role in today's clean energy economy, there is a long history behind photovoltaic (PV) that brought the concept of solar energy to fruition. With the way the cost of solar has plummeted in the past decade, it is easy to forget that going solar had a completely different meaning even just 15 years ago. Let's go back a few centuries to the origins of solar PV and explore the history of solar energy and silicon solar technology.

In theory, solar energy was used by humans as early as 7th century B.C. when history tells us that humans used sunlight to light fires with magnifying glass materials. Later, in 3rd century B.C., the Greeks and Romans were known to harness solar power with mirrors to light torches for religious ceremonies. These mirrors became a normalized tool referred to as "burning mirrors." Chinese civilization documented the use of mirrors for the same purpose later in 20 A.D.

Another early use for solar energy that is still popular today was the concept of "sunrooms" in buildings. These sunrooms used massive windows to direct sunlight into one concentrated area. Some of the iconic Roman bathhouses, typically those situated on the south-facing side of buildings, were sunrooms. Later in the 1200s A.D., ancestors to the Pueblo Native Americans known as the Anasazi situated themselves in south-facing abodes on cliffs to capture the sun's warmth during cold winter months.

In the late 1700s and 1800s, researchers and scientists had success using sunlight to power ovens for long voyages. They also harnessed the power of the sun to produce solar-powered steamboats. Ultimately, it's clear that even thousands of years before the era of solar panels, the concept of manipulating the power of the sun was a common practice.

**When were solar panels invented?**

The development of solar panel technology was an iterative one that took a number of contributions from various scientists. Naturally, there is some debate around when exactly they were created and who should be credited for the invention. Some people credit the invention of the solar cell to French scientist Edmond Becquerel, who determined light could increase electricity generation when two metal electrodes were placed into a conducting solution. This

breakthrough, defined as the "photovoltaic effect," was influential in later PV developments with the element selenium.

In 1873, Willoughby Smith discovered that selenium had photoconductive potential, leading to William Grylls Adams' and Richard Evans Day's 1876 discovery that selenium creates electricity when exposed to sunlight. A few years later in 1883, Charles Fritts actually produced the first solar cells made from selenium wafers – the reason some historians credit Fritts with the actual invention of solar cells.

However, solar cells as we know them today are made with silicon, not selenium. Therefore, some consider the true invention of solar panels to be tied to Daryl Chapin, Calvin Fuller, and Gerald Pearson's creation of the silicon photovoltaic (PV) cell at Bell Labs in 1954. Many argue that this event marks the true invention of PV technology because it was the first instance of a solar technology that could actually power an electric device for several hours of a day. The first ever silicon solar cell could convert sunlight at four percent efficiency, less than a quarter of what modern cells are capable of.

