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Generation and Utilization of Electrical energy Project

J-Component

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Renewable Energy Generation Through Underwater Generators

Aim:

In order to generate the renewable energy at mass and make our country carbon neutral we need to find more renewable energy sources and we must solve all the challenges related to this new form of energy harnessing mainly from untapped energy sources like energy from continuously moving water in oceans and rivers or we might increase the efficiency of our current renewable energy generation system and make all the required updates for it to harness energy from moving water bodies.

Objective/Conclusion that We made from our Literature survey

In the beginning of our project our team set to evaluate the present-day demand and supply of India as a nation and the following were the key highlight from all the stats that suggest that to total power demand of the nation is almost always upwards of 400GW. Further more we learnt that the Solar energy capacity stud at about 39 GW, Wind energy capacity was at 40 GW, India’s Hydroelectric capacity at almost 45 GW and total Geothermal capacity of about 10 GW.
Thus, after making the analysis we were able to conclude that at present the India energy market was still generating more than 260 GW of energy through more conventional ways of making energy like coal and other non-renewable sources of energy.
Although the number of renewable energy sources is continuously increasing in India there was still a very wide gap in it to be filled as India has one the biggest coastline of all nations.
With the total length of the coastline being more than 7516 Km. With the Bay of Bengal in the east and the Arabian Sea in the west. We have one of the biggest untapped energy resources in the form of moving water in tidal form or in the form of wave.
Thus, we decided to prepare our project on the topic of Renewable Energy Generation through Underwater generators. Following are some of the facts stated above.

1. Total Power demand of India = 392 GW
2. India’s Solar energy capacity = 39 GW
3. India’s Wind energy capacity = 40 GW
4. India’s Hydroelectric capacity = 45 GW

5. India’s Geothermal capacity = 10 GW
6. Total difference in capacity from total demand = 258 GW

Proposed Plan for new Energy sources

1.Underwater Ocean turbines - To harness tidal energy and reducing its cost rather than using conventional tidal power plants. Underwater (or tidal) turbines are a fairly straightforward concept, as far as cutting-edge energy technology goes. They are essentially windmills installed onto an ocean floor or river bed. The underwater current produced by the tides spins blades arranged like an airplane propeller.

2. **Hydrokinetic turbines** - To harness the energy of moving river. It is an alternative to the Hydropower dam. Hydrokinetic turbines are designed for the purpose of generating electricity. The turbines are intended to be placed underwater, in a fixed, floating, anchored or towed configuration, in any location where the effective water current preferably flows with a minimum speed of about 0.25m/s.

Methodology

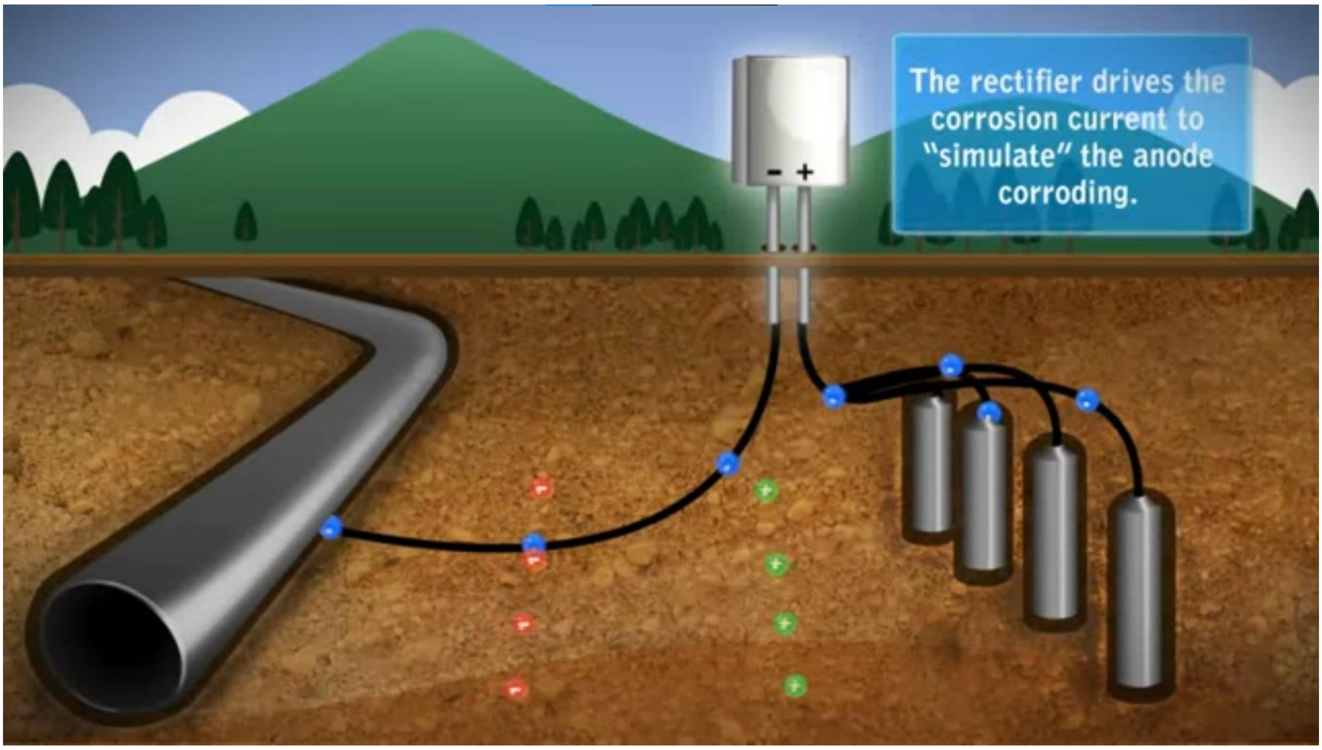
We will be using MATLAB Simulink for simulation purposes. Where we will be discussing:
1. How to simulate Underwater generator for harnessing ocean energy and river energy.
2. Making our Underwater turbines rust free.

