The Review of Innovation in Renewable Energy Sector in the World

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Abstract - There is significant damage to the world due to the continually increasing population and the resources that prefer instead of renewable energy resources. Due to the usage of non – renewable energy sources for many years, harmful environmental impacts happen, such as air pollution, climate change, and decay of natural resources. By using renewable energy sources, there is the least harm to the ecology. With the rising of the human population and energy demand, we have to use the new technologies and improvements in the renewable energy field to fulfill the global energy demand and increase energy efficiency. The innovation in renewable sources will grow the trend towards renewable energy at the right rate. Due to the change of the environment's nature, the desired lifestyle, and the inability of resources, people worldwide have to use innovation in the renewable energy sector to obtain maximum efficiency and less environmental pollution. This study mainly focuses on hydro, solar, wind, ocean, geothermal, and biomass as renewable energy resources and discusses innovation, improvements, and future view of renewable energy technologies.

Index Terms—Anti solar cell, hydro engine, hybrid solar – biomass energy, innovations, offshore geothermal energy, rectenna, run – of – river, tidal barrage, tidal kites

Introduction

People worldwide have to pay attention to renewable energy resources due to the limitation and impact of non-renewable energy resources. Global warming, greenhouse gas emissions, fluctuating oil prices, and rising electricity demand in developing countries have to think about new solutions [1]. So renewable energy is affected by the current energy structure and energy development direction as an essential part. Solar and wind energy are the most reputable renewable energy resources, and they are pollution-free and environmentally friendly. Furthermore, these resources have been extensive – scale development and full applications due to energy transmission limitations [2]. The renewable energy technologies such as wind energy, solar energy, hydropower, biomass energy, ocean energy, and geothermal energy can be used to change the world as a better place for living. Usually, renewable energy has many advantages than fossil-based coal and oil due to reduce carbon emissions, clean the air, and can generate again within human lifetimes [3]. In the present scenario of the world, the consumption of electricity has been increased, and therefore researchers have focused on developing renewable energy technologies to obtain the high-efficiency level with minimum investment cost and less environmental pollution [3].

When considering renewable energy technology, their intermittent and fluctuating characteristic, utilization, and efficiency are limited. Wind and solar hybrid power systems are generally used for rural and mountainous areas far away from large power grids. Due to randomness and fluctuation of wind and solar power cannot provide continuous and stable active power output [2]. In general, renewable energies are not adaptable to everywhere due to the distribution of natural resources are dependently on the culture of

individual community [4]. When considering fossil-based electricity generated systems such as thermal oil power plant and coal power plant, they can generate electricity with maximum power output than the renewable energy power plant. Other hands have to pay the high initial cost and use vast land for renewable energy power plants such as hydropower plants [4]. When considering the above things, researchers have to introduce and buildup innovation in the renewable energy field to overcome their disadvantages and challenges to fulfill the global rising energy demand.

In 2014, the total global primary energy consumption was about 160310 million MWh, and this value had been projected to be increased to 240318 million MWh in 2040 [5]. In 2010, the renewable energy-based electricity generation system had been raised about 20%, compared with total electricity generation, and it will be about 31% in 2035% [6]. According to the International Energy Agency's sustainable future scenario, by renewable energy resources, 57% of the world's electricity supply will be provided by 2025 [6]. Long term forecast and planning is required to achieve this ultimate target [7]. Generally, electricity production using renewable energy sources is overgrowing across the world [8]. There are some negative and irreversible externalities in conventional energy production, and therefore renewable energy supply technologies should be promoted and developed [9]. During recent years a large amount of investment has been made, and the advancement of technology has enabled countries to produce renewable energy more cost-effectively [9].

Researchers are doing a lot of innovation in the renewable energy field for obtaining high efficiency with less environmental pollution. Today, in the renewable energy field, crystalline silicon for fabricating solar cells can be expensive due to the cost of extracting and manufacturing processes. So, organic materials will be added as new materials for building solar cells [5]. Due to the lower production cost and environmental friendliness, organic materials for solar photovoltaic cells have some benefits [5]. When considering wind power, fiberglass blades, wood epoxy blades, teetered hub, and turbulence simulation is proposed as the wind power's mechanical and structural reliability. The soft-start electronics, variable pitch blades, variable speed, constant frequency are proposed as the power constraints, spherical purpose airfoils, tapered and twisted blades, filament and tape wound fiberglass are recommended as the cost and efficiency when generating electricity by using wind energy [10]. In hydropower technology, small scale hydropower systems are increasingly considered an essential source of renewable energy in the world, instead of large scale hydropower plant [11]. So, mainly in this review paper briefly discuss innovation and future of the renewable energy field such as hydropower, solar, wind, geothermal, ocean and biomass energy.

Research method

For better understanding, this study consists of a systematic literature review focusing on the renewable energy sector's innovation. The definition of the systematic literature review is identifying, evaluating, and interpreting available research topic areas of the phenomenon of interest [12]. The research questions of the study, search strategy, search database, search strings, and inclusion/exclusion criteria are a subsection of the research method [13].

A. PLANNING THE REVIEW

According to research objective, the review is planned by proposing the research questions. In here determined the search strategy, search strings, and inclusion/exclusion criteria.

1. RESEARCH QUESTIONS

To explain and understand the future of the renewable energy sector is the objective of this study. The following question is used to achieve the research objectives.

RQ1: HOW IS THE FUTURE OF THE HYDROPOWER?

This research question aims to study and understand the improvement of hydropower technology, and what are the innovations in hydropower?

RQ2: WHAT ARE THE INNOVATION IN SOLAR POWER?

This research question aims to recognize the future of solar power.

RQ3: WHAT ARE THE INNOVATION IN THE WIND POWER?

This research question aims to recognize the future of wind power.

RQ4: WHAT ARE THE FUTURE TRENDS OF THE OCEAN POWER?

This research question aims to recognize the innovation in ocean power technology and what are their improvements?

RQ5: WHAR ARE THE INNOVATIONS AND DEVELOPMENTS OF THE GEOTHERMAL POWER?

This research question aims to recognize the new technologies are used in the geothermal power and understand its future.

RQ6: HOW IS THE FUTURE OF BIOMASS ENERGY?

This research question aims to study the improvements in biomass energy and what are the new technologies and materials used in biomass energy.

2. SEARCH STRATEGY

At firstly, the studies were retrieved, and after that, particular articles were objected to for other significant studies. To allocate the relevant articles, inclusion and exclusion criteria ware applied [12].

Table 1: After filtering, the number of publication according to the inclusion and exclusion criteria

database	**retrieved**	**inclusion**	**exclusion**
IEEE Explore	40	18	22
Science Direct	30	15	15
Research gate	30	22	08
total	**100**	**55**	**45**

3. SEARCH STRINGS

The key terms of the topic area and objective of the review were used as the search terms of this study. When doing this study, the following search strings were used. "Innovation in renewable energy "OR "renewable energy sources" OR "hydropower" OR "new hydropower technology" OR " new turbine design for hydropower plant" AND " solar power" OR "innovation of solar power technology" OR "new generation of solar power" AND "wind power" OR "new turbine design" AND "tidal power" OR "future of tidal energy" OR "turbine design of tidal energy" OR "innovation of tidal energy" AND "geothermal power" OR "new technology of geothermal power" OR "future of geothermal energy" AND "biomass energy" OR " innovative new materials for biomass energy" OR "innovation of biomass technology."

4. INCLUSION AND EXCLUSION CRITERIA

The following inclusion criteria were applied to choose relevant articles.I1: in the English language; I2: published between 2009 to 2020; I3: peer-reviewed; I4: empirical research papers. The research papers that did not match the above inclusion criteria were excluded from this study. E1: papers are not focusing on innovation and new technologies of the renewable energy field; E2: papers are not talking about renewable energy resources; E3: grey literature; E4: papers discuss only current situations. Therefore the final selection was selected of 55 research papers.

B.CONDUCTING THE REVIEW

In this part, the extracted information is presented from relevant sources and databases.