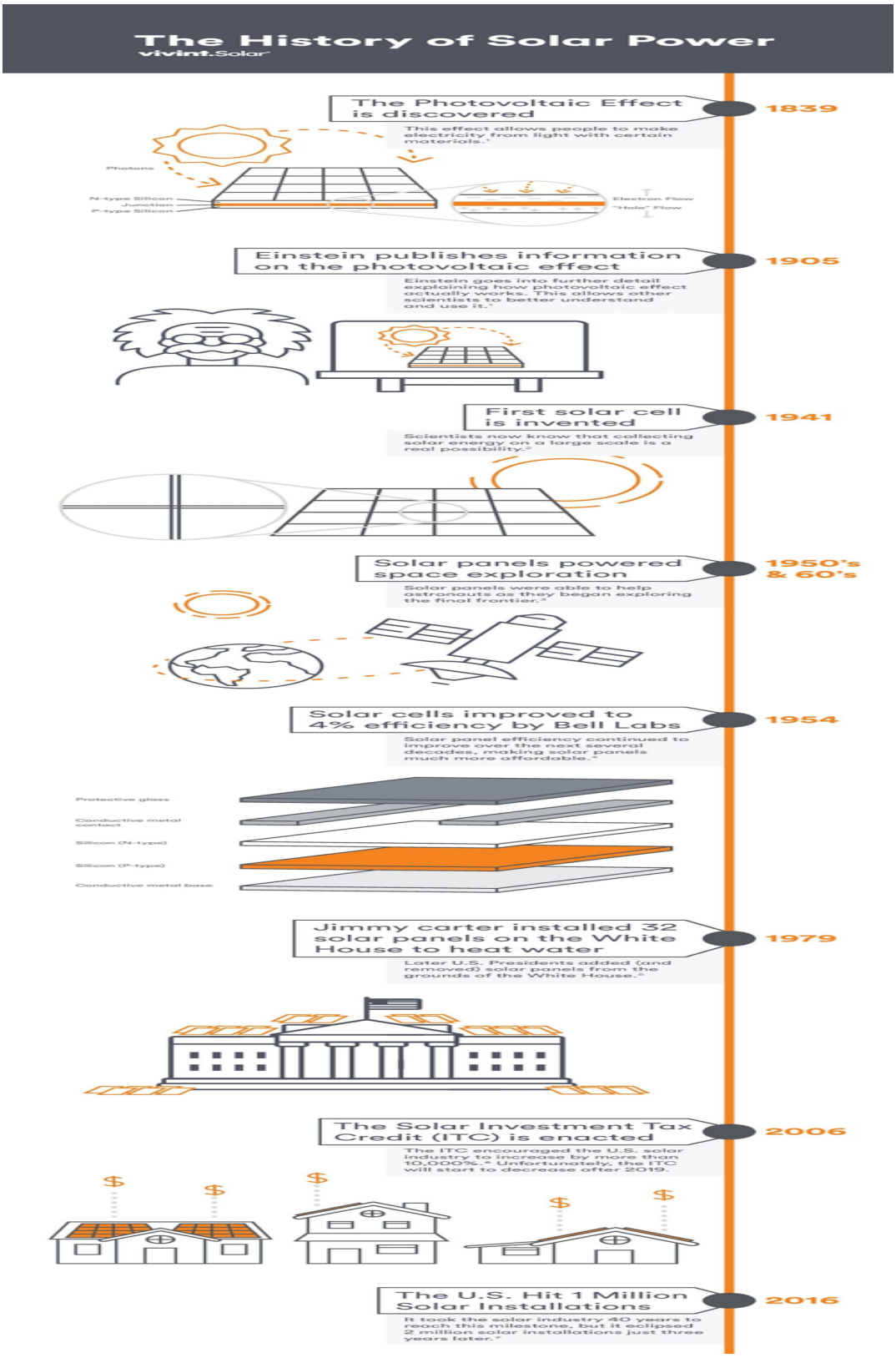
**Other major events in the history of solar energy**

- Solar panels in outer space – Some of the earliest uses of solar technology were actually in outer space where solar was used to power satellites. In 1958, the Vanguard I satellite used a tiny one-watt panel to power its radios. Later that year the Vanguard II, Explorer III and Sputnik-3 were all launched with PV technology on board. In 1964, NASA was responsible for launching the first Nimbus spacecraft, a satellite able to run entirely on a 470 watt solar array. In 1966, NASA launched the world's first Orbiting Astronomical Observatory, powered by a one-kilowatt array.
- First solar residence – In 1973, the University of Delaware was responsible for constructing the first solar building, named "Solar One." The system ran on a hybrid supply of solar thermal and solar PV power. It was also the first instance of building integrated photovoltaic (BIPV) – the array didn't use solar panels but instead had solar integrated into the rooftop, similar to the design for Tesla's new roof product.
- Achievements in solar conversion efficiency – Between 1957 and 1960, Hoffman Electronics made a number of breakthroughs with photovoltaic efficiency, improving the efficiency record from 8% to 14%. The next major achievement was in 1985 when the University of South Wales achieved 20% efficiency for silicon cells. In 1999, the

National Renewable Energy Laboratory collaborated with SpectroLab Inc. to create a solar cell with 33.3% efficiency. The University of South Wales broke that record again in 2016 when researchers reached 34.5% efficiency.

- Solar-powered airplanes – In 1981, Paul MacCready built Solar Challenger, the first aircraft to run on solar power, and flew it across the English Channel from France to the U.K. In 1998, the remote-controlled solar airplane "Pathfinder" set an altitude record after reaching 80,000 feet. NASA broke that record in 2001 when they reached 96,000 feet with their non-rocket aircraft. In 2016, Bertrand Piccard completed the first zero-emissions flight around the world with Solar Impulse 2, the world's largest and most powerful solar-powered airplane today.
- Solar-powered presidencies – In 1979, President Jimmy Carter had solar panels installed on the White House during his term as president. However, in 1981, President Ronald Reagan ordered the White House solar panels to be removed. In 2010, President Barack Obama requested that solar panels and a solar water heater be installed on the White House.
- Cost of solar over time – Prices for solar panels have dropped substantially over the past few decades, leading to a surge in consumer demand that has produced more than one million U.S. installations as of early 2016. In 1956, solar panels cost roughly $300 per watt. By 1975, that figure had dropped to just over $100 a watt. Today, a solar panel can cost as little as $0.50 a watt. Consider this: since the year 1980, solar panel prices have dropped by at least 10 percent every single year. The plummeting cost of solar is largely responsible for the growing popularity of solar and the legitimacy of PV as a reliable energy source in today's world.

