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# A sustainable integrated water and energy production plan to meet future requirements-A case study of Pakistan

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**Abstract**

Due to increasing demand of fresh water; water resource management is undergoing a major paradigm shift because of limited resources of water. In 2015, water scarcity was mentioned as largest global risk by World Economic Forum. If water resources are not managed properly, about 30% to 40% of world population will be affected from shortage of water by 2020. In recent years certain cities/states of Spain, Australia, Israel, Cape town, even USA had faced scarcity of water. The same problem is expected to be faced by Pakistan by 2025. An Integrated Water Resource Management (IWRM) approach is required to resolves this serious issue. IWRM focuses on protection of available water resources and exploration & development of alternative water resources. This paper describes Reverse Osmosis of sea water as an alternative water resource. One of major issues in introducing Reverse osmosis plant in Pakistan is cost overruns. Financial analysis of power consumption for plant along with membrane construction and maintenance make its installation very difficult even impossible for developing countries like Pakistan. A method for installation of reverse osmosis plant by economizing power factor to reduce process cost has been developed. For this purpose, electricity is generated by introducing wind turbines and solar panels along the coastal belt of Pakistan. This reduced fresh water production cost to 0.069 rupees per gallon along with electricity supply to Karachi at a production cost of 0.28 rupees per watt (1 PKR=0.0081 USD).

**Keywords:** Water, Energy, Climate

## INTRODUCTION

Water is essential for all habitants of earth. About 70% of earth is covered with water but fresh water is only 3%. Remaining 67% percent is salted water and cannot be use directly for human activities. Out of 3% of fresh water resources two third is located in ice caps, hailstones and glaciers. Remaining 1% is ground water (Gleick, 1993). So, it is very important to manage this little amount of useable freshwater to ensure availability of water in future. Improper management of these natural resources resulted in acute shortage of water that affected about 61% to 89% population of North Africa, South Asia, Middle East and South Asia in 2000 (Kummu et al., 2016). In spite of increasing world population according to prediction, stress on water resources is increased. Dereliction management of water resources is responsible for this level of stress. Cape Town, is a modern-day example of dry land where increasing scarcity of water is making life challenging. Climate change and mismanagement of natural resources lead Cape Town's mayor De Lille, on 8 January, 2018 to warn that by April 29, 2018 Cape Town's dam will have water level less than 13.5% and people will have to use 25 liters per person per day. April 29, 2018 was announced as "Day Zero". (Baker, 2018). But natural climate changes and proper management of water saved Cape Town from facing Day Zero. Water scarcity is not an issue for only developing countries. Developed countries like United States of America also faced an overbear drought of water in California state from 2011 to 2016. In 2014, USA Drought Monitor mentioned that California had never seen drought of this severity over 1200 years. In the same year, The Nature Conservancy declared Los Angeles among one of the most water stressed large city in the world (Williams, 2018). According to the recent research, out of 7.6 billion of world population 0.5 billion people are affected by water scarcity all over the year, 4.0billion people have to face sever water shortage for one month every year (Mekonnen and Hoekstra, 2016). This implies that 6.5% of world's population is confronting absolute water shortage and 52.6 % of world's population has to face water shortage for one month every year. Population is increasing at the rate of 83 million people per year (United Nations World Population Prospects Report, 2017) that predicts worsen state of water drought if water resources are not managed properly. Water scarcity is a global issue. In report of 2015, WEF listed it among top ten global perils (Cann, 2015) that will have adverse effect over decade.

Water scarcity effect all continents. In report of 2017, WEF mentioned that about half of largest cities of world are facing the problem of water shortage (Boltz, 2017). The result of a joint report led by World Health Organization (WHO) and United Nations Children's Fund (UNICEF) shows that about 1.1 Billion individuals have no access to safe water and using contaminated water (WHO/UNICEF Joint Monitoring program, 2001). Table 1 shows the areas and percentage of people using contaminated water.