1. ARTICLE SEARCH AND SELECTION

To retrieve the studies, the selected electronic databases were searched. The initial search found 55 research papers, as shown in Table 1 and in here by using inclusion and exclusion criteria, 55 research papers were selected. These 55 papers were used to do this study.

2. DATA EXTRACTION

A data extraction process was conducted to find the relevant information of 55 research papers. According to the inclusion criteria, filtered research papers were categorized as hydropower.

Related, solar energy-related, wind energy-related, geothermal energy-related, tidal and ocean energy-related and biomass energy-related research papers by using a spreadsheet. After that, relevant data for the research question were extracted from this well-arranged research papers. Table 2 shows the number of research papers relevant to the research questions.

Table 2: The number of research papers relevant to the research questions

Renewable energy resources	**Database**			**Total**
	IEEE Xplore	Science Direct	Research gate	
Hydropower	2	4	4	10
Solar	7	2	1	10
Wind	4	1	6	11
Ocean and Tidal	2	3	5	10
Geothermal	2	3	3	08
Biomass	1	2	3	06

Results

According to the research questions, relevant details are discussed in this section. These results were obtained from well-arranged 55 research papers.

(1)RQ 1: HOW IS THE FUTURE OF THE HYDROPOWER?

The hydropower plant is mainly three types. Impoundment, diversion, and run of the river are them. Furthermore, due to environmental and social impacts, the impoundment type hydropower plant is not a suitable one, and therefore, the run-of-river type hydropower plant is developing. The run of river hydropower system decreases the negative impact of the large hydropower plant causes of plant installation region as the flooding of the land and disturbances in the river's temperature and composition. In this run of the river hydropower plant, the moving water's kinetic energy is used to move the turbine. The kinetic turbines are used to harness the kinetic energy of water to produce energy in the run of the river system [14]. Fig. 01 shows a type of kinetic turbine.

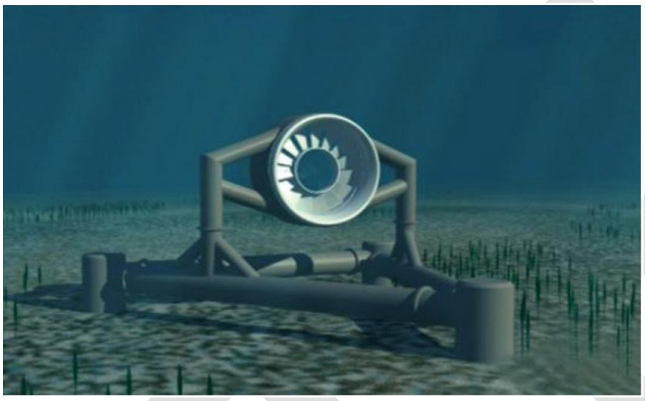

Fig. 01. A type of kinetic turbine for a run of river system [14]

When talking about to run off the river hydropower system, it belongs to the small hydropower system. Today, a small hydropower system is developing than the large hydropower system. The new technical concept has been applied at the intakes' hydraulic structures, the diversion pipe, and the features of power equipment to obtain the maximum efficiency [4]. The capital cost of the small hydropower plant in Europe range between 600€/kWh and 2000€/kWh. Due to not requiring a dam for retention of a large body of water, the run of river type power plants expected to cost in the lower half of the scale [15], [16], and [17].

When talking about hydropower, the wasted energy of daily used water and rainwater can be converted into electrical energy. There is kW range of electrical energy that can obtain this method, which is sufficient to lighten a garage of multi storage building or small needs of the home. Furthermore, the generated electricity is stored in a battery for future uses. This method is fallen into the Pico hydropower system. In this system, where the water is falling, a turbine is fitted there. So, the potential energy of water has rotated the turbine and the gear system connected with the turbine. To rotate the gears of the dynamo shaft, a chain drive is connected with the gears. When rotating the dynamo shaft, the mechanical energy is converted into electrical energy. Fig.02 shows the turbine and dynamo arrangement of this Pico-hydropower method [18].

Fig. 02.The rainwater converting into the electricity Pico hydropower system [18]

The whole system can represent by a block diagram, according to Fig. 03.

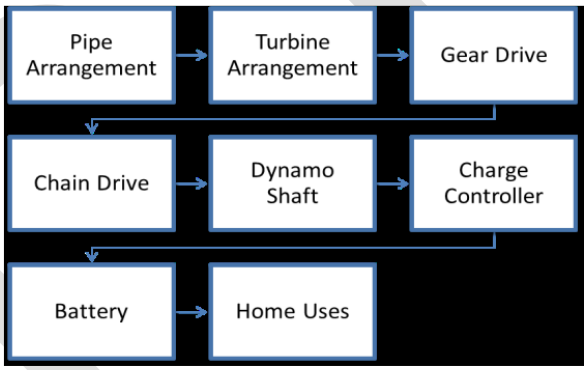

Fig. 03. Block diagram of whole Pico hydropower system [18]

The pumped hydro energy storage plants (PHES) are some hydro plants. In recent years, increasing interest in renewable energy sources has turned public attention about the PHES as a mature and large scale energy storage technology to support green energy production and to provide grid stability. New PHES has been planned in Europe to obtain a total power capacity of 7420 MW, and some of them will adopt the variable speed reversible pump-turbines breakthrough technology. This variable speed technology is used to improve the pump-turbine efficiency over a broader range of operating conditions and to improve the capability in grid regulation of the PHES [19].

The continuous rotation of a freely rotatable body in uniform flow without external sources of supplied power is called a phenomenon of autorotation. This phenomenon is used in hydropower technology as a new concept for new turbine design. The bodies with autorotation motion have good potential to extract the energy from the current. A flat plate, which is pivoted on its axis of symmetry, can consider as an object that shows the autorotation behavior. The plate can rotate freely around its vertical axis, and this whole system has the potential to harvest the energy from the current as a turbine. This system is called a vertical axis

autorotation current turbine (VAACT), and this concept is introduced by Fernandes and Postami in 2013 [20].

The turbine is one of the central parts of the hydropower plant. The improvements on the turbine performance are necessary to ensure better efficiency and possibly at a lower cost. There are two main types of turbines. The reaction turbine and impulse turbine are them. New reaction turbine technologies are significant variations from conventional reaction turbines such as Kaplan or Francis turbines. The development of a compact and modular turbine is a recent trend in turbine technology. The siphon turbine and axial-type propeller turbine generator unit is the examples of modular reaction turbines. According to the siphon technology, in the siphon turbine, energy is captured from water by using a Kaplan-type runner with four manually adjustable blades [21]. Fig. 04 shows a siphon turbine.

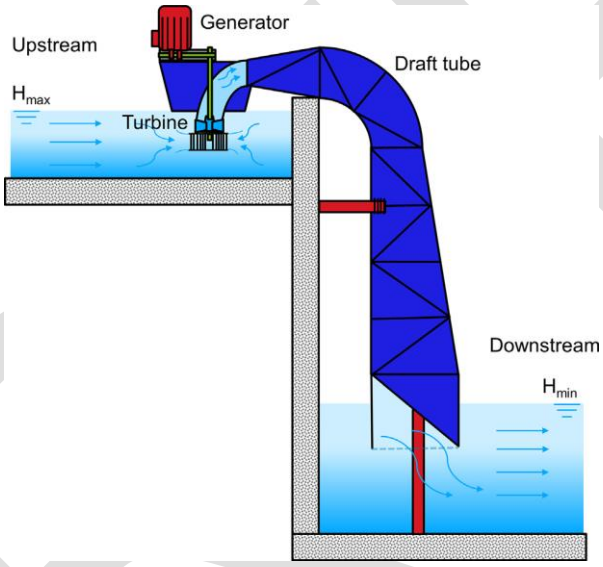

Fig. 04. The siphon turbine arrangement [21]

The Archimedean screw turbine, hydro engine, and lucid pipe turbine are examples of new generation impulse turbines. Archimedean screw turbine and lucid pipe turbine are most suitable for conduit applications. The hydro engine can handle lower head systems with a wide range of flows. After several modifications to the original turbine, the latest version of the linear Pelton hydro engine is currently available in the market [21], [22]. Fig. 05 shows the Archimedean screw turbine, fig. 06 shows the hydro engine, and fig. 07 shows the lucid pipe turbine.