3.What type of generator we are using and why?

Synchronous Generators	**Induction Generators**
1. In synchronous generators, the waveforms of the voltage generated are synchronized and directly correspond to the speed of the rotor. The frequency of the output can be given as f = N * P / 120 Hz. where n is the rotor speed in rpm and p is the number of poles. 2. An alternating or synchronous generator requires a separate DC excitation system. 3. The brushes in the synchronous generator are required to supply DC voltage to the rotor for excitation.	1. In the case of induction generators, the output voltage frequency is controlled by the power system to which the inductions generators are connected. 2. An induction generator takes reactive powers from the powers system for field excitations 3. The construction of an induction generator is less complicated as it does not require any brush and slip ring arrangement.

By looking at the above differentiation it will be the best to use Induction generator because once installed underwater maintenance of the machine will be both hard and risky.

How We Will Protect Our Underwater Generators From Rusting?



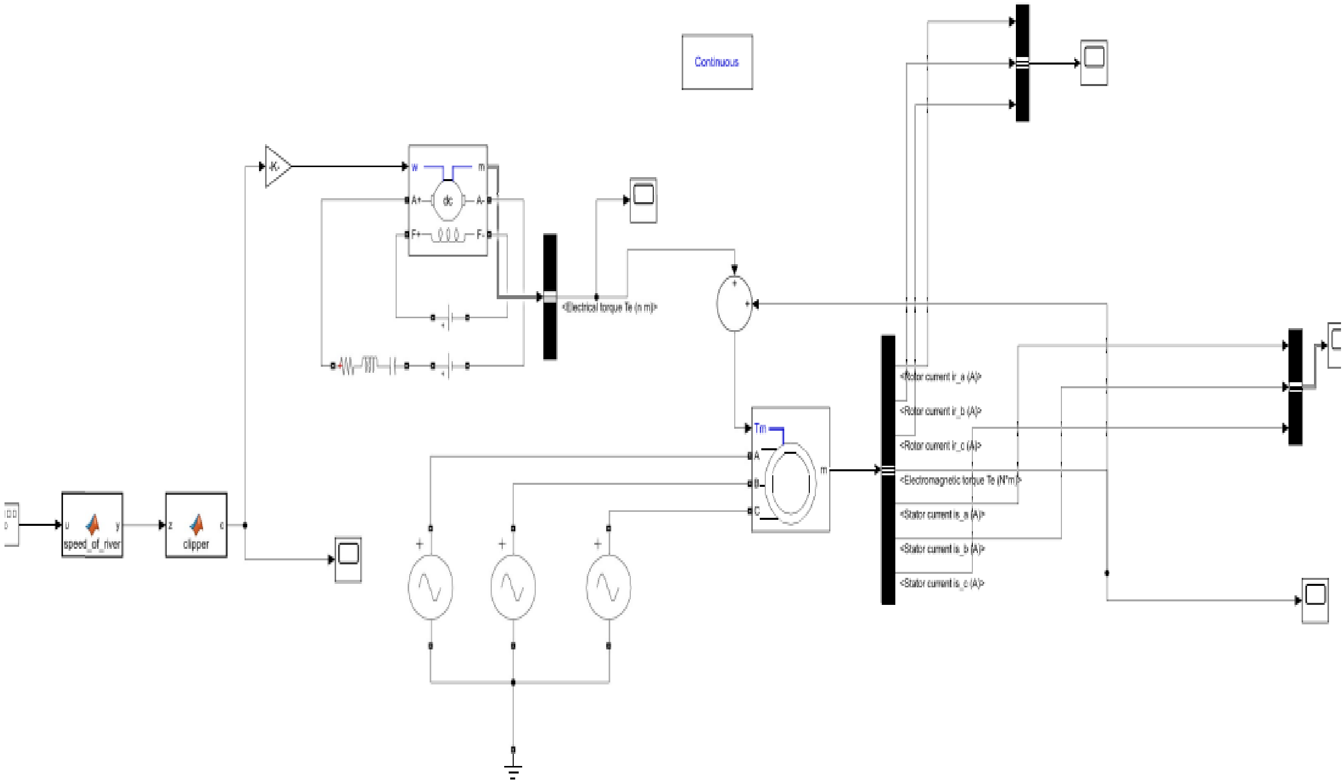
Impressed current cathodic protection (ICCP) is a corrosion protection system consisting of sacrificial anodes connected to an external power source. The external power source, often a DC power supply, provides the current necessary to drive the electrochemical reaction required for cathodic protection to occur.

