Technical and Financial Analysis of the Solar Energy Harnessing in Karachi

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Abstract:
In this paper the technical and financial analysis was done for the extensive market survey relating to the solar energy harnessing in Karachi which is the biggest import, whole sale and retail market and follow as role model for most of other Pakistani markets. The severity of the electrical energy crises leads to the pressure on the individual user to find solutions for their long, load shedding hours. The marketing and advertisement exaggerated the Solar Photovoltaic panels as the best solutions which trigger the impulsive buying of solar modules and related accessories to produce the “free of cost” electrical energy. However, it was not proven as simple and free as it was marketed and advertised which leads to the tremendous loss of capital / investment and foreign exchange because of the major portion of solar energy related products are imported. In this work, several markets were survey and investigated i.e. Saddar, Bolten Shareshah, Qaidabade, Gulshan and Sohrab Goth where various brands of the solar panels were investigated by means of technical, financial and environmental based in order to optimize the policies and guideline for the investment, installation, operation and maintenance (OEM).

Keywords: Solar, irradiance, Photovoltaic, electronic waste, energy efficiency, infrared, Ultraviolet, visible.

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Introduction:
Sun emits energy in the form of electromagnetic radiations (see Fig. 1) in the range of $3.8 \times 10^{23}$ kWh per second. This makes the sun a biggest source or renewable and environmental friendly energy on the earth. Since, earth is surrounded by various atmospheric layers therefore, most of high energy radiations are reflected back to space and only ~ 51 % of radiations are absorbed at earth’s surface.
The solar radiations reaching the earth’s surface are ranging from 200 – 2500 nm (see Fig. 2) where 5 % are ultraviolet, 43 % are visible and 52 % are infrared radiations. The earth’s surface, buildings, rocks, water and vegetation are heated up due to absorption of solar radiation and re-emit some of the absorbed radiation as infrared radiations. The re-emitted infrared radiations are absorbed by water vapors and green house gases such as CO₂, O₂ including trace gases such as methane, halocarbons and nitrous oxides.

Several techniques are used since the ancient times to harness solar energy by using several techniques. Typically, the solar power reaching the ground in per square meter is around 1340 watts. Trees and vegetation need natural sun light for the photosynthesis which uses around 0.1 to 2 % of radiation to help the plant to grow. In this sense a typical solar panel is around 10 times more efficient to utilize the solar radiations for conversion in electrical energy.

Indeed, trees have several advantages as to reduce pollutants and their wood and residue use for the burning fuel as renewable energy resources. Using trees and their residue for cooking and heating which widely used even in developed countries and are found more environment friendly compare to the advance techniques. The wood and their residues can be easily transported and stored without any expert labor and sophisticated techniques. This mean the solar energy is stored in the form of the wood and their residues which is easier and user friendly compare to the sophisticated electro-chemical batteries and devices.

![Fig. 1: Distribution of the solar spectral radiation over the earth atmosphere.](http://jn.wum.edu.pk)
option specially in densely populated city like Karachi, where the concrete roof top are heated in hot summer days. The heat is stored in these concrete buildings and re-radiate after the sun sets and create elevated temperatures inside the building and their surroundings. Therefore, the roof top can be the ideal location for the solar energy extraction which will gives an additional benefit of the cooled rooftop due to the shadow of the solar installations.

On the other hand, Coal Power Plants are more efficient i.e. in the range of 25 to 32 % but their contributions to the environmental pollution are much higher and are less likely in use now. The efficiency of natural gas is reached up to 43 % and produces less pollution compare to coal power plants but these resources are need to mined, process, transported to the Location where they are burned to harness the electrical energy. In addition, the quality of these fuels is very important otherwise the conversion efficiencies drastically reduced which increases also the operation and maintenance (O&M) cost of the plant.