***Figure 1.1**


The History of Solar Power
vivint.Solar
The Photovoltaic Effect is discovered
1839
This effect allows people to make electricity from light with certain materials.
Photons
N-type Silicon
Junction
P-type Silicon
Electron Flow
"Hole" Flow
Einstein publishes information on the photovoltaic effect
1905
Einstein goes into further detail explaining how photovoltaic effect actually works. This allows other scientists to better understand and use it.
First solar cell is invented
1941
Scientists now know that collecting solar energy on a large scale is a real possibility.
Solar panels powered space exploration
1950's & 60's
Solar panels were able to help astronauts as they began exploring the final frontier.
Solar cells improved to 4% efficiency by Bell Labs
1954
Solar panel efficiency continued to improve over the next several decades, making solar panels much more affordable.
Protective glass
Conductive metal contact
Silicon (N-type)
Silicon (P-type)
Conductive metal base
Jimmy carter installed 32 solar panels on the White House to heat water
1979
Later U.S. Presidents added (and removed) solar panels from the grounds of the White House.
The Solar Investment Tax Credit (ITC) is enacted
2006
The ITC encouraged the U.S. solar industry to increase by more than 10,000%. Unfortunately, the ITC will start to decrease after 2019.
The U.S. Hit 1 Million Solar Installations
2016
It took the solar industry 40 years to reach this milestone, but it eclipsed 2 million solar installations just three years later.

Pakistan's sunny climate makes it a perfect place to develop solar power. But it still depends on dirty fossil fuels, and is building more coal power plants. Pakistan has immense potential for generating electricity through solar power. Almost all parts of the South Asian country are dry and hot, barring a few areas in the northwest.

However, the country currently only produces a meager 1.16% of its electricity through solar power and 64% with fossil fuels. Other electricity sources include hydropower at 27% and nuclear at 5%. Renewable energy sources count for only 4% of total electricity production.

Despite being located in a region severely affected by climate change, Pakistan continues to invest in environmentally unfriendly methods of power production.

Recently, the government approved seven Chinese-funded coal power projects, which will add up to 6,600 megawatts to the national grid in the coming years.

Last year, Prime Minister Imran Khan's government promised that Pakistan would produce 60% of its electricity from renewable sources by 2030. This would require Pakistan to install around 24,000 megawatts of solar and wind power capacity by 2030, up from just over 1,500 megawatts now.

Environmentalists have said that building solar power is well within the nation's capabilities, if enough politicians will to support development.

## *1.2 Defining the Product*

Solar is the most abundant source of energy on Earth. About 173,000 terawatts of solar energy strike the Earth at any given time - more than 10,000 times the world's total energy needs.

By capturing the sun's energy and turning it into electricity for your home or business, solar energy is a key solution in combating the current climate crisis and reducing our dependence on fossil fuels.

**How Does Solar Energy Work?**

Our sun is a natural nuclear reactor. It releases tiny packets of energy called photons, which travel the 93 million miles from the sun to Earth in about 8.5 minutes. Every hour, enough photons impact our planet to generate enough solar energy to theoretically satisfy global energy needs for an entire year. Currently photovoltaic power accounts for only five-tenths of one percent of the energy consumed in the United States. But solar technology is improving and the cost of going solar is dropping rapidly, so our ability to harness the sun's abundance of energy is

on the rise. In 2017, the International Energy Agency showed that solar had become the world's fastest-growing source of power, marking the first time that solar energy's growth had surpassed that of all other fuels. Since then solar has continued to grow and break records around the globe.