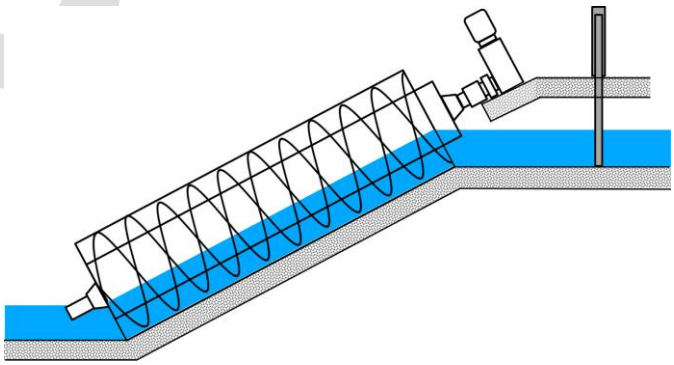

Fig. 05. The Archimedean screw turbine [21]

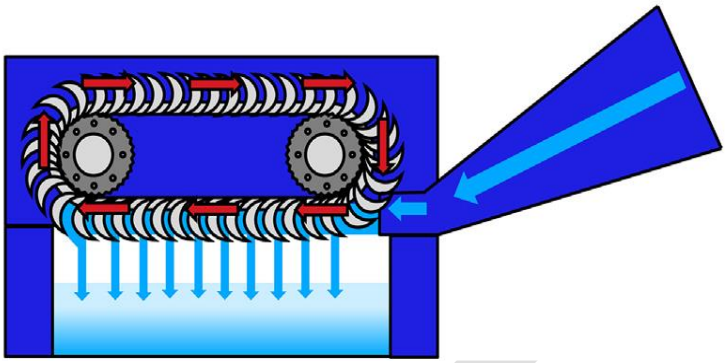

Fig. 06. The hydro engine [21]

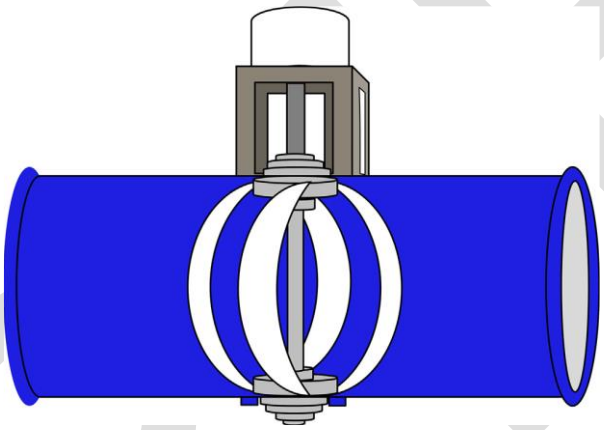

Fig. 07. Lucid pipe turbine [21]

In 2050, the worldwide hydropower capacity is expected to be reached to 1947 GW. Due to the advancement of control system technology, hydroelectric power plant control systems have gone through evolutionary development. The electromechanical relays and integrated circuits are used for the traditional hydropower control system. Nowadays, by using computer-based programmable logic control (PLC), automatic start and stop sequences systems are made, and they can apply in to control systems. These control systems apply to hydropower plants' significant components such as turbine, generator, smooth starting of the pump in case of pump storage, electrical braking, fire protection, and electrical protection. The effective control of the terminal voltage of the unit and improvement in the system stability is provided from this excitation control system [23]. Fig. 08 shows the components to be controlled in a hydroelectric power plant by using a PLC control system.

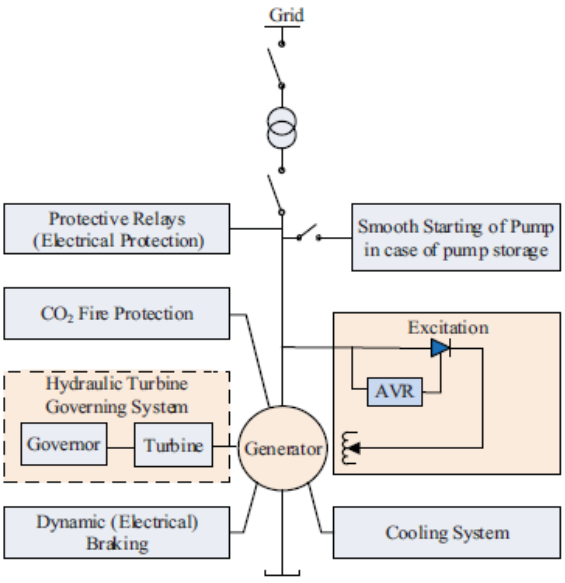

Fig. 08. The diagram of the PLC control system for hydroelectric power plant [23]

The above details are some brief discussion about innovation and the future of hydropower technology, and some of that methods are using in nowadays in hydropower plants, and in the future other methods will be used and developed to get better performances.

RQ 2: WHAT ARE THE INNOVATION IN SOLAR POWER?

The concentrated photovoltaic technology (CPV) is new in solar power technology. Here, mirrors and lenses are used to focus the sunlight on solar cells for generating electricity. CPV has an advantage over nonconcentrated photovoltaic. The lower number of solar cells is required for the same power output is one of them. The intensity of sunlight and temperature are greatly affected by the performance of the solar cell. At the high temperature, solar panel's output performance decrease as compared with lower temperatures. According to the case study of Akbarzadeh and Wadowaski, under concentrated solar radiation, the performance of solar cell decrease 50% when its temperature rises from 46ºC to 84ºC. An efficient cooling system is essential to get the maximum solar cell's efficiency and prevent the cell from degradation and damage. By using actively or passively method, the photovoltaic solar panel can be cooled. In the active system, some external power source is needed to cool the system, but there is no additional power source [24]. Table 3 shows the performance of the active cooling system solar panel under different concentration techniques.

Table 03. The performance of the active cooling system solar panel under different concentration method [24]

CHANGE IN CURRNET, VOLTAGE AND POWER W.R.T CONCENTRATION AND COOLING

Voltage	Current	Power	Concentration
12.98	1.91	24.84	Without
15.02	1.92	28.838	1 mirror
15.43	1.93	29.625	Plus cooling
16.11	1.94	31.253	2 mirrors
16.50	1.94	32.011	Plus cooling
16.71	1.95	36.929	3 mirrors
16.91	2.23	37.709	Plus cooling

When talking about solar panels' cooling system, there is a micro-heat-pipe arrays system proposed to dissipate heat from the operating temperature of solar cells. This proposed method can solve the problem of low energy output efficiency and thermal failure due to high solar cell temperature [25]

Solar energy is currently widely used in various fields because it has unlimited reserves; it is universality, clean, and has many other advantages. The efficiency of the solar cell is an essential thing. So below, several important ways are proposed to improve the efficiency of solar power [26].

- Improving solar panel conversion efficiency – Solar panel is the main component for converting solar energy into electricity. In recent years, scientists are developing researches to invent new solar panels. The Nano solar panel shows a new development direction as the latest achievement of solar panels in recent years.
- The automatic tracking system – Solar light and solar panel are vertical. The solar cell generating capacity will change with time due to the sunlight is in a changing perspective. By using adopting automatic tracking system can increase the generating capacity [27]. Fig. 09 shows a simple automatic tracking solar system model.