![Solar irradiance spectrum as a function of wavelength.](http://jn.wum.edu.pk)

**Fig. 2:** Solar irradiance spectrum as a function of wavelength.

In case of solar energy the phases for the fuel mining, processing and transportation are eliminated. This mean the input fuel cost is close to zero and the energy received is depends only on the weather conditions, installation, and O&M cost. Therefore, even with lower efficiencies, the solar systems attract the world leading manufacturing industries to invest in the research, development and fabrication. Few of the most commonly techniques to harness solar energy is reviewed briefly as follows.
The Concentrated Solar Power (CSP) system uses solar concentrator (mirrors or lenses) to converge the solar radiation over the objects (water or oil) to heat and run the engine and turbine to generate the electricity. Their efficiencies are greatly depending on the thermal properties materials and storage of the thermal energy which can be used later in night time or cloudy weather. Therefore, inclusion of thermal storage and advance materials increase their efficiencies in the range of 7 to 25%. Additionally, storing thermal energy in the reservoir is much cheaper than storing electrical energies in batteries. Therefore, CSP systems even work in cloudy weather or in night time by using their store thermal energy.

Real installed systems and several companies such as Sterling Engine System (SES) and United Sun System (USS) claimed the efficiency of 20 to 31% for Parabolic sterling dish and power tower CSP system. However, due the variation in solar power the actually observed efficiencies lie in the range of 7 to 20% for the Pilot scale Power tower. For the sterling dish system the efficiency was observed in the range of 12 to 25% for the demonstration scale project. SES later bankrupted due the drastic reduction in prices of the photovoltaic cell.

However their installation is not feasible for the domestic scale and often installed at utility scale which need large area and investment. However, it also jobs for the operational and maintenance activities and cater thousands of users with several mega-watt of power. Most of the CSP projects are installed in Spain.

The Photovoltaic cell converts directly the solar radiation to the electrical energy with the efficiency in the range of 10 to 20% for the purest silicon crystal. As it is evident in Fig. 2, that 52% of solar spectrum is consist of infrared regime while the visible spectrum part is around 43%. The silicon crystal has a band gap of 1.11, electron volt (eV) which uses only a fraction of light and converts it into electricity. In traditional first generation solar cell, silicon’s wafers were cut from the block and assemble in the form of the solar cells. For the second generation solar cell thin film technology was use for which increase the production with lower wastage materials.

Third generation a solar cell uses several thin film technologies to maximized efficiency of solar cell by utilizing maximum bandwidth of the solar spectrum. There are some highly advance solar cells with the efficiency of around 40% are available.
Similarly, **Photon Enhanced Thermionic Emission** is an advanced technique that harnesses the thermal and photovoltaic energy from the solar radiation. This enhances the efficiency of these cells by a factor of 10 to 15% which is indeed a major breakthrough to have solar cells with the efficiency in the range of 30 to 40%. However, these high-quality advanced solar cells are extremely expensive and are not viable for the commercial and/or domestic applications.

**Materials and method:**

The electricity shortage in Pakistan affects both industrial and domestic sectors, causing several problems. The load shedding problem was not properly identified, understood, and addressed at the national level, therefore, general public and industrial users try to cope up the problem by following some market trends and quick fixes. This results in chaotic conditions and a huge amount of money and time is wasted in the power sector.

Generally, the public trying to cope up with their problem by installation of the Photovoltaic Solar panels. In Karachi, several brands of solar panels are available as summarized in Table 1. The prices vary for several categories such as the domestic user who wants to buy solar panels can afford or try only 150 watt solar panels which have minimum cost of 5500 PKR for a single panel. Several sizes are available in these categories such as 20 watt, 50 watt, 150, 165 and 185 watts. Their prices change without following any formula or logical trend. Just as a rule of thumb, the 150 watt panel with several brand names, such as A0, A1 or A2 (see Table 1) was bought for 5500 PKR for a single piece in the mid of the year 2017.