## *1.3 Geographical Locations*

Solar energy represents the best opportunity for off-grid power generation in the rural areas of Balochistan as the province receives large amounts of solar irradiance on its vast lands. The World Bank, in its solar energy assessment of Pakistan, reported that the entire Balochistan is rich in solar energy and has the highest average sunshine hours in the world. The World Bank, in its solar energy assessment of Pakistan, reported that the entire Balochistan is rich in solar energy and has the highest average sunshine hours in the world. The report further states that the northern parts of the province, with peak direct normal irradiance (DNI) value of 2700 kWh/m2 are the most desirable for solar energy generation. Additionally, the report compares these values with those received in the Sinai Peninsula, which is one of the top solar radiance receiving location in the world. Similarly, Sustainability Advocacy suggested that the solar photovoltaic (PV) is the best choice for electrification due to the high temperature in Pakistan. Also, Sustainability Advocacy argued that instead of extending grid lines to remote areas, giving a
Solar panel to each house is a more economic approach to empowering the socio-economic condition of Balochistan's rural population. Further, the Asian Development Bank believes that the off-grid power is the only solution to electrifying the remote areas in Pakistan.
Moreover the recent government has introduced lucrative incentives for the solar development in the country. Investors are offered financial and fiscal benefits that attract them to this market. The federal government is set to spend Rs. 23 Billion to replace 30,000 conventional tube wells with solar tube wells in Balochistan, which shall save federal government 23 Billion from conventional tube well subsidies.

## *1.4 Core Cluster Actors*

### *1.4.1 Size of Sector*

The province of Balochistan is rich in renewable energy (RE) resources, which must be explored for the sustainable development of the province. For remote areas and small power requirements photovoltaic technology is particularly suitable. Balochistan is also the largest province by area, yet, there is low density of population. Majority of its populations is living in villages and rural areas, i.e. 77%. These villages have no easy approach to the roads and are separated by large distances. Several houses in villages have very low requirement of power which varies between 50-100 W. Transmission of power lines for small villages and for very low power requirements is economically not feasible. Use of renewable energy can easily meet the requirements of such houses where electricity is mainly needed for light and fan or for charging mobile phone. This

section provides an overview of the solar power in Balochistan. Solar radiation in Balochistan is highest compared to other parts of Pakistan, as annual average mean daily solar radiation is at 5.9-6.2 kWh/m2/day in the province. In view of the growing energy demand the solar energy potential of Balochistan must be fully exploited. Solar energy is a reliable and copiously available renewable energy source. The province has an annual mean sunshine duration of 8- 8.5 hours with an average daily global insolation of 19-20 MJ/m2/day. These are among the highest solar energy potential values available in the world. The areas where the solar irradiation is highest are ideal for concentrated solar power (CSP) and photovoltaic (PV) systems. In 2016, Government of Balochistan (GoB) signed a Memorandum of Understanding (MoU) with Inter-teck Kuwait Investment Authority to fulfill the energy demands of Quetta city by setting up a solar energy power plant of 50 MW which will be gradually upgraded to 500 MW. Another agreement was signed with CK Solar Korea to establish a 300 MW solar power plant in Quetta. 1500 acres of land is allocated by GoB near Kuchlak, District Quetta for this solar power plant project.