The ICCP protects the main body of the pipes or other metal objects by corroding the anode with the help of electric charges which in our case will be produced by the generators itself.

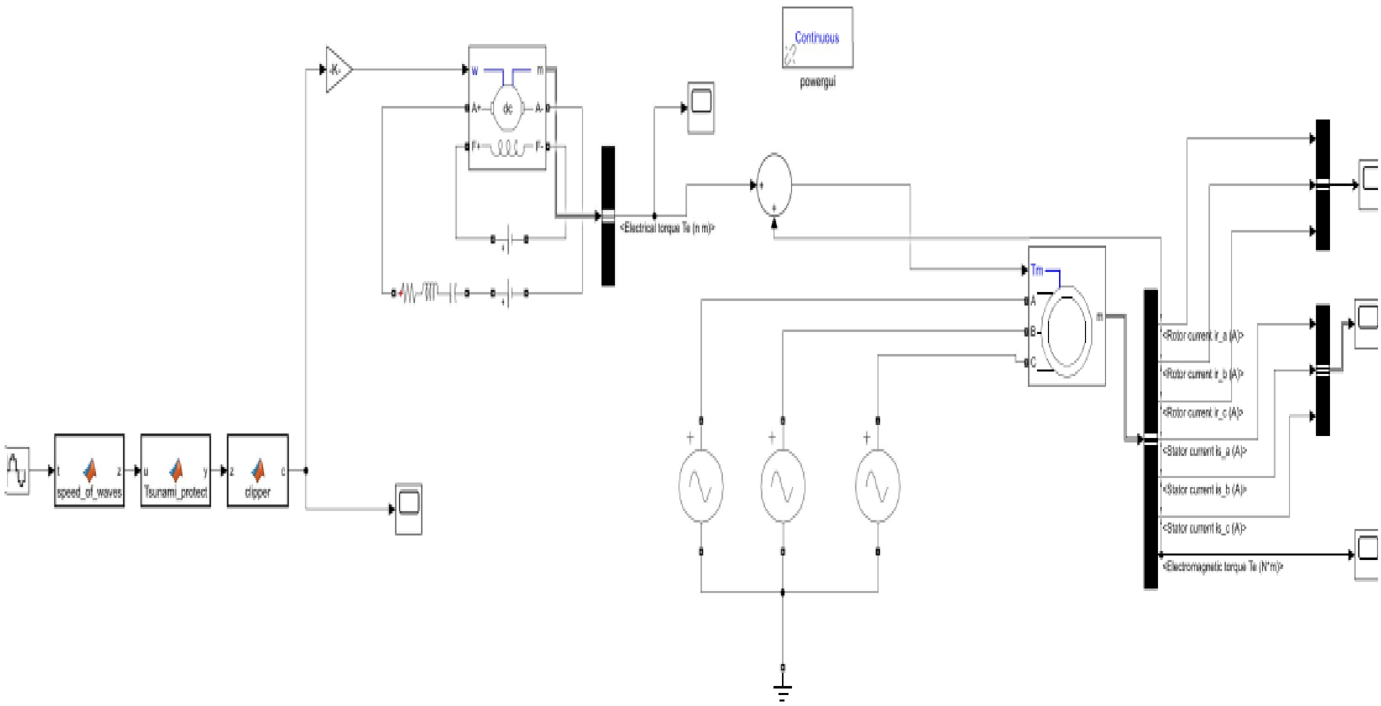
Impressed current cathodic protection systems are typically used in relatively large structures, where passive cathodic protection methods are ineffective or impractical. For example, passive cathodic protection is suitable for protecting individual structural members and appurtenances.

Which makes this method of corrosion protection best for our purpose of protecting the underwater generators.

Simulink model For the Under Water River Generator:



Simulink model For the Under Water Ocean Generator:



Working of the above Simulink Circuits:

1. Here we took sinusoidal signal to simulate the movement of ocean currents.
2. "Speed of waves" block is giving us the magnitude of the velocity.
3. The "Tsunami_protect" block is helping us the shut down the generator when ocean current speeds are too high.
4. The DC machine is helping us to simulate the turbines which will rotate due to the Kinetic energy of the ocean currents.
5. The 3 sinusoidal input is helping us to give reactive power so that our induction generator can work. The supply is coming from the main grid.
6. Then we have a induction machine block which takes input stator current from the main grid. and due to the rotation of the turbine. the rotor speed becomes more than stator speed which in itself results in negative slip.