United Nations predicted that by 2025, 22% of world population will be living in areas of absolute scarcity (Tiboris, 2018). Water supply of many countries like Pakistan and Egypt is threatened. UN climate change report stated that Himalayan glacier, the source of biggest network rivers of Asia including Indus and Ganges will disappear in 2305 (Sundaresan et al., 2013).

Along with water crisis, energy crisis is also one of an important global issue. This paper proposes solution to water crisis and to eliminate of energy issues. Energy crisis means preeminent demand of energy consumption for population with limited natural resources that takes thousands of years to replenish the source. World has faced worse energy crisis from 2003 to 2008, known as 2000s energy crisis. In 2003, midterm price of crude oil was $ 25/barrel. Price of crude oil was on peak in 2008 and market settled at $ 108/barrel (Wilen, 2008). Developed counties have also faced energy crisis. For example, during 2000 to 2001 California faced a worst electricity crisis known as Western Europe Energy Crisis. In April 2000, per unit cost of electricity was about $ 30 and increased to $ 100 by June 2000. In November 2000 California population purchased a unit of electricity for $ 250 to $450 (Sweeney, 2002). In 2004 another energy crisis was faced by Argentina. Before 2004, Argentina was completely relying on its natural gas resources, industries and electricity production plants were also utilizing natural gas resources even surplus gas was supplied to Brazil and Uruguay. In 2004, Argentina was using all resources of energy at full capacity having no storage for emergency and could not meet increasing demand of energy. This situation created so devastating condition that heavy industries had to face about 20% electricity shortage in a day than normal. As a result, by winter 2004, government had to resign the contract of supply of natural gas to Brazil and Uruguay. Consequences of this shortage was not only faced by Argentina by also by Brazil and Uruguay (Honoré, 2004; Atlas World, 2017). So, the only way to survive in global village is to manage natural resources and use alternative methods of energy production.

**Table 1.** Percentage of People using contaminated water.

| Areas using contaminated water | Percentage of People |
|---|---|
| North Africa | 4% |
| Europe and Central Africa | 4% |
| Latin American | 6% |
| South Asia | 19% |
| Sub-Saharan Africa | 25% |
| East Asia | 42% |

*Source: WHO/UNICEF Joint Monitoring program, 2001.

**Table 2.** International Standard About per capita availability.

| S. No | Per capita Water Availability | State |
|---|---|---|
| 1. | 1,700m$^3$ or more | Normally required |
| 2. | 1,000m$^3$ to 500 m$^3$ | Water Scarcity |
| 3. | 500 m$^3$ or less | Absolute Water Scarcity |

Source: (Jenkins & Sugden, 2006)

## A Case Study of Pakistan

In spite of having some of world's longest glaciers outside the polar region like Hispar, Siachen and Biafo Pakistan is expected to have a drought by 2025 because by then population of Pakistan is expected to be 227 Million (Pakistan 2025: One Nation-One Vision. 2018). To meet water demands of 227 Million people Pakistan has to not only manage its water resources but also develop alternative water resources.

The main resource of water for Pakistan is Indus river and its tributaries that make fluvial water system by collecting water from glaciers, ice caps and rivers of Himalayas. About 56% of Indus river lies in Pakistan (Rehman and Kamal 2018) that brings about 189.95 BCM to Pakistan. Most of Indus water, almost 128.2 BCM is used in irrigation with 6% water loss during supply, remaining 26% water flows to sea (IUCN: World commission on Dams) Secondary sources of water for Pakistan is Rain water and ground water. Pakistan has high reliance on groundwater. In 2015, Pakistan was mentioned among top five highest users of ground water. It is estimated that Pakistan has more than 74 BCM ground being extracted at a rate of 65 km$^3$/year (Arif, 2018). Pakistan, on average, has dry climate and rain fall less than 250 mm of rain fall per year (Pakistan Meteorological Department, 2009). On an average Pakistan have water resources of 217.5 BCM (Kahlown and Majeed, 2003). According to census of 2017, population of Pakistan is about 207 Million (Pakistan Bureau of Statics, 2017). That implies per capita availability of 1050 m$^3$. This per capita availability will reduce to 958m$^3$ by 2025 that shows water scarcity as per international standards as shown in Table 2.