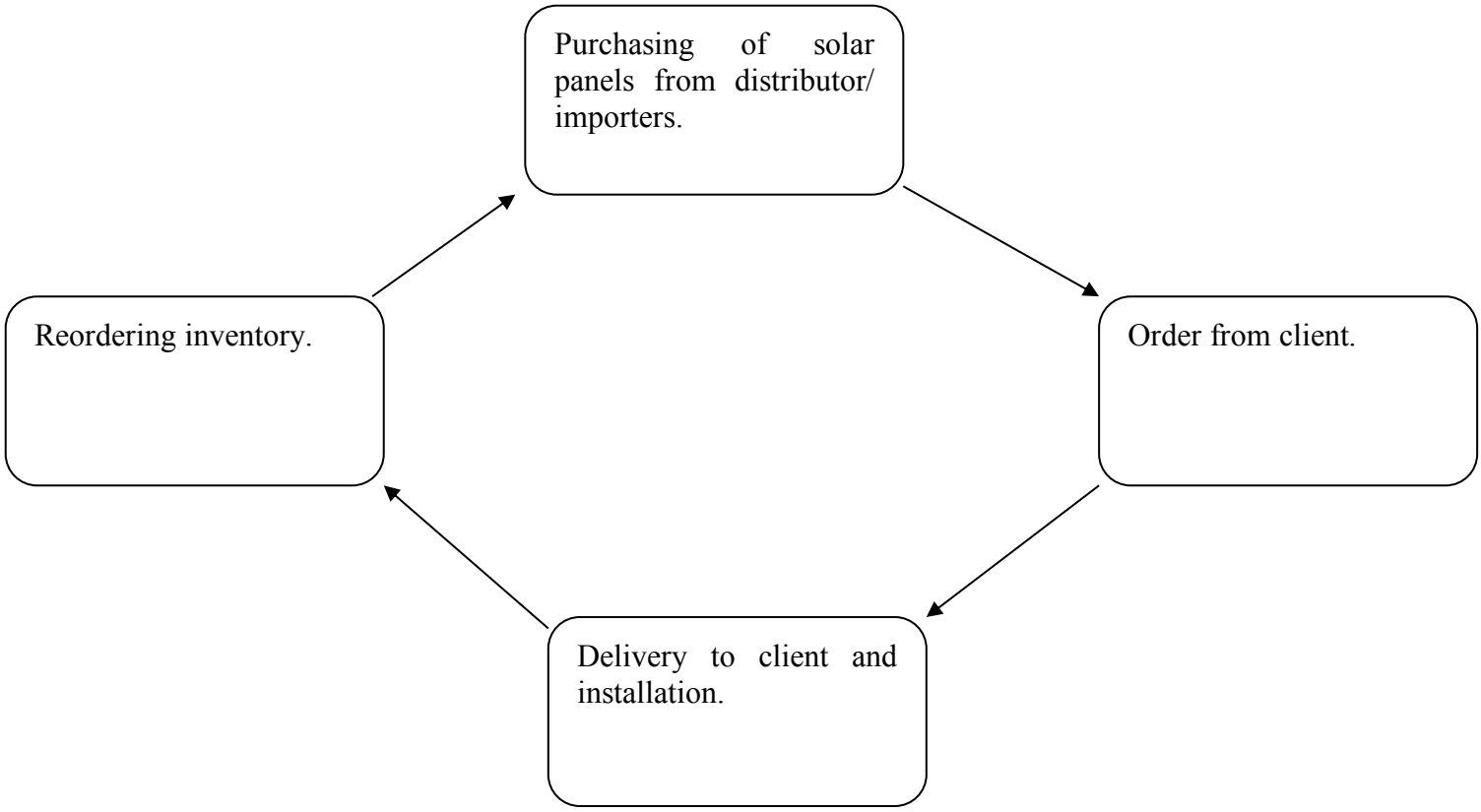
Solar power projects in Balochistan.

| Project | Capacity | Status |
|---|---|---|
| Solar power project kuchlak. | 300MW | MOU signed |
| Tehsil Jaffarabad | 7.9kw | completed |
| Tehsil Zehri, District khuzdar | 10kw | Completed |
| Hospital electrification, tehsil Kalat. | 14.5kw | In process |
| Rural electrification, tehsil Kalat. | 41.1kw | In process |
| Rural electrification, tehsil Surab | 59.5kw | In process |
| Rural electrification, tehsil khuzdar. | 37.3kw | In process. |

### *1.4.2 Current Cluster Scenario*

The Balochistan provincial government devised the Balochistan Power Generation Policy 2007 for promoting project development using renewable and indigenous coal resources. The policy document consists of various procedures and incentives mainly adopted from the previous federal power policy, the Policy for Power Generation Projects 2002. Under this policy, the provincial government established the Balochistan Power Development Board as a one-window facilitator to help the private sector invest in the province's vast renewable energy potential, particularly solar and wind. Due to the challenging terrain and long distances from the grid, the board has thus far not been able to mobilize private investment in renewable energy projects in the province.

## 2 ANALYSIS OF BUSINESS OPERATIONS




- Stage 1: purchasing from certified distributor/ importer takes place to maintain minimum inventory and fulfill the demand on time.
- Stage 2: Demand from clients is analyzed.
- Stage 3: Delivery and installation at the premises of clients take place.
- Stage 4: Reorder of inventory according to demand.

## *2.1 Technological Analysis*

There are three types of Solar (PV) Systems widely available:

- The first type is the Grid Tied Systems that are connected to the utility power grids, which is an alternative power generation method like the hydel or fuel or gas generators used by power companies to meet the needs of the area or city or country and they will only work in the presence of sunlight.
- The second type is the Off-Grid PV System that is also known as standalone Systems. This type of Systems is not connected to the grid and it requires batteries. The batteries ensure the availability of electricity even in the absence of sunlight. These types of systems are mainly used in the remote areas, which are not in the reach of national power distribution.
- The third type is the Hybrid PV Systems; it is best suited for households because of the flexibility to connect along with the national grid electricity connection.