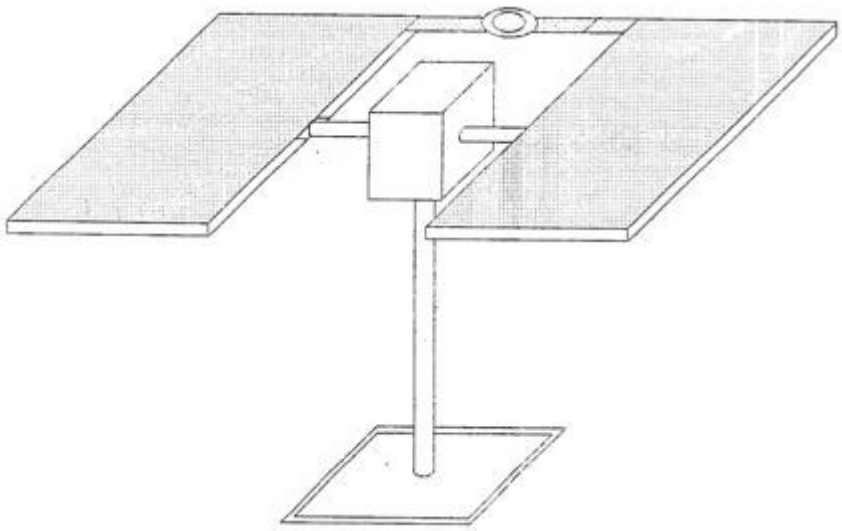

Fig. 09. The simple automatic tracking solar system model [27]

- Separate the collection and transformation part into two independent devices – The collector is one of them, and it is the serial collection and to strengthen the solar energy. The converter is another one, and it converts the light energy into electrical energy. This collector is made by using mirrors. The converter converts the thermal energy into electrical energy and, so the generating capacity is increased a thousand times the general solar panel.

The solar cell is an device that converts the sunlight into electrical energy by flowing electrons between two layers of semiconductors. The panel's surface wants to be dust-free and in the absence of any particles that obstruct photons' flow. Then solar cell operates at optimum efficiency without any loss of energy. For extracting maximum output, keep the panels and arrays clean with the help of a highly controlled process. Water is used for the cleaning process because most commercial crystalline silicon photovoltaic cells observe a suitable current-voltage characteristic at lower temperatures. An automation system is mostly required for this cleaning process, and it is a better solution than a manual one [27]. Fig. 10 shows a cost-effective automation system for a hugely optimized cleaning of solar panel arrays.

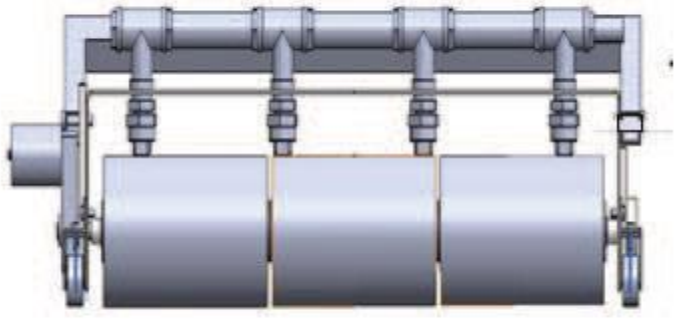

Fig. 10. The automation system for cleaning the solar panel [27]

When talking about the generation of the solar cell, the thin film is a second-generation solar cell. Cadmium telluride (CdTe), copper indium gallium diselenide (CIGS) are some second generation materials. This thin-film solar cell is flexible, and therefore it is getting popular with acceptable efficiency and excellent performance [28]. The multi-junction solar cell is a type of thin-film solar cell, and it has made by consisting of two or more subcells together. The traditional solar cell converts some part of the sunlight spectrum into

electricity and but in the tandem solar cells convert the more of the sunlight spectrum into electricity. Therefore increases the overall cell efficiency.

The solar tree concept is the best innovation idea in solar cell technology. Because today the human population is rising rapidly and, therefore, cannot find ample space for installing the solar panel. However, this solar tree is required a very less space to produce efficiently. Therefore the solar tree could be the best one for today's world. Compared with the traditional system, in the traditional system, it requires a huge amount of land to generate a small capacity of power. This artificial tree with photovoltaic cells arranged in a Fibonacci series manner in place of leaves. When considering trees, green leaves produce food materials for organisms; likewise, this solar tree leaves are producing energy for society [29]. Fig. 11 shows the artificial solar tree.

Fig. 11. The artificial solar tree [29]

According to the environmental conditions of Medellin in Colombia, a solar unit tree was designed when talking about the solar tree PV system. This is about 3.5m height tree, and it has four leaves made of acrylic with solar panels on the top. The energy storage capacity of this tree is about 180 Amp, and it has 6 USB ports to connect mobile devices and two 110v – 200W electrical outlets to connect those devices to the electricity [30], [31], [32].

To meet future energy demand solar energy is one of the best options. Researches have measured successfully in Detail the flow of solar energy in and between different parts of a photosynthetic organism for the first time. This result can develop to get high-efficiency solar energy technology than what is currently possible. Researchers have spotted that the device can absorb the sun's broad spectrum radiation and convert it to electricity by using a heat – resistant device made of tungsten and alumina layers. For fabricating the dye-sensitized solar cells, a green polymer derived from biowaste was applied [33].

RQ 3: WHAT ARE THE INNOVATION IN THE WIND POWER?

The airborne wind technology (AWE) is a new concept in wind power technology. Here, convert wind energy into electricity with the characteristic feature of autonomous kites or unmanned aircraft, linked to the ground by one or more tethers. AWE technology has several potential advantages over conventional wind turbines. They require less material than tower-based turbines, manufacture at low cost, be deployed faster, and harness stronger and steadier winds by flying at higher altitudes are some advantages of this technology [34].

The multi-rotor wind turbines system is proposed to improve the efficiency and reduce overall loads on a wind turbine, and it is possible to replace a sizeable single rotor with a multiple rotor system. Due to this innovative solution could allow an extensive power system (70 MW or more) to be installed at a single site utilizing a high number of standard led rotors. Mitigate the structural and material problems associated with the scaling up to the large device, and there is also the possibility of yawing without the requirement for a separate mechanism are some advantages of this multi-rotor wind turbines system [35]. Fig. 12 shows a multi-rotor wind turbine system.

Fig. 12. The multi-rotor wind turbines system [35]

When considering Atlantic regions and other polarity regions in the earth, floating hybrid energy platforms system can apply to extract the wind energy. This system can combine with more resources, and wind with a wave energy system is an example. This system consists of synergy between vertical axis wind turbine, wave energy converter, horizontal sea level generator, submerged wave energy converter system, and a single mooring line with integrated cable [35]. Fig. 13 shows the hybrid wind-wave platform system.

Fig. 13. The hybrid wind-wave platform system [35]

By continually upgrading turbine style, rising turning motor execution, and improving general rotating motor efficiency, the wind revolving motor innovation has been produced. Focusing on cutting edges, generators, coordinate drive methods, pitch, and yaw administration framework, there are many ages of advancement and change in turbine innovation. To obtain the extra power from wind energy, develop inventive procedures, reduce the working and support costs, improve wind turbine execution and efficiency, and decrease wind turbine costs through innovation progression [36].

Like any other renewable energy resource, wind power grows more significantly and is becoming an essential player in the modern energy supply system. In Denmark, 30% of the electric power consumption is covered by wind, and this country will achieve a 100% non-fossil – based power generation system by 2050 [37]. Fig. 14 shows the global cumulative installed wind power capacity from 1999 – 2020.