Thus, our induction motor becomes an induction generator due to the negative slip.
In this way our induction generator helps as underwater electricity generation.

Conclusion:

Thus, through this project we were able to discover the various ways in which ocean and rivers flowing water can be used to in an effective way to generate clean energy without emissions of any carbon to the environment. We also tried to see how such a system can be utilized in real world and solved some of the challenges that one will encounter while making such a system. We also discussed about the ways we can protect our underwater generators from rusting underwater.

Future scope:

1. Through this generator we will be able to realize the dream of 100% renewable energy generation.
2. Underwater ocean turbine will also help us to reduce our dependencies on both nuclear and thermal energy.
3. Since India has a vast resource of 7516.6 km coastline, then ocean energy generation will be a game changer for our economy and will also be able to generate large amount of employment.

References:

1. https://www.youtube.com/watch?v=CIYA6Jwwp4s&list=WL&index=7 – By learn engineering
2. https://www.youtube.com/watch?v=Ax6KhYCu-90&list=WL&index=6&t=1116s – By Ahmed Adel

Literature Survey by Siddhant Abhyankar

S. No	Link of the Research Paper	Title of the paper (with Author and pub. year)	Brief discussion of the Abstract	Details of techniques and the test systems	Discussion of the results obtained
1	https://www.researchgate.net/publication/328763926_Solar_energy-A_look_into_power_generation_challenges_and_a_solar-powered_future	"*Solar energy—A look into power generation, challenges, and a solar-powered future*" by Muhammad Badar Hayat, Danish Ali, Keitumetse Cathrine Monyake, Lana Alagha, Niaz Ahmed published on November 2018 in "International Journal of Energy Research"	The research paper discusses on the possible direct and indirect ways to produce electricity from sun and an in-depth analysis has been made towards PV characterization and performance rating of Solar pannels	In this paper different types of tests have been given for PV cells for checking their performance such as "Current Voltage Measurements" which measures the maximum output the PV cells can give , "Spectral Reponsivity measurements" which measures the photocurent produced by incident light of a given wavelength and power.	1. There is a dire need for proper solar energy storage , currently available options for example flywheels, capacitors, supercapacitors, fuel cells, lead acid batteries, metal-air cells, NiCd batteries are not at all cost effective for solar energy storage. 2. The economics and efficiency of a solar PV cell depend mainly upon its material. 3. 80% less greenhouse gases are emitted through solar energy rather than the conventional system.
2	https://www.researchgate.net/publication/343434968_A_review_of_non-destructive_testing_on_wind_turbines_blades	*"A review of non-destructive testing on wind turbines blades"* by Fausto Pedro García Márquez and Ana María Peco Chacón published on August 2020 on "Research gate"	The research paper discusses techniques based on non-destructive testing and methods for wind turbine blades . It also discusses the future trends and challenges for wind energy generation.	The techniques for testing of wind turbine blades mentioned in the research paper are as follows. 1.Visual Testing:- this method to finds faults in Wind Turbine Blades in the form of discontinuities and cracks which happen due to harsh environments. 2. Ultrasonic testing:- is used to detect internal and external faults. 3.Electromagnetic testing:- used to detect delamination in turbines and many more tests have been given in the research paper.	1. Offshore wind turbines give more energy than Onshore wind turbines. 2. Offshore wind turbines require more maintenance than Onshore wind turbines. 3. A new approach in maintenance needs to be developed.
3	https://www.researchgate.net/publication/355779001_One_Sun_One_World_One_Grid?enrichId=rgreq-5aee3e526026df00d3a3c65d5f290fbc-XXX&enrichSource=Y292ZXJQYWdlOzM1NTc3OTAwMTtBUzoxMDg4MzQ1Njk4NTAwNjA5QDE2MzY0OTMyNDMxODU%3D&el=1_x_3&_esc=publicationCoverPdf	"*One Sun One World One Grid*" By Hardik Patel, Published at ResearchGate on 9th November 2021 ,	The research Paper discusses the problems related to the interconnected grid system for "One Sun One World One Grid"	1. Geopolitics :- Many nations don't want interconnected grids with their own neighbouring countries who are playing as their enemies. 2. Finance: Big developed countries are reluctant to invest money in underdeveloped countries for building the infrastructure. 3. Transmission: Nations can't trade their solar energy through AC system , this can only be done with the help of HVDC, but right now our HVDC system has many challenges for transmission under the sea	"One Sun One World and One grid" is a very revolutionary idea but it cannot be fulfilled if problems like Corruption , Finance , Geopolitical Game , Technical difficulties etc aren't resolved