According to the report of Statistical Yearbook for Asia and the Pacific (2013), Pakistan is one of the top 10 countries confronting absolute energy crisis. About 1300 million of world population is living without electricity. Out of this, 858 million people are living in 10 Countries. Pakistan is one of them (Dawn, 2013). These crises are not only affecting economy of Pakistan but also creating unrest in people. In 2008-2009, Pakistan faced an electricity shortage of 4025 MW because demand of electricity was 19080MW with supply of only 15055 MW. In 2010 this shortfall increased to 5529 MW (Dar et al., 2013). To eradicate this shortfall 6 electricity plants in 2015, 12 plants in 2016 and 6 plants in 2017 were installed (Pakistan Economic Survey, 2016-17). But this could not meet growing energy requirements. According to present data, generation capacity of Pakistan is predicted to be 22500 MW (About Pakistan, 2017), according to Ministry of Water and Power actual production is only 15400 MW to 15700MW (Dawn, 2017) due to inefficient power plants, improper maintenance and poor management. As a result, Pakistan has to face a short fall of 7000 MW in 2017. International Energy Agency (IEA) projected a demand of about 49000 MW by 2025 (Zeb Y, 2017). If current production rate of electricity will not change a short fall of 30500 MW will occur by 2025 (Pakistan, 2017). To meet these increasing energy demands Pakistan has to shift its reliance from nonrenewable resources of energy production to renewable sources of energy production. Figure 1 show reliance of Pakistan of different sources to produce energy.

The aim of research is to propose a sustainable solution to prevent Pakistan from predicted water and energy crisis. A large size reverse osmosis plant of capacity 3600 MGD along with cost analysis is proposed to meet water requirement of population. For energy requirements of plant an electricity generation plant is also introduced. Wind turbines and solar panels are proposed to install along the costal belt of Pakistan. After providing electricity to RO plant, excessive electricity generated by electricity generation plant will be utilize to meet energy requirements. The proposal promotes IWRM and also in accordance with terms and conditions of International Environment Law, UN Environmental Program (UNEP), Integrated Water Management Institute (IWMI) and other leading organizations of environment.

Pakistan, 6th most populous and 33rd largest country by area, located in South Asia, at GPS coordinates of 30.3753° N, 69.3451° E. Karachi is most populous city of Pakistan located at GPS coordinates of 24° 56' 46.3848'' N, 67°0' 20.2140'' E and is considered for this case study. Pakistan has four seasons. December to February is cool and dry winter, March to May is summer season, June to September is monsoon rains period, October to November is retreating monsoon period and driest part of the year.

## BACKGROUND

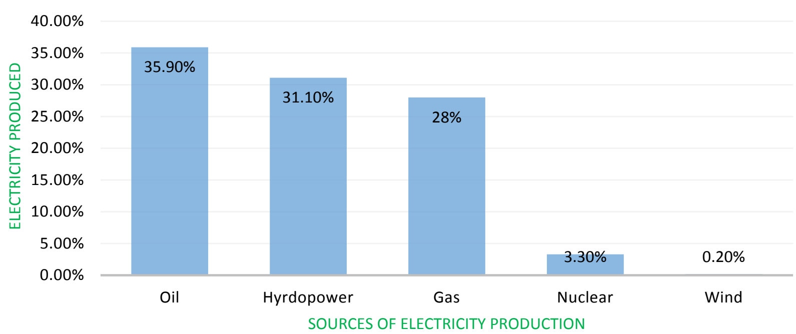
### Integrated Water Resource Management (IWRM)

Global Water Partnership (GWP) defined Integrated Water Resource Management (IWRM) as a process which aggrandize the strategic development and management of water, land and other natural resources, to optimize the economic and social welfare in an impartial manner without having adverse effect on vital ecosystems. In 1992, International Conference on Water and the Environment held at Dublin. In this conference water ministries and experts decided to take adequate steps to eliminate water scarcity from world. In the final report of this conference IWRM was recommended on following basic principles as basic framework of IWRM.