The varying powers such as 150, 165 and 175 or etc are the market’s buyer-catching techniques when the seller observed that the buyer is reaching after a market survey and/or has some technical knowledge. But even paying higher prices for the brands as mentioned with codes i.e. A0, A1, A2, B0 Poly, B1 Mono and B2 Mono are seems to be performed in average similar with price range from 5,500 – 7,800 PKR. In fact, the panel’s bellow 6,800 PKR are seems to be overly used and/or not properly refurbished. Few Market sellers claimed that these are new panels but came in the boat/launches via sea to Pakistan therefore, their conditions are seems not good.

| S. No. | Solar Panel Brand | Power Watt | Volt Voc | Isc max A | Price PKR |
|-------|-------------------|------------|----------|------------|-----------|
| 1     | A0                | 150        | 15-17    | 9          | 5,500     |
| 2     | A1                | 150        | 15-17    | 9          | 5,800     |
| 2     | A2                | 165        | 15-18    | 9          | 6,500     |
| 2     | B0 Poly           | 150        | 15-18    | 9          | 6,000     |

http://jn.wum.edu.pk
Table 1: Details of the solar panel specifications and their prices in the market survey of Karachi in mid of 2017. The brand names are omitted and represented with letters A, B, C etc. Voc is short circuit voltage; Isc is maximum short circuit current. The specifications are shown according to the seller / supplier quotes / queries.

Meanwhile, it was not possible to check the power (wattage) of the panels at the buying instant. In fact, there were some expert technician who used volt / current meter to check the open circuit voltage (Voc) and short circuit current (Isc) of the panel by placing the panel in the full sun light which is possible only in the markets with exta open area such as Sabzi Mundi, Share Shah and / or Sohrab Goth markets. But in down town markets such as Saddar / Tower, where excess open area is not available in order to check it open circuit voltage (Voc) and short circuit current (Isc).

However, this method of checking Voc and Isc is greatly weather and environmental dependent because unless the solar panel is fully shine by the sun light it cannot delivered it full rate output. In Karachi the weather is normally filled with aero-sole and particulate matter with mixture of clouds made from the emission from the burning fuel such as petrol, diesel or coal [0]. Therefore, it was not possible to exactly check the actual power (wattage) of the solar panel on the spot. This is an advantage for the seller, because whatever the claim / specification were told for the panels, the buyer has option to testify it.

In fact, the exact amount of power can only be calculated if sun simulator / flasher will be used in order to calculate the maximum rated power for the studied panels.

Furthermore, several sellers have Mono-crystalline panels, which has better conversion efficiency from the Poly-crystalline solar panels. So even with lower sun shine time, the open
circuit output voltage (Voc) and short circuit current (Isc) for the Mono-Crystalline solar panel shows higher reading than Poly-crystalline solar panels, i.e. Voc up to 22 volts and Isc up to 8.5 A in normal weather conditions in Karachi.

On the other hand, Mono Crystalline solar panels are not good for the warmer areas because their operating efficiency and performance is greatly influence by the higher temperatures from 38°C. Therefore, Poly-crystalline solar panels are suited better for the Karachi and similar warmer climate. Indeed their conversion efficiency is lower than Mono-Crystalline Panels but better in long run.

Several markets were searched such as Sadder, New Sabzi Mundi (new vegetable market) at the super highway where the quality of solar panels were seem to be broadly diversified in terms of prices, brands and their specification as summarized in Table 1. The company’s name / brands are not shown in order to avoid conflicts and /or advertising any brands. Therefore, the brands are shown as A, B, C, D, E and F etc.

![Solar Panel Diagram](image)

**Fig. 3:** The history of the Mono-crystalline solar cell from 1954 to 2015 for the improvement in the efficiency and power (wattage) for the similar cross-sectional area of 65 x 39 inch = 2535 square-inch. The concept is re-drawn from the American Physics Society (APS), National Renewable Energy Laboratory.

The prices of the investigated solar Photovoltaic panels were ranging from 5500 PKR to 23,000 PKR for 150 watt solar while few of them claim for 165 Watts for the same price as shown with A1 brand name in
Table 1. The highest cost of 23,000 PKR was found for the panel which was claimed for their written specifications with the “cells” made in Germany.