4	https://www.researchgate.net/publication/334988672_Geothermal_Electricity_Generation_Challenges_Opportunities_and_Recommendations?enrichId=rgreq-bcfb7b900cb62c4b19297c988389af33-XXX&enrichSource=Y292ZXJQYWdlOzMzNDk4ODY3MjtBUzo3ODg4MjE4NTk5MTM3MjhAMTU2NTA4MTE5NTQ5MA%3D%3D&el=1_x_3&_esc=publicationCoverPdf	*"Geothermal Electricity Generation, Challenges, Opportunities and Recommendations"* By Moses Jeremiah Barasa Kabeyi , Published at Research Gate on August 2019	The research Paper discusses Geothermal energy resources as significant and if the technical, financial, environmental, social and logistical challenges are addressed, it can be a major player in global energy and electricity market as renewable, safe and cheap resources. The paper also discusses technical barriers, high financial costs related to geothermal electricity.	The research paper tells about the following tests for finding Geothermal locations: 1.Seismic reflective analysis: Seismic reflection is one of the most precise methods to detect geological structure. 2. Electromagnetic Survey: this method works by measuring the electrical resistivity of the earth. EM methods make use of the response of the ground to the propagation of electromagnetic field.	The Seismic reflective analysis has a disadvantage like faults were not always detected clearly by the reflection data generated by the process and the main advantage of the EM method is that they do not require direct contact with the ground as in the case of DC electrical methods. Therefore, the Measurements can be carried out in a faster way than the DC measurements.
5	https://www.researchgate.net/publication/336578408_Testing_of_a_hydro_power_plant%27s_stability_and_performance_using_PMU_and_control_system_data_in_closed_loop	*"Testing of a hydro power plant's stability and performance using PMU and control system data in closed loop"* -By Sigurd Hofsmo Jakobsen, and Kjetil Uhlen, Published at researchgate on October 2019	The research paper will demonstrate standard system identification techniques to tell whether the plant is in normal operation or not. This paper uses the measurements readily available from the plants control system or from a phasor measurement unit (PMU)	At first we will find out the transfer function of that hydroelectric power plant and then we will assume different cases to find out the stability and performance of the Hydro-electricdam. Case 1: The plant is operating under normal conditions with speed feedback and we have access to the control system signals. Case 2: The plant is still operating under speed feedback, but we don't have access to the control system signals for the identification. Case 3: The plant is operating with frequency feedback and we have access to the frequency measurements. Case 4: In this case we are operating the plant in open loop.	In this paper we have presented a method for testing a hydro power plant's stability margin and disturbance rejection using PMU and control system measurements. The main advantage is that is the tests can be performed while the power plant is in normal operation, Furthermore, the best results are obtained if one has access to measurements of the rotor's speed, since this allows for obtaining a good estimate of the plant's inertia. Otherwise, one can use measurements of frequency and one should get an estimate which is not any worse than what one would get using the proposed method.
6	https://www.researchgate.net/publication/315493188_Hydroelectric_Power	"*Hydroelectric Power*" By SAMEER SAADOON AL-JUBOORI, Published on ResearchGate in March 2016	This research paper tells us the possible ways we can use Hydro Power for Renewable energy generation and also lists some challenges related to the hydropower project and ways to solve them	The paper tells us about the following ways we can use hydropower dams: 1. Grid-independent Applications 2. Variable speed technology 3. Matrix technology:A number of small identical units comprising turbines and generators are inserted in a frame in the shape of a matrix . During operation, it is possible to start and stop any number of units so those in operation can always run under optimal flow conditions. 4. Fish Friendly trubines:While conventional hydropower turbine technologies focus solely on electrical power generation, a fish friendly turbine brings about benefits for both power generation and protection of fish species. 5. HydoKinetic turbines: technologies are being developed to take advantage of the kinetic energy in the stream flow rather than potential energy.	Hydropower generation can be increased at a given plant by optimizing a number of different aspects of plant operations, including the settings of individual units, the coordination of multiple unit operations and release patterns from multiple reservoirs. Moreover, it is highly probable that the hydropower resource potential will increase significantly if new resources are closely investigated and technology is improved.