- Social egalitarianism: to provide freshwater to all people by managing water quality
- Economic viability: water supply to world with available financial resources
- Ecological Sustainability: The aim of not disturbing aquatic ecosystem

To save world from water scarcity integrated water resource management is an imperial tool. IWRM is a framework that collaboratively decides the goals of water management and also coordinates use of different techniques and instruments to achieve these goals. IWRM includes

- Water Demand management




Source: Energy Year Book-2013

**Figure 1.** Percentage share of different sources in Electricity production for Pakistan

- Protection of available water resources
- Development of sustainable alternative water resources

### Alternative Water Resources

Nowadays, world is facing challenges related to quality and quantity of freshwater. Increasing population is a threat to water resources because available limited water resources are being depleted at high rate. The best way to manage stress on available water resources is to use alternative resources of water to meet demands of growing population. A list of some alternative water resources is following.

- Reclaimed waste water
- Rain water
- Storm water
- Air handling condensate
- Water discharged from water purification System
- Sea water Desalination
- Gray water

### Reverse Osmosis

RO is a water purification technique in which water is purified by passing through a semipermeable membrane in a direction opposite to natural osmosis by application of hydrostatic pressure which is always greater than osmotic pressure. RO is used is both industrial processes and production of portable fresh water. Reverse osmosis is most economic and energy efficient method of water purification.

### Available Methods

There are many methods of water treatment and purification. Some of them are described below.

### Distillation

Distillation a simple and one of an effective method of water treatment. In this process first water is boiled then vapors are condensed to get purified water. When water is boiled microbes, bacteria, viruses and protozoans present in water are killed before reaching to boiling point of water. After a series of experiments Wilderness Medical Society (WMS) of USA concluded that all pathogens like bacteria, viruses and protozoans present in water are killed within 30 minutes when temperature raised above $75^0$C, and within a few minutes when temperature is raised above $85^0$C (Curtis, 1998). This pathogen free steam is condensed in another tank. No doubt, water distillation is an effective method of purification but it cannot be adopted at large scale. Because for phase change process much more fuel and time is required that make it economically inefficient. Moreover, this method cannot remove substances like oils and alcohols that have melting point lower than $100^0$C. So, this method of water purification cannot be introduced for supply of water to population of a country.

### Filtration

It is one of an oldest method of water treatment. To purify water different microbes are filtered using filtration medium. Selection of filtration medium is a big challenge in adopting this technique of water purification. Filter paper requirements for different microbes are described below.

- Protozoa required filter paper of size 5 microns or large
- Bacteria required filter paper of size 0.2-0.5 microns
- Viruses required filter paper of size 0.004 microns

In spite of being one of an oldest method of water purification, it cannot be adopted to fulfill demand of a country because filter paper clogged due to suspended particles and require high maintenance that make it economically ineffective.

### Chemical Method

Different chemical like Chlorine, Alum and Iodine are being used for water treatment. Chlorination is easiest, inexpensive, and most effective method of killing bacteria and viruses. But chlorination also has some drawbacks. It doesn't kill all parasites and formation of organic compound make its use hazardous for long time. Moreover, chlorinated water can be store only for a short time. Iodine purified water contains lower amount of Iodine in purified water whose long-term use stimulate thyroid activity. These precarious impacts of chemical make it ineffective when installed at large scale. Algaecides like Cupper Sulphate ($CuSO_4$), Benzalkonium chloride ($C_6H_5CH_2N(CH_3)2RCl$) are also used as modern chemical method of water purification. It effectively removes all types of algae such as blue and green algae but it cannot be adopted at large scale for permanent use because these Algaecides cannot remove hazardous effect caused by algae before death.