The market survey was conducted again in the mid of 2020 and it was found the more watts i.e. 165 and 185 watts solar panels were available for the same price i.e. 6000 PKR without any proof for their claim specifications. This means even with the high inflation rate and pandemic due to COVID-19 their prices are even reduced. Since, the market survey was done at various occasions from last three years which gave us the following results / findings.

Generally, the available solar panels in Karachi’s market for the domestic roof top installation, can be broadly classified in two sizes in terms of dimensions, i.e. The bigger size solar (see Figure) whose dimension are around 1980 x 991 x 35 (thickness) millimeter which is claimed to be 350 watts.
Fig. 4: Global total percentage of Annual production of Photovoltaic modules in GWp by various regions where ROW represent the, Rest of World. The Blue color of years 2005, 2006 and 2007 is shown for tremendous increase in the China’s Market share.

The smaller size panel dimensions were 58.26 x 26.37 x 1.37 inches (1480 x 670 x 35 mm) and normally claimed to be 150 watts with Aluminum frame and tempered glass. The cross sectional area is 58.26 x 26.37 = 1536.32 square-inches. So the wattage per square-inches are 1536.32 / 150 = 10.24 square-inch area is required to extract one watt from the sun light. The weight is in the range of 10 to 12 Kg. Both panels 350 and 150 watts have written specification with short circuit protection for maximum current rating of nine (9) Amperes.

In case of the 150 watt solar panel, the open load voltage (Voc) were observed around 18 - 20 V which drop down to 14 to 12 V when the load was connected to the panel at the maximum solar irradiance with clear sky around 12:00 mid day. So the maximum DC (direct current) power of the solar panel can be written as follows.

\[
\text{Power (DC)}_{\text{max}} = \text{Voltage} \times \text{Current}
\]
\[
\text{Power (DC)}_{\text{max}} = 14 \times 9 = 126 \text{ W}
\]

The power was decrease further when the drop voltage of 14 V at 9A was considered as follows.

\[
\text{Power (DC)}_{\text{max}} = 12 \times 9 = 108 \text{ W}
\]
Thus the maximum rated power from the claimed 150 watt panel was lied in the range of 126 to 108 watts as observed in our study. It was observed that at the maximum current rating of 9 A the power lines breaks / burnout more often in several panels because of the lower load bearing capacity of the current circuit wires tracks which ultimately causes increase maintenance cost of the systems. Thus it was found save to operate these panels in the current range of 7 - 8 Amperes, which ultimately further decrease the output power of these 150 watts panel to the 84 to 98 watts.

So the actual observed unit power (wattage) per square inch that can extract from the brands names A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, B<sub>0</sub>-Poly, B<sub>1</sub>-Mono, B<sub>2</sub>-Mono (see Table 1) was in the range of 18.28 – 15.67 square-inches. This is in contradiction with the details shown in Fig. 3.

The cross-sectional area required to extract unit wattage from sunlight in 1954 was 2535/20 = 126.75, which is increased to 12.67 square-inches in 2012 and 9.56 square-inches in 2015. Therefore, this seems that these panels are either developed in 2012 or earlier or maybe they are used for many years which decline their conversion solar efficiency to such a lower level.

Similarly, in case of the bigger panel which often claims for the 320 - 350 watts have dimension of 77.79 x 39.01 x 1.37 inches as shown with brands names of G-Poly (320 watts) and H-Mono (350 watts) in Table 1. The cross-sectional area is 77.79 x 39.01 = 3034.58 square-inches. It was observed in several installed operating systems that their open circuit voltages (Voc) for G-Poly (320 watts) was in the range of 44 - 46 V and for H-Mono (350 watts) in the range of 44 - 48 V at full sunny and clear sky view in Karachi. The open load voltage (Voc) drop to 34 to 35 V, once the load is connected.