7	https://www.journals.elsevier.com/renewable-energy	"*Tidal range energy resource and optimization -Past perspectives and future challenges*" - By Simon P. Neill a, Athanasios Angeloudis, Peter E. Robins, Ian Walkington , Sophie L. Ward , Ian Masters , Matt J. Lewis, Marco Piano, Alexandros Avdis, Matthew D. Piggott, George Aggidis, Paul Evans, Thomas A.A. Adcock, Audrius Zidonis, Reza Ahmadian , Roger Falconer , Published on Elsevier in May 7th 2018	In this journal paper the Authors have explained the main principles of tidal range power plants and have reviewed two main research areas: the present and future tidal range resource, and the optimization of tidal range power plants and have also discussed how variability in the electricity generated from tidal range power plants could be partially offset	In this paper the Authors have drawn different numerical models for tidal power plants to assess different tidal range schemes like 0D,1D,2D,3D numerical models. This paer also focusses on increasing the efficiency of tidal power plants through energy and economic optimization. For example in case of Energy optimization numerical solution of the 0D model was taken numerous times and is the basis for most energy yield estimates. The codes seeks to find the optimal generation start and stop times, and in most cases this is achieved through the use of fixed start head values for the ebb and flood tides. Moreover for Economic optimization a much wider range of data regarding economics and other constraints (e.g. environmental or practical) have to be accounted for. The basic approach is to determine the Levelised Cost of Energy (LCoE) for a given lagoon design.	1. Using these numerical models we can simulate our tidal power plants mathematically and can decide whether or not we should have a tidal power plant. 2. These models also help us to optimize our tidal power plants through energy optimization or economic optimization.
8	https://iopscience.iop.org/article/10.1088/1757-899X/955/1/012075	*"A Magnetohydrodynamic (MHD) Power Generating System: A Technical Review"* By Tushar Kanti Bera Published in "iopscience.org" on September 2020	In this technical review paper the author has explained the MHD system for generation renewable energy . Moreover the author has also highlighted the major developments in this technology. The present scenario and the future trends are also discussed along with the challenges related to this technology.	In this paper different types of MHD generators have been mentioned and each of them has their oen specialities. 1. Faraday MHD generator 2. Hall effect MHD generator 3. Disc MHD generaotr 4. Coal fired MHD system 5. Liquid metal MHD 6. Open and closed cycle MHD	Electrical energy generation is essential for the survival of the modern society. Fossil fuels are limited and create pollution. Also the conventional power generation systems using fossil fuel have lesser efficiency due to a higher amount of losses in different sections of the plants. MHD is found as a nonconventional energy generation system which has the capability to enhance the thermal power plant efficiency significantly.MHD generation is very promising in the multimodal power generation systems when coupled with the thermal power plants.
9	http://www.ijsrp.org/research-paper-0613/ijsrp-p18106.pdf	"*Magnetohydrodynamic Power Generation* " By Ajith Krishnan R, Jinshah B S , Published in "International Journal of Scientific and Research Publications" on June 2013	In this technical review paper the author has analysised the MHD generator and has introduced some ideas where MHD generator can be used to increase the efficiency of the output power.	The following assumptions are made in the analysis of the MHD generator: 1. working gas is an ideal gas 2. gas flowing at constant velocity and pressure 3. magnetic flux generated remains constant 4. no heat transfer to the surroundings 5. gas flow is uniform There are also some near future MHD generators proposed by the author: 1. Energy Re-Circulating LNG/MHD System 2. Energy Re-Circulating Nuclear/Gas Turbine System 3. Energy Re-Circulating Nuclear/MHD System 4. CO2 Recovery Type MHD Power System	Electrical energy generation is essential for the survival of the modern society. Fossil fuels are limited and create pollution. Also the conventional power generation systems using fossil fuel have lesser efficiency due to a higher amount of losses in different sections of the plants. MHD is found as a nonconventional energy generation system which has the capability to enhance the thermal power plant efficiency significantly.MHD generation is very promising in the multimodal power generation systems when coupled with the thermal power plants.

Advantages	**Limitations**	**Future scope**
1. Best option for renewable energy generation in Hot and Arid regions of earth 2. If PV cells are not enough then CSP technologies can also be used as an indirect process to generate electricity from solar power where solar radiations are concentrated to produce hot air and then it is used to generate electricity through a conventional power cycle.	1. The efficiency of PV cells needs to be raised because right now they are only 34% efficient 2. In case of solar power tower technologies(CSP), we need new types of heat transferring fluids for better efficiency in power generation. 3. We also need better and cost effective energy storage elements for Distributed generation of Solar energy so that when needed we can use the stored energy	1. Research in the field of materials science need to be enhanced to find cheaper construction materials for PV cells. 2.Research efforts in the field of environment and safety are required to minimize the risks associated with the toxic and flammable materials used in the PV cells through appropriate handling and disposal. 3.Research efforts need to be directed towards reduction of thermal losses in solar power technologies.
1. Wind energy genertion gives the most clean and affordable energy 2. It generates huge amount of employment. 3.Non distructive testing helps in preliminary testing of wind turbines before using them on wind farms.	1.Offshore wind industry has a high percentage of the operating and maintenance costs. 2. Some of the Non destructive testing metods are very expensive example X-ray computed tomography and radiography.	1. Special UAV's are needed for the maintenance of wind energy farms. 2. Artifical intelligence and new Architecture algorithms are required to increase accuracy. 3. New approaches in maintenance are required for cost cutting.
Renewable enrgy generation will become more viable if we have an Interconnected solar grid . It will also generate an alternate source of revenue for nations around the world if they trade solar energy with the neighbouring country who are in a need for energy.	1. We need more R&D on HVDC transmission under the sea lines. 2. Finance is also a big issue thus special emphesis on public private partnership is required.	"One sun One world and One grid" has a good future scope to generate high amount of jobs in green energy sector and it will be beneficial for both people and environment.