### Desalination

The process of removing minerals and salts from water is called desalination. Usually, desalination is adopted in dry countries like Australia which rely on desalination of rain water. The different methods used for sea water desalination are Multistage Flush (MSF), Multi Effect Destination (MED) and Mechanical Vapor Compression (MVC). In 2015, International Desalination Association reported that currently 18626 desalination plants are being operated worldwide. These plants produce 22.9 Billion US gallons of fresh water per day to meet water demand of more than 300 million people (Lisa, 2012). Desalination is largely used as alternative water resource but this process is not very economic.

## MATERIALS AND METHODS

This paper incorporates with development of sustainable alternative water resources and exploration of renewable energy resources. This paper approaches the solution of forecast water scarcity by installation of reverse osmosis plant as sustainable alternative water resource. This method is also adopted by some countries like Spain, USA, Australia and Israel. To meet energy requirements of RO plant and to deal with predicted energy crisis wind power plant and solar power plant is proposed to install. The quick fix of water and energy crisis is described below.

### Proposal for Water Production

A reverse osmosis plant is a water purification plant that works on the basic principal of reverse osmosis. Contemporary reverse osmosis is most energy efficient method of water purification because no phase change process takes place and only 3.84 kWh/$m^3$ energy is required (Ghiu, 2013). Reverse osmosis is economic, efficient, and fast-growing technique of water purification.

In this paper proposal of a large-scale reverse osmosis plant is presented that produce 400 million gallons of high quality fresh water per day.

A reverse osmosis plant consists of four major processes. These processes are described below.

### Pre-treatment

Selection of pretreatment depends upon salinity and turbidity of sea water. Pretreatment is performed to make water compatible with membrane. Salinity of sea water at Karachi coastline varies between 1.7 ppm to 7.8 ppm and turbidity varies between 2.9 NTU to 43 NTU. Sea water from 5 different locations was taken as sample and observed. Results are given in Table 3.

Dual media filter is used to remove suspended particles in the sea water such as dirt and iron particles. After it semi filtered water is passed through activated carbon filters to remove ordure, color and organic compounds from sea water.

### High Pressure Pumping

Pretreated water is pressurized by a pressure pump according to compatibility and capacity of RO membrane. For brackish water pressure is maintained between 250 psi to 400 psi and for sea water pressure should be 800 to 1000 psi.

### Semipermeable Membrane

High pressured pretreated water is passed through semipermeable membrane. Membrane should be selected in such a way that it should stand pressure of water. This membrane allows water to pass through by rejecting salts that are removed time by time. The product of this membrane is fresh water. Exactly 100% salts are not removed in this process because no process is so much efficient. Produced water also contains 100 ppm to 400 ppm of dissolved salts. This membrane is heart of reverse osmosis plant. There are many types of semipermeable membranes; most commonly used membranes are two as described below.

**Table 3.** Salinity and Turbidity along costal belt of Pakistan.

| Sr. No | Locations | Salinity in ppm | Turbidity in NTU |
|---|---|---|---|
| 1. | Gulshan e Johar | 2.4 | 35 |
| 2. | Malir Hut | 1.7 | 13.9 |
| 3. | New Karachi | 7.8 | 8.9 |
| 4. | Clifton | 3.9 | 2.9 |
| 5. | Quaid Abad | 2.0 | 29 |
| 6. | Mahmudabad PECHS | 3.2 | 43 |

- Spiral wound
- Hollow fiber

Nowadays partially semipermeable membranes are used in reverse osmosis plant. These membranes perform an additional work as washing of membrane. The rejected water moves in downward direction washing salt on membrane. Then this downstream water is pumped up to pass it through washed membrane.

Maintenance of membrane is an important factor. It depends upon salinity of water that how many times membrane has to wash. Normally, membrane is washed 3 times a year. This cleaning may be air flush cleaning or chemical cleaning. In air flush cleaning air is passed through membrane that causes high turbulence to wash membrane. In chemical washing first membrane is dipped in a solution of hydrochloric acid, chlorine and hydrogen. Then for rinsing high pH and low pH cleansers are used. Low pH cleanser for scaling removal and high pH cleanser for foul smelling removal.