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## *2.2 Market Mechanism*

The solar (PV) system consumers are increasing in Pakistan as more people are shifting from fuel generators to solar power for power needs. The potential customers are segmented into following groups: Small Businesses and Organizations: Small businesses operating in areas with disrupted electricity supply opt for solar power systems for their electricity needs. Organizations including Health facilities, Government offices and NGOs operating in remote rural areas with no grid power access also install PV systems to meet their electricity needs. Such customers are found both in rural as well as urban areas of Pakistan

Currently solar panels are mainly sold to farmers affiliate with agriculture sector of Balochistan due to non-availability of electricity and farmer's dependency on tube wells. Moreover, residents of rural areas use it for electrifying their houses. The Sustainability Advocacy has suggested that instead of extending grid lines to remote areas, giving a solar panel to each house is a more economic approach to empowering the socio-economic condition of Balochistan's rural population therefore there's tremendous market gap which could be fulfilled through investment in this particular sector. Furthermore, the Asian Development Bank believes that the off-grid Power is the only solution to electrifying the remote areas in Pakistan.

### *2.3 Human Resource*

Human resource is locally available which is mostly university graduates' example Electronic and electrical engineers, however training and development could be done to further enhance their capabilities and to produce specialized human resource.

## 3 INSTITUTIONAL SETUP

### *3.1 Associations*

Renewable & Alternative Energy Association of Pakistan (REAP) is the first ever registered entity of the country in Alternative and renewable energy sector with a mission to minimize the national dependence on conventional resources of energy by promoting renewable resources of energy in Pakistan. REAP is a nonpolitical, non profitable organization to serve the community without any discrimination of cast, creed, clan, gender or religious discriminations. Standing shoulder to shoulder with Ministry of Water & Power and AEDB.

### *3.2 Government Support Institutions / Educational Institutions*

Alternative Energy Development Board (AEDB) is the sole representing agency of the Federal Government that was established in May 2003 with the main objective to facilitate, promote and encourage development of Renewable Energy in Pakistan and with a mission to introduce Alternative and Renewable Energies (AREs) at an accelerated rate. The administrative control of AEDB was transferred to Ministry of Water and Power in 2006. The Government of Pakistan has inter alia mandated AEDB to:

- Implement policies, programs and projects through private sector in the field of ARE.
- Assist and facilitate development and generation of ARE to achieve sustainable economic growth.
- Encourage transfer of technology and develop indigenous manufacturing base for ARE Technology.
- Promote provision of energy services that are based on ARE resources.
- Undertake ARE projects on commercial scale (AEDB Act 2010)

## 4 SWOT ANALYSIS

### *4.1. Strengths.*

- Market gap between demand and supply
- Availability of skilled and qualified engineers.
- Farmers being dependent on solar panels for their irrigational purposes.

- Cheap source of energy.
- Incentives from the government for this particular sector.
- Availability of finance through financial institutions.
- Tax free import.

### *4.2. Weaknesses*

- Limited life span of solar panels
- Efficiency of solar panels (output)
- Space needed for installation.
- Awareness.

### *4.3. Opportunities*

- Introduction of new technology
- Lenient rules and regulations from government for registration.
- Increasing market demand for solar panels.

### *4.4. Threats*

- Fluctuation in dollar price.
- used solar panels imported from china
- cost of solar panels and batteries is still a major threat for this industry
- No quality control law exists.

## 5 INVESTMENT OPPORTUNITIES

The sector itself is very lucrative sector for investors in Balochistan as electricity is basic necessity for livelihood moreover agriculture sector being dependent on electricity while there's shortage of electricity in rural areas. Through market research it's observed that demand is increasing for solar panels and current suppliers can't meet the demand. Moreover private institutions and publics offices are taking initiatives to convert to green energy.

## 6 STRATEGIC RECOMMENDATIONS TO UPLIFT THE QUALITY & PRODUCTIVITY

- Private investors need to be mobilized by formulating a legal framework for investment in rural electrification.

- Demarcation of off-grid rural areas accompanied by energy resource maps should be created by the appropriate institutes, i.e., AEDB and PCRET. The data should be made available online with
- The government should finance rural areas where private investors find it difficult to generate significant profits. However, priority should be given to private investors in areas where solar PV systems are economically viable.
- Strict adherence to quality control and quality assurance standards must be observed for solar PVs systems. Standard operating practices should be developed for manufacturers and importers of solar PVs to restrict the sale of substandard solar PVs.
- Rural electrification programs should be initiated countrywide with key strategies and concrete action plans. The government should design supportive policies that provide incentives for both low-income communities and private investors.