1. Provides clean and safe and renewable energy just by using little land. 2. Generates continuous, reliable power at high load factor and capacity factor making it ideal for base load power generation. 3. No combustion of fuels hence conserves fossil fuels and contributes to diversity in energy sources hence reduced demand for fossil fuels and hence reduced pollution and power plant equipment needs. 4. Avoids importing and benefits local economies in terms of foreign exchange savings and security of power supply in case of conflicts.	1. Only few sites have potential of geothermal energy exploitation and location is a challenge often requiring huge capital investments. 2. Geothermal resources are often located in areas with active volcanoes hence the location has inherent risks due to volcanic activities. 3. Geothermal development requires huge investment in exploration and drilling with no guarantee for commensurate power/energy output from the investment as several wells may not yield enough steam to operate. This makes the undertaking financially risky.	1. Development of better standards for monitoring and reporting geothermal operations and resource exploitation 2. Improvement of power plant designs is also needed 3. Minimizing water use by developing appropriate technologies. 4. Developing better prediction techniques for heat flows way ahead of drilling.
1. The proposed method is that it is almost non-intrusive such that the tests can be performed while the power plant is in normal operation, with the only restrictions that the scheduled power production of the plant should remain constant during the test. 2. The estimate of the stability margin and distrubance rejection obtained using the proposed method is also closer to the analytical calculated values, means accuracy is good.	1. However, the method is most applicable to power plants where there is no have a significant input deadband. Input deadband is sometimes set intentionally to prevent wear and tear of the power plant components 2. On the other hand the test mostly depends on the type of turbine. Generally, one can expect a significant backlash in Kaplan turbines and high pressure Francis turbines. For these types of turbines the method proposed in the draft requirements could be used as it handles backlash better.	1. It should be noted that if one uses PMU measurements for the identification, the faster dynamics will be estimated incorrectly, Thus we need more research in that area to fill that loop hole. 2. The method depends on the type of turbine we are using which is also a problem thus more research is also needed to solve this issue as well.
1. Once built and put in operation, hydropower plants usually require very little maintenance and operation costs can be kept low, since hydropower plants do not have recurring fuel costs. 2. Hydropower on a small-scale is one of the most cost-effective energy technologies to be considered for rural electrification in less developed countries. 3. High head hydro generally provides the most cost-effective projects, since the higher the head, the less water is required for a given amount of power, so smaller and hence less costly equipment is needed.	1. Investment cost is very high. 2.Hydropower plants are equally harmful for agriculture because they block the fertile alluvial soil which can be used for agriculture. 3. It also disturbs the livelihood of the people living near the dam because they will be displaced.	it is clear that substantial operational improvements can be made in hydropower systems, if given a new investment in research and development (R&D) and technology transfer. In the future, improved hydrological forecasts combined with optimization models are likely to improve operation and water use, increasing the energy output from existing power plants significantly

1. Using 0D model ,operation can be modelled using a water level time series as input, governed by the transient down stream water elevations at the site location. 2. 1D models are useful for modelling tidal lagoons and barrages, as they are able to capture some of the changes to tidal hydrodynamics due to the presence and operation of the tidal range power plant without the computational demands of more complex models.	1. 2D modelling tends to produce lower energy returns than 0D modelling due to the impact of hydrodynamics on the system. 2. This approach is computationally expensive, and while the fixed start head simulations can be run in several seconds, the full optimization simulations can take significantly longer. 3. Prandle and Rainey used an electrical circuit analogy to model the potential energy yield of a tidal power plant. Although this approach takes into account some of the potential hydrodynamic effects but it does not allow for the discrete operation of the lagoon as in the standard numerical approaches.	The potential of tidal range power plants for storage is a particularly powerful concept when we consider several plants operating in harmony no research has yet been conducted on this topic, there is scope for optimizing the scheduling (both generating and pumping) of several tidal range schemes to resolve some of the issues associated with temporal variability. Similarly to tidal elevations, tidal streams are also predictable, and so complementary phasing of sufficiently large tidal stream arrays, in conjunction with tidal lagoons, offers the potential for power production.
1. MHD generators can take the efficiency of coal power plants from 30 percent to 60 percent. 2. In MHD generators there are no solid moving parts and hence frictional or mechanical losses are very less thus running cost is less compared to the conventional thermal power plant. 3. CO2 emissions are negligible and could be avoided in the MHD power generation.	1. The higher cost is required for the construction of MHD systems and is one of its major hurdles. 2. Huge amount of magnetic field is required which needs a special design, higher cost and magnetic shielding in some cases. 3. Plasma or ionized fluid velocity must be high for large amount of energy generation. 4. Heat losses of plasma is also a porblem	1. Plasma generation needs seeding elements to reduce the heat energy requirement in MHD systems. 2. More research investigation is required in various parts of the MHD systems such as fluid, electrodes, magnetic field and the system geometry.
1. In Energy Re-ciculating nuclear/gas turbine system: we can observe that the plant's efficiency reached 47% as compared with 35% for the case of BWR/steam turbine system. 2. In almost every case with MHD generators combined with conventional power plants , the effeciency has always increased.	1. The higher cost is required for the construction of MHD systems and is one of its major hurdles. 2. Huge amount of magnetic field is required which needs a special design, higher cost and magnetic shielding in some cases. 3. Plasma or ionized fluid velocity must be high for large amount of energy generation. 4. Heat losses of plasma is also a porblem	1. Plasma generation needs seeding elements to reduce the heat energy requirement in MHD systems. 2. More research investigation is required in various parts of the MHD systems such as fluid, electrodes, magnetic field and the system geometry. 3. If more R&D is done then we can combine MHD systems with any systems to increase the efficiency of any conventional Power plants.