### Post-treatment

Semi-permeable membrane effectively removes all pathogens. Post treatment is a secondary treatment of water so that if water contains salts and pathogens due to downstream or membrane inefficiency they may be removed effectively. For this purpose, UV radiations of wavelength 254 nm are incident on water. Special lamps are designed that provide high amount of energy at this wavelength that kills germs effectively.

### Specifications of RO plant

Table 4 describes specifications of RO plant:

**Table 4.** Specifications of RO Plant.

| Sr.No | Component | Description |
|---|---|---|
| | Initial Water feed pump | Type: Centrifugal<br>Flow rate: 200 MG per hour<br>Average efficiency: 89.5<br>Power: 27704 hp |
| | Dual Media Filter | Type: Multiple port<br>Capacity: 200 MG per hour |
| | Activated Carbon Filter | Capacity: 200 MG per hour |
| | Pressure Pump | Operating Pressure: 1000 psi<br>Capacity: 200 MG per hour |
| | RO membrane | Type: Spiral wound module<br>Capacity: 200 MG per hour |
| | UV System | Capacity: 180-200 MG per hour |

## Maintenance of RO plant

- Initial water feed pump (checking and servicing)
- Dual media filter (cleaning, checking & replacement)
- Activated carbon filter (cleaning, checking & replacement)
- Membrane (checking & replacement)
- High pressure pump (checking and servicing)
- Water lines (checking and servicing)

## Annual Production of Plant

Per hour production=180 million gallons

Working hours in a day=20

Working hours in a year=(365) (20)

=7300 hours

Total production per annum=(Per hour production) (Working hours in a year)

=(180 million gallon/hour) (7300 hours)

=1314000 million gallons

=4.97 BCM

## Energy Requirements of Ro plant

For reverse osmosis plant 3 to 10 kWh electricity is required for 1 $m^3$ fresh water productions (Dashtpour & Al-Zubaidy, 2012). Taking an average 6.5 kWh/$m^3$ all calculations are performed.

Total Energy required = (energy for 1 $m^3$) (total annual production)/(working hours)

= (6.5 kWh/$m^3$) (4.97 billion $m^3$)/(7300 hours)

= 4425.342 MW

## Proposal for Energy Production

Pakistan has a limited natural nonrenewable energy resource. These resources are depleting with increasing population of Pakistan. The best way to meet demand of energy is to use renewable energy resources like wind and solar. This paper proposed an energy production plan to supply electricity to RO plant and to meet future demands of Karachi.

## Wind Turbine Plant

The length of costal belt of Pakistan is 1100 Km. But wind zone suitable for installation of turbine is 1050 km, 250 km in Sindh and 800 in Baluchistan (Baloch et al., 2017). Additional 4 Km along width is also covered that make a total of 1050×4 $km^2$ area suitable for installation of wind turbines. For wind plant three blade turbine AN Bonus 600/40 MKV at height of 50 m is to be installed for theoretical analysis whose specification is tabulated in Table 5. Remaining area will be a solar park.

The distance between two adjacent turbines of a row is 5D i.e. 220 m. The distance between two adjacent rows is 10D i.e. 440 m. Total number of installed turbines will be equal to 42948. Pakistan Meteorological Department estimated wind speed at coastal belt of Pakistan. National Renewable Energy Laboratories (USA) confirmed the report by wind mapping of Pakistan. According to this report average speed is 5.4 $ms^{-1}$ to 6.2 $ms^{-1}$ which is classified as marginal resource of energy. According to rule of thumb 1 $km^2$=5MW (Baloch et al., 2017). So, total production of wind plant will be 5×4200=21000MW.

## Solar Plant

Total area of park is 200 $km^2$. Mutual shading of solar panels is an important factor for installing solar panels. To get optimum results 1/3 of total area is to be cover by solar panels. i.e. 66 $km^2$ (Quaschning and Hanitsch, 1998). So, area receiving rays will be 66 $km^2$. For installing 4 kW solar panel 28 $m^2$ per panel is required that means installations of 2,357,142 solar panels.