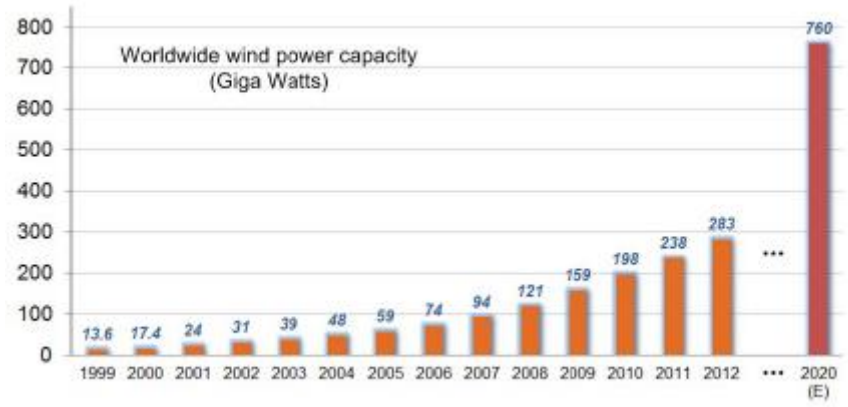

Fig. 14. The world cumulative installed wind power capacity from 1999 – 2020 [37]

When talking about wind turbine technology development, a synchronous generator with a full-scale power converter is a new concept for wind turbine technology. This concept introduces a full-scale power converter to interconnect the generator's power grid and stator windings; thus, all the produced power from the wind turbine can regulate [37]. Fig. 15 shows the synchronous generator with a full-scale power converter.

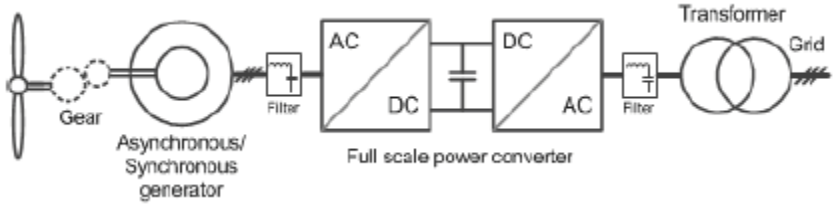

Fig. 15. The diagram of the synchronous generator with a full-scale power converter [37].

The future wind generator systems consist of hydraulic transmission, alternative direct drive (DD) generators, brushless doubly-fed induction generators (DIGS), magnetic pseudo-DDs, superconducting generators, and power electronic converters [38]. Fig. 16 shows a brushless DFIG with six nested loops.

Fig. 16. The brushless doubly-fed induction generator [38]

Due to the potential for high torque density and efficiency, superconducting machines have been proposed for wind turbines. Superconductors exhibit almost zero DC resistance and due to, in this case, commonly proposed for field windings in wound field synchronous generators. There are three types of superconducting wires: low-temperature superconductors (LTSs), high-temperature superconductors (HTS), and MgB_2. For a 10MW DD wind turbine, LTS has been proposed. By the American superconductor, HTS has been proposed for a 10MW DD wind turbine. The cooling system and thermal insulation can be relatively simple are the advantages of HTS. By advanced magnet lab (AML), MgB_2 has been proposed in a fully superconducting 10 MW DD wind turbine, where both armature and field winding are superconducting [38]. Fig. 17 shows the proposed 10MW HTS wind turbine generator. Figure 18 shows the proposed 10MW MgB_2 wind turbine generator.

Fig. 17. The 10MW HTS wind turbine generator [38]

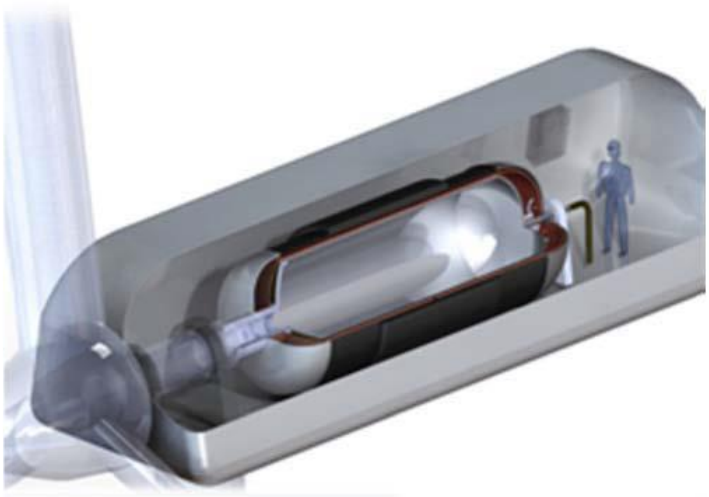

Fig. 18. The 10MW MgB_2 wind turbine generator [38]

The more giant wind turbines are used in remote locations, which are increasingly offshore for optimal wind conditions, is the current wind energy industry trend. The wind turbine industry is going towards intelligent machine health management. Below incoming tendencies can be mentioned regarding the new tendencies in the wind turbine industry [39].

- Towards smart monitoring
- The necessity of remote and E – monitoring
- In – service structural health monitoring
- Integration and interaction of monitoring and control system

By three major markets, namely Europe (Germany and Spain), North America (the US), and Asia (China and India), global wind power markets have been dominated for the past several years. Today there is an important trend in wind power technology. Then, in developed countries, more new wind power capacity was installed in developing countries. There is way to provide a resource that meets both the needs of peak reduction and wind power shaping by combining "smart grid" technology with storage devices [40].

When considering wind power technology, the blade design of the wind turbine is an essential thing. Wind turbines have different shapes and sizes and the elements of innovation to develop their operation's power and speed. The wind turbine categorizes as a vertical axis and a horizontal axis. Fig. 19 shows the innovative wind turbine with a horizontal axis. A new blade design of the wind turbine was proposed using the shape of a submarine's rotor blade [41]. Fig. 20 shows an example of a rotor blade of a submarine.

Fig. 19. The innovative horizontal axis turbine [41]

Fig. 20. The rotor blade shape of the submarine [41]

According to the above mentioned vertical axis wind turbine (VAWT) is one type of turbine structure. An innovative concept was applied to this structure. By Gabriele Bedon, Macro Raciti Castelli, and Ernesto Benini, the innovative VAWT is characterized by three twisted blades. Placed at a fixed distance by the rotational shaft and the airfoil section is NACA 0018 with a chord length of 200mm [42], [43], [44]. Fig. 21 shows this innovative wind turbine.

Fig. 21. The innovative vertical axis wind turbine [42]

RQ 4: WHAT ARE THE FUTURE TRENDS OF THE OCEAN POWER?

The blue energy concept is a new vista of renewable and sustainable energy forms with the ocean's power. Under this concept, other new concepts are developing for ocean power. Tidal barrages, tidal current turbines, and smart city with blue energy concept are some of them [45]

- Tidal barrages – Tidal barrages are usually similar to the dam. Here, tidal barrages allow water to flow through from both sides in the way when the tide level is high when the tide level is low, water will enter the basin while it will discharge water from the basin. The schematic diagram of the tidal barrage is shown in fig. 22.

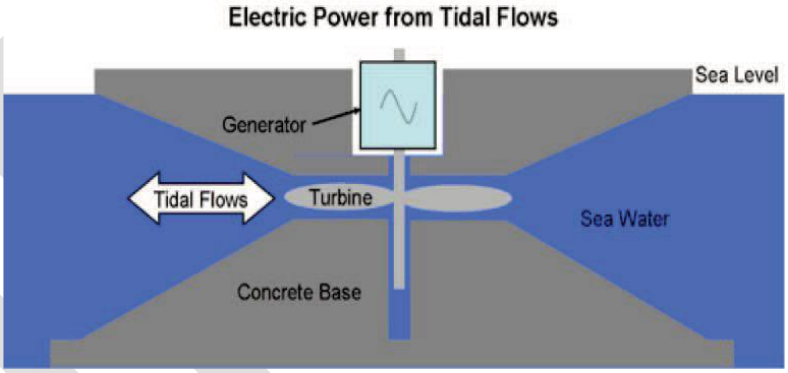

Fig. 22. The schematic diagram of the tidal barrage [45]

- Smart city with blue energy – In this concept, smart cities should be included in a group of smart systems to satisfy the requirements for both people and the environment. In this concept, blue energy will be done an excellent job. According to the smart city concept, blue energy is not limited to tidal energy. It will have consisted of salinity gradient (osmosis), wave energy, ocean thermal energy, marine biomass, and marine windmills. Fig. 23 shows the smart city concept with blue energy.