So, their actual observed maximum rated DC output power was lies in the range of 272 - 315 watts. The cross-sectional area use for extracting unit wattage is 11.15 – 9.63 square-inches which shows these panels belongs to the bit higher family as developed in the year 2012 to 2015. The cost for bigger panels which are claimed for 320 as shown in Table 1 with G (320 watt) and H (350 watt) are available for the price of 10,000/- PKR.

The advance technologies such as **Half-Cut**, the solar cell cut into half by laser in order to make two parts of the cell. The power lines are taken out from the middle of Panel which ultimately decreases the I<sup>2</sup>R losses with only a slight increment of the efficiency in the range of 1 to 3 % [0, 0].
Similarly, the **PERC** (Passivated Emitter and Rear Cell / Contact) is another advance technology in which a dielectric passivation layer is fabricated on the rear side of the solar cell which enhance it efficiency of the cell up to 22% for the industrial scale production. In fact, it was developed in the lab scale in 1989 but took more than twenty years for the industries to take over and start large scale productions. It contributes to the 10% of the current market shares and the market trend / analysis shows it may increase to 35% of market share [0, 0, 0, 0].

Several solar brands in Karachi’s market claimed for their solar panels fabricated with combination of both, the “Half–Cut” and “PERC” Technologies and therefore, the panel has much higher cost up to 16,500/- PKR for 150-165 (shown as brand E in Table 1) and for 350 – 400 watts solar panel the cost increases up to 25,000/-PKR as shown with brand name E. This means more than double amount of investment capital is required for the installation of Half-Cut – PERC solar panels.

![Fig. 5: Global Cumulative percentage of Photovoltaic modules installation by region. The installed market volume of the China is 36% according to year 2019.](http://jn.wum.edu.pk)
Most of the sellers connected directly a DC pedestal fan of around 30 to 50 watts to the solar panel of 150 watts and placed outside their shop and face manually towards the sun. This impresses the domestic user by observing the direct conversion of solar light in the form of electrical energy which is using operating the fan. Indeed this fascinates the general public which leads to the **impulsive buying** and losing money. This is irrespective, whether 150 watt solar panel is driving a DC fan whose power demand is in the range of 30 – 50 watts. Furthermore, there were no a satisfactory answers about question their electrical power output as in their claim specification, thermal degradation coefficient, declination in yearly power output, warrantees/guarantee claims and services.

Majority of public could not resist to their **Impulsive behavior** and bought the whole setup which contains; a solar panel (100 – 150 W) and a DC pedestal fan with the connecting wires. The cost was; solar panel (150 W) is 5500 PKR, pedestal DC fan (metal blades) cost 2500 PKR with connecting wires depending the length of solar panel and the pedestal fan length which cost around 500 PKR in the mid of year 2017.

Thus for around 8,500 PKR, one and / or two person can get fan’s air during the sun shine hours. The fan speed shows maximum during 12:00 AM to 4:00 PM in hot summer bright sunny days in Karachi unless no high-rise building would be present which can shadow the solar panels at some hours. Otherwise the speed of the pedestal fan reduced which leads to the lower air flow.

However, when the quality of solar panels were investigated in details by asking proper logic / proofs for their claimed specifications in the market executed in Sadder, Share shah and their neighboring markets. Several varieties of solar panel were found which claim to be the new, German cells and original from the company outlets.

In market, it is common trend to ask more money for the un-justified / proofs / claims and guarantees. Most of the contractor / dealers claim that, the panel which cost of 6000 PKR for 150 watts is sale for higher prices up to 15,000/- just for their claims and guarantees. Thus once the user buy the panel he cannot show / proof to the seller and /or contractor that their supplied solar panels are not performing up to their claimed standards and specifications.

Indeed, the market shares were widely capture by USA, Japan and Europe from the year 1997 to 2008 but later their market’s shares were started to decline considerably and leaving only a
fraction of the market shares until the year 2012. Meanwhile it can be seen that the Chinese manufacturer start to grow considerably from the year 2005 (see Fig. 4) and shows doubling of their market shares (as marked with blue color) in the years 2006 and 2007 and reaching up to 65% in the year 2019.