Area exposed to sun=66 $km^2$

=66 $Mm^2$

Solar constant=1.366 kW/ $m^2$

Solar energy received=(Solar Constant) (Area exposed to sun)

=(1.366 kW/$m^2$) (66 $Mm^2$)

=90156 MW

Efficiency of Solar Panel=21%

Total Energy production =(Solar energy received) (Efficiency of Solar panel)

=(90156 MW) (0.21)

=18932.7 MW

Grand Energy production=energy from wind plant+energy from solar park

=21000 MW+18932.7 MW

=39932.7 MW

## Cost Analysis

- For RO Plant:

  Purchase cost=113562 M

**Table 5.** Specifications of Wind Turbine

| Type | Manufacturer | Diameter of turbine | Cut in wind speed | Cut out wind speed | Swept area of turbine | Rotor speed |
|---|---|---|---|---|---|---|
| LM 19.1 | LM Glasfieber | 44.0 m | 5 $ms^{-1}$ | 25 $ms^{-1}$ | 1520 $m^2$ | 28 U/min |

Installation Cost =37854 M

Total cost of RO plant=(Purchase cost)+(Installation Cost)

=(113562 M)+(37854 M)

=151416 M

Life span of plant=30 years

O & M of plant=2% of total plant cost

=(0.02) (Total cost of plant)

=(0.02) (151416 M)

=3028.32 M

Per unit cost=(Total cost of plant/Life span+O&M)/ Production

=(151416 M/30 + 3028.32 M)/31400 M gallons

=0.06 rupees per gallon

### For Energy production plant

- Wind turbine:

Cost of Turbines=1,717.92 M

Installation Cost=24,268.8 M

Total cost of plant=(Purchase cost)+(Installation Cost)

Total cost of plant=(1,717.92 M)+(24,268.8 M)

Total cost of plant=25,986.72 M

Life span of plant=20 years

O & M of plant =20% of total plant cost

=(0.2) (Total cost of plant)

=(0.2) (25,986.72 M)

=5197.3 M

- Solar Park:

Purchase & Installation=9,4285.68 M

Life span of plant =20 years

O & M of plant =0.8% of total plant cost

=(0.008) (Total cost of plant)

=(0.008) (94,285.68)

=754.2 M

Total Cost of plants =(Cost of wind plant)+(Cost of Solar Park)

=25,986.72 M + 94,285.68 M

=120,272 M

Total O & M of plants =(O & M of wind plant)+(O & M of Solar Park)

=5197.3 M+754.2 M

=5951.5 M

Per unit cost=(Total cost of plants/Life span+O&M)/ Production

=(120,272 M/20 + 5951.5 M)/39932.7MW

=0.299 rupees per watt

## RESULTS

To meet increasing demands of population sea water is desalinated at a cost of 0.06 rupees per gallon. Water production at this economic cost is achieved by producing electricity, required for Ro plant, from costal belt of Pakistan. Electricity is produced by installing wind plant and solar plant on coast of Pakistan. After meeting energy requirements of RO plant, excessive energy is supplied to country to meet energy requirement at a rate of 0.29 per watt. In future, these plants can be further extended specially RO plant to meet requirements to that time.

## DISCUSSIONS

This paper proposed a sustainable, economic and efficient solution to forecasted water and energy crisis of Pakistan. This research promotes Integrated Water Resource management. The proposal meets all requirements of international standards for environment protection. Paper explains an integrated alternative water resource and integrated renewable energy resource to decrease stress on available natural resources.

## CONCLUSION

Pakistan has a restricted natural nonrenewable energy reserve. These resources are reducing with growing inhabitants of Pakistan. To meet demand of energy use renewable energy resources like wind and solar. This paper give an suitable plan of energy production to supply electricity in Pakistan.

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