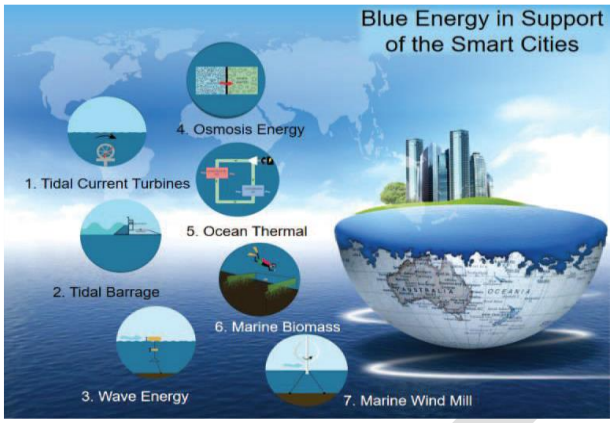

Fig.23. The schematic diagram of the smart city concept with blue energy [45]

When considering ocean power, stream turbines are an essential thing. They have two types. Horizontal axis turbine and vertical axis turbines are them. When comparing the above two types, the vertical axis turbines will be a popular choice for tidal stream energy exploitation. In 1923 by Darreius, a vertical axis turbine was first invented [46]. After developing this turbine type, the Gorlov turbine is better to design for tidal power [47]. Fig. 24 shows the Gorlov turbine.

Fig. 24. The Gorlov turbine [47]

When talking about ocean power's future, the multipurpose offshore platform is proposed as an innovation by the European MERMAID project. In 2012 by the European Commission, the planning, designing, and operating has been launched for this project. This MERMAID project will test design concepts on four very different European representatives for the European water. To develop novel, generic, and innovative design concepts for multiple ocean space uses, including energy extraction, aquaculture, and platform – related transport, 28 partners across Europe have joined this project to give their forces [48].

The tidal enclosure is the fence of the cycle of revolving doors. It is turned through typical coastal water contemporary. By blue energy Canada, the tidal fence has been designed, making use of a vertical moving turbine [49]. Fig. 25 shows the series tidal fence system. This design has many advantages. Some of them can mention below.

- The components of the generator parts can be attached by the top of the sea surface, reducing the cost of repairs.
- For transport, the upper part of the tidal fence can be used.

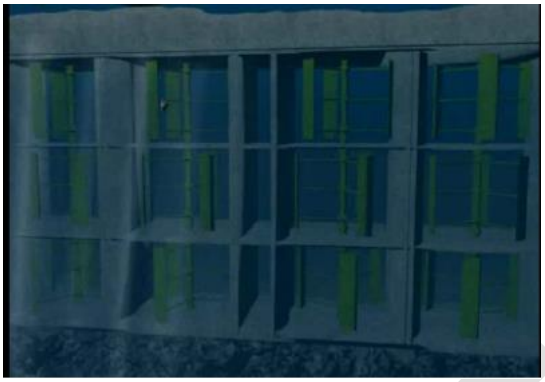

Fig. 25. The series tidal fence system [49]

Forgiving protection against wave attacks on berths, maneuvering areas, and port facilities, harbor breakwaters are built. Coastal engineers design breaker waters to dissipate incoming wave energy by wave breaking and porous flow in the mound and partly reflecting the wave to the sea and transmission into the harbor in case of penetration and overtopping. Innovation in coastal engineering design is beginning to move from this traditional system to the new concept of capturing the wave energy. This innovative harbor breakwater wave energy converter has several advantages, such as low construction costs, considering that the breakwater would be built regardless of the inclusion of the wave energy convert device [50].

When talking about ocean power, the ocean thermal energy conversion method is one of them (OTEC). Due to more disadvantages of the traditional OTEC system, need an innovative concept to overcome this situation. The innovative J – spar floating structure concept is one example of it. This concept is practically new and very innovative in the field of offshore technology. When considering this concept, by eight-column jacket legs, the deck is supported. For providing adequate upward force, buoyancy – capsules (pressure – vessel type) are entrapped inside the jacket. For using the jacket structure to entrap the buoyancy capsules in the J – spar design, the jacket – frame could be neutrally buoyant and, thus, no penalty. When considering the J – spar's hydrostatic stability, that is very similar to the conventional spar [51]. Fig. 26 shows this innovative J – spar floating structure.

Fig. 26. The innovative J – spar floating structure [51]

When developing the ocean energy sector, the wave energy converts were also developed. The Archimedes wave swing (AWS) is an innovative energy convert. This AWS is made up of large air-filled cylinders, and these cylinders are submerged in the water. At the topmost part of the cylinder, the pressure of the water is increased as the crest approaches, and this leads to compression of the air inside the cylinder to keep the pressure balanced. Then it expands as the trough passes, and this is cause to generate power. In 2004 during, a pilot program in Portugal, a prototype was tested [52]. Fig. 27 shows this AWS system.

Fig. 27. The AWS system [52]

Tidal kite technology is a smart idea for ocean power. In this tidal kite technology, the tidal kite device is made up of kites that can rotate with the tidal motion, and by using a fixed point, they are tethered. To transmit the generated electricity, the cable is also used. Usually, the kites are equipped with gearless generators [52], [53], [54]. Fig. 28 shows the tidal kites [55].

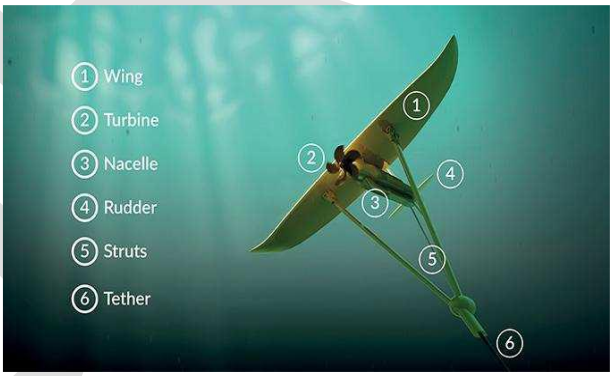

Fig. 28. The tidal kites technology [55]

RQ5: WHAT ARE THE INNOVATIONS AND DEVELOPMENT OF THE GEOTHERMAL POWER?

Iceland is one example country for the highest development of geothermal energy in the world. Mainly, in Iceland, geothermal energy is used for space heating due in Iceland's cold climate and in addition to using it to electricity generation. The five largest geothermal stations are presently working in Iceland, and they can mention like below [56].

- Hellisheidi power station (303MW)

- Nesjavellir geothermal power station (120MW)
- Reykjanes power station (100MW)
- Svartsengi power station (76.5MW)
- Krafla power station (60MW)

Fig. 29 shows the historical development of geothermal electrical energy generation in Iceland.

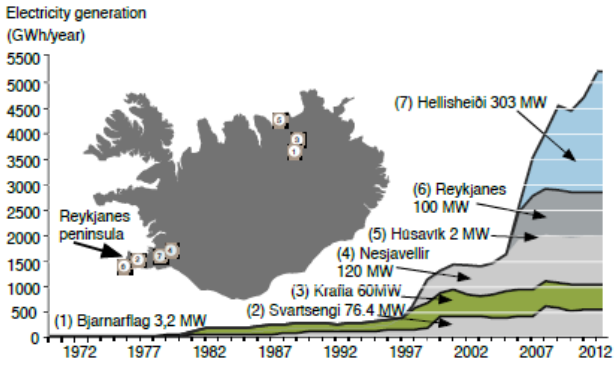

Fig. 29. The historical development of geothermal electrical generation in Iceland [56]

The geothermal resources could be a cost-effective option for a sustainable future power supply in Indonesia and the Philippines. Because these countries are situated near the geothermal boundaries, and therefore they have excellent geothermal energy resources. To replace coal-fired power generation by renewables, geothermal resources are a significant contributor in these countries and hence reduce CO_2 emissions most cost-effective [57].