Mostly, in Pakistan, the seller/contractor claim their expensive panels for the original German or Japanese quality and manufacturer in these countries. However, it is not reasonable to accept their claim because it can be seen in Fig. 4 the market shares of the Japan, Europe and USA were widely suppressed and replaced by the Chinese manufacturers with market capital of around 65%. Only the claims can be true in the case if these panels were manufacture earlier than the year 2007. Therefore, these panels may be used and/or decommissioned/scrap and might be near its end of life cycle.

In this case it is strongly suggested that not to pay extra money for their claim of made in Europe and/or Japan. Indeed the percentage of ROW’s (Rest of the World) market shares are increased up to 23% in the year 2019 but China also contribute to 36% of the world’s cumulative installed solar panels as depicted in Fig. 5. This mean the China has its own consumer market which might not be intruded by the ROW manufacturers. This also leads to the drastic reduction of the prices for the solar PV modules due to the lower purchasing power of the Chinese end users.

The extensive market survey leads to ambiguous results and for even scientific/technical person it was not easy to decide which solar panels and their accessories are good to buy in order to solve our problem. Hence forth we also consulted to several expensive contractors/sellers, who offer turnkey solutions for solar photovoltaic power systems but most of them were not able to satisfy us to invest money in such systems.

Most of them claim for 10 to 20 years warrantee with 80% rated output power but even after few years the company or the seller were not found. Most of them were either wind up their business to some other fields or to other brands names. Therefore, the long term grantees i.e. above five years was not found a lucrative benefit in order to invest huge amount of money to achieve better quality.
Similarly, most of the domestic users with installed higher cost solar photovoltaic power systems are not happy with their systems due to under-rated performance and without support from their respective companies / supplier / contractor. User and the companies are blaming each other for the under rated performance for not maintaining properly their installed / fabricated systems.

Also, several streets light’s coupled with solar panels and battery backup were installed in big cities at various locations which are now under performed or even completely become trash. Meanwhile it is not easy to claim / Guarantee the contractor or the supplier because of the various complications associated with the solar panels, batteries (Lead acid, or Li-Ion), inverters along with the environmental issues such as aero-soles, dusts, low rains, temperature ranges. These issues were not address scientifically before signing the contracts with companies / supplier and left various loop holes / voids and which go against the end user.

Similarly, the Quaid-e-Azam Solar Park is a 100 MW Photovoltaic Power plant at the Bahawalpur, Pakistan which spanned over around 500 acres as shown in Fig. 6. The cost of the installed project is around $ 131 million in 2015 when USD exchange rate was 103 PKR gives around an investment of 131,000,000 x 103 = 13,493,000,000 /= PKR, i.e. 13.49 billion rupees. However, the plant is producing around 18 MW due to various hurdles, i.e. higher temperatures,
low raining, high dust count along with their cleaning / washing water and labor cost affects it smooth operation and with high production cost, i.e. USD 1.31 million per mega watts.

Besides the reports and investigation reported in the news papers as cited above in paragraph from the reference numbers 0, 0, 0, it would be helpful to make some concrete scientific and technical investigations to address the ground realities and hurdles faced by Quaid-e-Azam Solar Park. Indeed, this will help to find the solutions for these hurdles and optimized the performance as well as to make upgrade policies and guideline for the future’s investment in such huge projects.

It is also important to note that, more than seven hundred companies are shut-down / bankrupted / defaulter since 2011, such as Solar Fabrik (German), Masdar PV (German), Soitec (France), RSI (China), Solibro (China), HelioVolt (Korea), Green Solar (Australia), etc are few of them. This can also be depicted from Fig. 4, where the market shares of the European, USA and Japanese companies drop tremendously after 2009.