Recently, geothermal resources are used for electricity generation with a temperature of around 150ºC or above. Generally, the geothermal power plant works in lower steam temperatures, e.g., below 250ºC, compared with steam temperature used in nuclear or fossil energy-based power plants. Due to that case, the geothermal power plant's efficiency ranges nearly from 10 to 17%. The dry steam power plant, flash power plant, and binary cycle power plant are the main three geothermal energy technology groups for power generation. By using self – superheating geothermal power plant and combined cycle geothermal power plant concept can obtain the high efficiency for geothermal power generation. The self – superheating geothermal power plant modification of the geothermal fluid pathway in the single flash and the double flash cycle. After the geothermal fluid reaches the wellhead, it enters a value that controls the flow rate and reduces the fluid pressure to the separator pressure in the self-flash type. In the case of pressure drop fluid flashing, that creates it into a mixture of saturated liquid and saturated vapor. The fluid flashing is designed to produce vapor, and it is used to expand in a turbine and generate work. The combined cycle geothermal power plant is also a new concept. The combined cycle is consist of dry/wet steam and binary cycle geothermal power plant. Steam is first used to generate electricity in a typical turbine in the combined cycle geothermal power plant. Low-pressure steam leaving of the turbine is then condensed in the binary cycle system. To achieve more effective use of resources to compensate for the system's complexity, the combined cycle system is developed. The combined cycle geothermal power plant can obtain maximum efficiency for systems utilizing high – pressure production well. The relatively low investment cost of the wet steam power plant and the ability to improve the binary system's efficiency are some advantages of this combined system [58].

When considering the research on geothermal utilization, regarding the optimization of the organic Rankine cycle (ORC) system, Li T, Zhu j, Hu K, Kang Z, and Zhang W proposed a parallel double – evaporator

organic Rankine cycle (PDORC) system. Using this concept can reduce the system's irreversibility and increase the power output of the geothermal power plant. Fu W, Znu j, Li T, Zhang W, and Li j proposed a cascade utilization system. It is included the Kalina cycle subsystem and oil production process subsystem and compared it with an existing organic Rankine cycle geothermal power system in an oilfield [59].

The Hot Fractured Rock (HFR) method has been proposed to extract the crystalline rocks' geothermal heat. In the Soultzsous Forets (Alsace, France), this method was successfully demonstrated and is now being considered by the first industrial projects. According to the method mentioned above, hydraulic fracturing is used to widen natural rifts in the rock in order to establish an artificial circulation production can supply by using thermal energy stored in crystalline rocks [60].

When considering the geothermal energy price, the higher production costs have laid in a remote area. Fig. 30 shows the electricity benchmark of the geothermal selling price in Indonesia. According to this chart, area 1 shows the Sumatra, Java, and Bali, and these regions have the most widely available geothermal energy and the lowest selling price benchmark. According to the future forecasting, in 2021, the geothermal selling price will be 14.2 US cents/kWh, and it will be nearly 16 US cents/ kWh in 2025. Sulawesi, Halmahera, Maluku, Papua, and Kalimantan are included in area 2, and in these regions, the benchmark is about 6 cents higher than area 1. The benchmark will be increased in 2025, about 23.3 cents/kWh in these regions. The highest benchmark price has lied in area 3. In this region, the benchmark will be 29.6 cents/kWh in 2025. Within this tariff, Indonesia's government hopes to attract more investors in geothermal development [61].

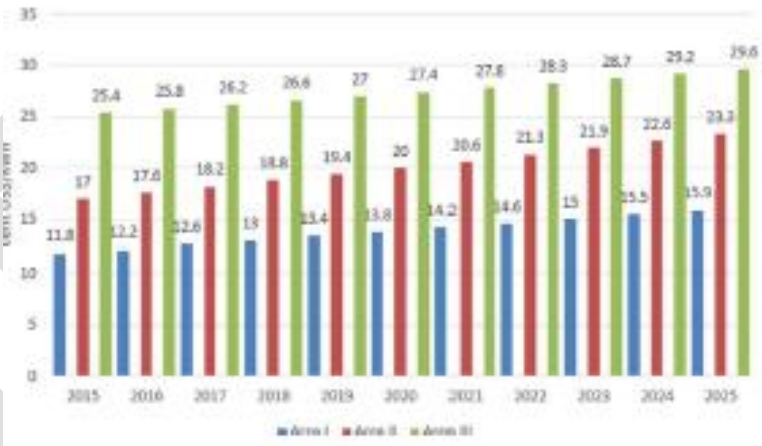

Fig. 30. The electricity benchmark of the geothermal selling price in Indonesia [61]

Geothermal energy is one of the most and reliable energy resources in the world. However, in the same way as drilling petroleum well. Drilling a geothermal well is generally time consuming and expensive. To overcome this situation, a new concept was proposed. A massive amount of costs can be saved by making use of an already drilled petroleum well. The high cost is decreased by 50% when using an existing well. Existing wells also give the benefits of drill a lateral to access for improving thermal conditions or geothermal reservoirs father away at a lower cost [62].

The offshore geothermal energy project is the best method to extract energy from the volcano. The drilling site will be located along the volcano crest, and the depth of the well will be between 1.5 km and 2 km. The semi – submergible platforms could represent a new solution, considering the rocks' volcanic nature and the great depth of the basin [63]. Fig. 31 shows the schematic drawing of an offshore geothermal system.

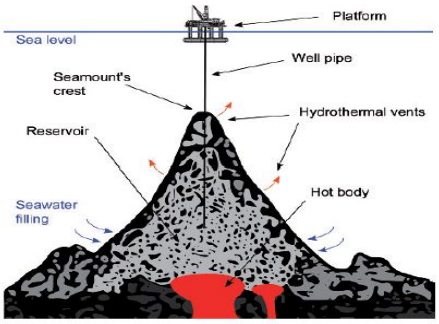

Fig. 31. The schematic drawing of an offshore geothermal system [63]

RQ6: HOW IS THE FUTURE OF BIOMASS ENERGY?

The gasification process is a crucial technology for the use of biomass. To promote biomass energy in the future, advanced, cost-effective, and high-efficiency gasification processes and systems are required. The UNIQUE gasification concept is the new gasification concept. This new gasification concept is used to a compact integration of biomass gasification and hot syngas cleaning, and conditioning systems were outlined initially in patents, deeply investigated in its different technical aspects utilizing a collaborative R and D European project and applied in future developments and industrial testing campaigns [64].

Biodiesel is an essential creation of biomass energy. When talking about biodiesel, the raw material is an essential thing. So, the microalgae have become a key point of biomass energy-related studies. Using microalgae pyrolysis can obtain a high heating value of biomass fuel, which is 1.4 – 2.0 times higher than the wood and straw. So, in the future, microalgae will be considered as one of the best choices of biodiesel raw materials [65].

Saline soil is one of the essential land resources distributed on earth. Its total area is about 25 percent of the land area on the earth and approximately 27 million ha saline-alkali land in China. So, China is developing its saline soil resources for cultivating trees and energy crops, and by using them, china hopes to increase their biomass production. More than 393 plant species and variations can grow in saline land, and most of them are salt – tolerance. Furthermore, hundreds of new salt-tolerant species have been introduced in recent years. By developing saline soil land resources, china's hope to expand its acreage of trees suitable for providing feedstocks for power plant and biodiesel makers comes down to an increase by 16 times during the future [66].

The textile industry is concerned one of the most complex industries due to variety of processes. The biomass boiler has been proposed to the textile dyeing industry. A modern biomass boiler (for pellets, chills, and woods) is an ecological and conventional solution, alternatively or by integrating traditional heating systems for fossil fuels [67]. Fig. 32 shows the biomass steam boiler of a textile production plant.

Fig. 32. The biomass steam boiler of a textile production plant [67]

The biomass energy can be defined as the energy from organic matter used to generate electricity, heat, and transportation fuel. When talking about the raw materials of biomass energy, now Malaysia has used Bamboo for biomass production. There are 50 Bamboo species in Malaysia. The area covered by Bamboo in Malaysia was estimated to be approximately 0.67 million ha in 2010. About 200,000 BDM/ annum (Bone Dry Metric Ton Per Annum) of Bamboo biomass can be available in Malaysia. For converting Bamboo biomass to solid or liquid fuels, there are alternative methods of utilizing Bamboo as an energy source by using techniques to convert the lingo cellulosic biomass to gaseous fuels. Then this gas can be combusted for the production of steam. It can be utilized in internal combustion energies or gas turbines for generating electricity [68].

The hybrid solar – biomass plant for power generation is a new concept for generating electricity by using solar power and biomass power. Here, concentration solar power (CSP) technology is used as solar power. According to the CSP technology, the solar radiation is forced on to the heating fluid and after generating steam and drive a steam turbine by using mirrors. According to the hybrid solar – biomass system, the electricity is generated by using CSP during the day time, and biomass is used for periods of reduced irradiation (night, cloudy periods, transients) [69]. Fig. 33 shows the solar – biomass hybrid configuration with CSP and biomass unit.

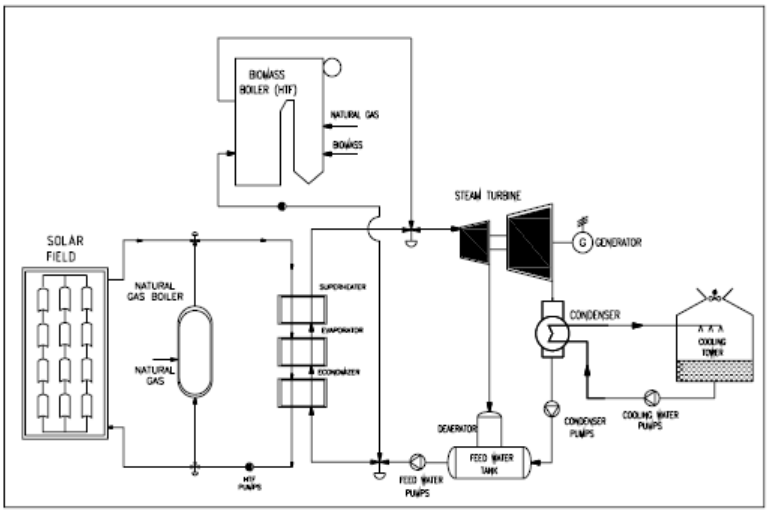

Fig. 33. The solar – biomass hybrid configuration with CSP and biomass units [69]

Discussion

The energy resources mainly divide into two categories as renewable and non – renewable. Nonrenewable energy resources have been used for more years. Conventional energy sources based on oil, natural gas, and coal are the highly effective drivers of the economic process. Worldwide primary energy consumption grew by 1.8% in 2012, with the rapid depletion of conventional energy sources and increasing energy demand. Many organizations have encouraged intensive research for more efficient and green power plants utilizing advanced technology [70].

There is an increased demand for energy, especially for electrical power in the world. All of the issues mentioned above encourage the investigation of using solar, wind, and other renewable energies to generate electrical power [71].

When considering about renewable energy technology, it has lower efficiency compare with nonrenewable technology when generating electricity. Can create maximum electricity capacity by using nuclear power plant and fossil-based power plant than solar or wind power plant. Furthermore, when talking about hydropower and biomass energy, there are many environmental impacts and social impacts are included with them. Therefore overcome these challenges, obtain maximum efficiency, and fulfill the future energy demand, should be done innovation and researches in the renewable energy sector. This is not a simple way. Researchers have to pay a high initial cost for doing investigations and have to study advanced technology. However, doing innovations and research in the renewable energy field can change the planet as a better place for living by decreasing the environmental impacts involved with non – renewable technologies.

Hydropower is one of the leading renewable energy resources. Using a sustainable hydropower project can overcome the issues of degradation of the environment and climate change-related to hydropower. There is a trend to build a small hydropower project instead of a large project. A pump – storage hydropower system is one of the best hydropower project [72]. A micro-hydro turbine is a new concept in the hydropower. According to this new concept, it can obtain some benefits. They can mention below.

- Reduce the submerged area from the water
- Can use for full filling energy demand when camping somewhere
- Can supply electricity day time as well as peek time
- Low noise pollution

Solar power technology is developing for the second and third generations. More researches have been done with nanomaterial for using them in solar technology. By using the traditional silicon-based solar panel only can extract some parts of the solar spectrum. Using a multi-junction solar cell can extract all the parts of the solar spectrum and then improve the solar cell's efficiency. Using hybrid solar power technology, such as solar – wind and solar – biomass technology, can generate electricity during cloudy days and at night. Due to applying innovations in solar technology below benefits can get.

- By extracting many parts of the solar spectrum, can get maximum efficiency
- Reduce the initial cost
- Can get a flexible solar cell and fewer environment impacts
- Can generate electricity during the day
- Can generate electricity very efficiently by using concentrated solar technology in the high-temperature regions than traditional solar technology

More energy can be extracted from wind due to the innovative ideas of wind power technology. Especially high altitude areas such as mountain regions have more wind flows. However, traditional wind turbine technology cannot be installed in those areas due to environmental factors. Therefore wind kite technology is proposed for that region for generating electricity by using wind flow. Due to innovation in wind technology, below benefits can obtain.

- Can generate energy during day time as well as at night time
- Reduce the initial cost
- Can get maximum efficiency
- Can generate energy when changing wind direction
- Can install in the remote areas such as mountains and hills

The ocean has covered almost 71% of the surface of the earth. Waves carry a massive amount of energy within them. Due to the gravitational force between earth and moon, tides generate and recent years, electricity generation by using these tides. However, ocean thermal and salinity gradients are also types of energy in the ocean [73]. Due to the ocean thermal and salinity gradients' innovation, the maximum amount of energy can be extracted from the sea. This sustainable energy source has not been fully exploited yet, due to the high cost of generation and lack of enough research. However, in the future, all kinds of ocean energies will be developed to fulfill the global energy demand.

The massive amount of power had been stored in the underground of the earth. This energy is called geothermal energy, and mainly in recent years, this geothermal was used for space heating instead of electricity generation. There are many geothermal resources in the world, such as volcanoes. Especially should mention about Pacific fire ring. These resources are freely available. However, some money has been paid at an initial cost. However, when compared with fossil-based resources, these resources have many benefits. Developing innovative ideas related to geothermal energy will be developed electricity generation field, and from it, some parts of global energy demand can be covered with less environmental pollution.

In the biomass sector, biomass energy is mainly used in the transport sector. However, due to innovation, it is developing for the electricity generation field. New raw materials have been proposed for biomass energy, and due to its highly efficient, can be obtained from biomass technology. Solar – biomass hybrid system and wind – biomass hybrid system is a new biomass energy field concept.

Before encountering some interrelated incidents which result in the global tragedy of a measure that has never been experienced in human society history, it is understood that need to substitute the current reliance

on fossil fuels. However, there are some disadvantages of renewable energy sources. Renewable energy technologies are incapable of providing adequate energy to sustain the gradually increasing global energy needs while reducing the effects on the health and environment before on the current finding [74]. The innovation and improvements are needed to overcome the situations mentioned above and to get higher efficiency, similar to nonrenewable technologies such as nuclear power and fossil-based power. So, this paper was discussed innovations and future trends of the renewable energy sector under hydro, solar, wind, ocean, geothermal, and biomass, for understanding the future tendency and future direction of the renewable energy field.

Conclusion

The traditional power generation based on fossil fuels is generally considered to be unsustainable in the long term, due to the storage of inexhaustible resources and environmental problems caused by emissions. As a result, more renewable energy technologies are introducing all over the world. For electricity generation, renewable resources are innovative options. Based on the current technology, renewable energy technologies are in the cable to provide adequate energy to rising energy needs, and when comparing with the nonrenewable technologies, these renewable technologies have low efficiency. So, innovations are an essential factor in the renewable energy sector to develop it with maximum efficiency. This paper presents innovative ideas and future views of renewable energy technology such as hydro, solar, wind, ocean, geothermal, and biomass. As a final word, innovation is a panacea for renewable energy technology to fill the future rising energy demand effectively.

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