Even in developed countries such as Australia, have several millions of installed solar system which are called “Orphan”, because their companies are shut-down / bankrupt. Their companies prefer to file bankruptcy instead of replacing huge amount faulty systems rather to invest more money for their payback claims /warrantees and /or guarantees which ultimately lead to the tremendous financial loss from the end user.

Furthermore, the environmental hazards regarding the solar waste disposition / dumping and recycling is getting a serious issue. This can be depicted from Fig. 7 that the material throughput for the Solar Photovoltaic (PV) modules is much higher in comparison other energy resources for producing per unit of TWh (Tera-watts-hour). The nuclear material throughput is seems negligible while hydro power plants has Concrete as s major represented as grey region in the bars.

The solar PV has Steel (dark blue region) as a major material preceded by Cement (light-blue regime) and Glass (light- green regime) with others which also contains hazardous / toxin such as lead (Pb), cadmium (Cd), Copper-Indium-Gallium-Selenide (CuIn_{(1-x)}Ga_{(x)}Se_{2}), hexafluoroethane (C_{2}F_{6}), etc. These materials needed to be recycled before contamination otherwise they can pollute the underground water and resources.
In fact, it is not worth to discuss about the environmental hazards related to the manufacturing and production processes because Pakistan’s solar market is heavily based on the imports of the refurbished / used and / or damage solar modules which are cheaper and meets the buying power of the Pakistani end users.

The international Renewable Energy Agency (IRENA) estimated around 250,000 metric tones of the solar Photovoltaic waste expectation in the year 2016 [0, 0]. In the earlier loss scenario several installed PV modules couldn’t perform according to their projected specification and reaches their End of life” earlier than 25 years. It was observed that the solar panels whose prices are below 7,000 for 150 watts and for 10,000 for 350 watt panels might be refurbished and /or near their End of life.

![Graph showing material throughput for major energy sources per TWh (tera watt hour) in comparison with Solar Photovoltaic (PV) modules.](http://jn.wum.edu.pk)

**Fig. 7:** The material throughput for the major energy sources per TWh (tera watt hour) in comparison with the Solar Photovoltaic (PV) modules, where the Nuclear energy has minimal material throughput.

Indeed their cost are lowered and are installed with some electrical output which can make the end user happy for their nominal / electrical output but after sometimes most of these modules perform with much lower efficiencies and becomes useless / scrap which needs to be de-commission, recycle and dispose.

However, recycling is an expensive process therefore, in most of the poor / under-developed countries, the Solar PV module’s wastes are mixed with the ordinary scraps of electronics / electrical devices. The materials such as steel, Aluminum and /or glass are separated by manually
by using labor while the rest is dumped to the landfills where it is burned by the poor peoples to extract their residue materials (such as copper) which results in the emission of toxic gases / chemicals and residues. Therefore, solar waste management is very crucial for Pakistan in order to dispose-off the faulty / damage solar panels and their accessories without harming the environment.

Conclusion and Outlook:

The extensive market survey was performed at several times specifically in 2017, 2019 and 2020 which shows chaotic condition of the solar panels available in Karachi’s market. The prices vary tremendously from 5,500 to 23,000 PKR for 150 and 350 watts panels without proper proofs / guarantee for their claim specifications. Several installed high paid solar panels also under-performed leaving them Orphan after few years which means higher investment for better quality may not work as well.

The solar energy sector is un-regulated even in developed countries and cause severe financial damages to the end users such as cited in the reference where most of the big companies file bankruptcy instead of paying back or replacing their faulty solar systems. Also, these faulty solar panels are needed to de-commission / dissemble and ship to their waste dumping and /or recycling locations would charge extra financial investment.

The environmental friendly disposition of solar Photovoltaic panel is getting crucial environmental issue. Only European Union made legal rules which enforce the manufacturer to collect, recycle and dispose-off their developed products in the environmental friendly ways. Therefore, it might be good to avoid the import of the refurbished, low quality and / or under rated solar PV modules should be avoided in order to prevent our environment from the associated hazards and toxins.

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