Literature Survey by Shreyansh Tyagi

S. No	Link of the Research Paper	Title of the paper (with Author and pub. year)	Brief discussion of the Abstract	Details of techniques and the test systems	Discussion of the results obtained
1	https://www.sciencedirect.com/science/article/abs/pii/S0360544216309434	"Energy harvesting from ocean waves by a floating energy harvester" by N.V. Viet, X.D. Xie, K.M. Liew, N. Banthia, Q. Wang published on 1 October 2016 on Science Direct.	A floating energy harvester using the piezoelectric effect is developed to harvest the energy from intermediate and deep water waves. A mathematic model is established based on the Lagrangian-Euler method and solved by the iteration method to calculate the root mean square value of the generated electric power. The results show that a power up to 103 W can be harvested for a practical floating energy harvester with a width, height, length, mass of the mass-spring system of 1 m, 0.5 m, 1 m, 100 kg, and an amplitude and period of a sea wave of 2 m and 6 s, respectively.	Wave vibration is a ubiquitous energy existing in our environment, but efficient vibration energy harvesting at ultra-low frequency and multi-directions is still a challenge. This paper proposes a piezoelectric vibration energy harvester for multi-directional and ultra-low frequency waves driven by a rotating rolling ball. The energy harvester is designed to float on the water's surface; it will be tilting vibration in the corresponding direction once driven by the wave from any direction.The energy harvester then converts the vibration wave energy into electrical energy due to the basic characteristics of frequency up-conversion.	Piezoelectric based generators use thin membranes or cantilever beams made of piezoelectric crystals as a transducer mechanism. When the crystal is put under strain by the kinetic energy of the vibration a small amount of current is produced thanks to the piezoelectric effect.
2	sciencedirect.com/science/article/abs/pii/S0360544215004831	"High performance ocean energy harvesting turbine design–A new casing treatment scheme" by PareshHaldera, AbdusSamada, Jin-HyukKimb, Young-SeokChoi published on 15 June 2015 in Science Direct.	TC (tip clearance), which is used in a bi-directional flow Wells turbine of an ocean wave energy device, changes the flow pattern on the turbine blade suction surface, while changing or modifying the TC zone can help obtaining a delayed stall. In the present work, a new tip grooving scheme is introduced and the performance is compared for different tip groove depths and TCs of a Wells turbine. It was found that the grooves improve the turbine operating range and power production as compared to those of the turbine without a groove. Using the circumferential groove, 26% increase in turbine power output for a particular operating point is achieved.	• A new casing grooving scheme for Wells turbine for wave energy conversion is proposed. • An optimal groove depth performs better in terms of operating range is reported. • A comparative study of different tip clearance and grove depth is presented.	Through the paper we were able to observe that only the change of groove depth of 3% of the chord length produced highest power and widest operating range. Using the circumferential groove, 26% increase in turbine power output for a particular operating point is achieved.

Advantages	**Limitations**	**Future scope**
1.Renewable source of energy 2.Free source of energy at very minimum maintainance. 3.No effect of day or night conditions. 4.Simple Mechanism for production.	1.Very high R&D cost. 2.Untested in real world environments. 3.Very expensive to produce. 4.Energy output is very less conpared to other renewable souces of energy.	The technology can have a great application in future with advancements in Piezoelectric based generators. There sea worthness can be of great consern as there small size and lack of firm ground support make them more prone to being thrown out of the sea during extreme weather conditions.
1.Increase in efficiecny. 2.Simple to execute. 3.Easy to produce. 4.Saves material cost. 5.26% increase in power output was observed by the experiments.	1. Lowers the strength of the blade. 2.Only effective for a short period of time. 3.Requires regular maintenance for effective results. 4. Not Viable for underwater operations as maintenance will be difficult. 5.Long-term use of the improvement made to the blade are not possible.	The technology can have a great application in future with advancements in metallurgy. As much more stronger alternatives will help solve the problem of strenghts in under water operations.

3	https://www.mdpi.com/2071-1050/9/4/613/htm	"Offshore Wind and Wave Energy" by by Pasquale Contestabile ,Enrico Di Lauro , Paolo Galli ,Cesare Corselli and Diego Vicinanza published on 4 April 2017 in MDPI Open Access .	he present study aims to evaluate the strategic effectiveness to face these issues by wave and offshore wind energy. Resources using a 10-year hindcast dataset are here examined. The annual offshore wave power was found to range between 8.46 kW/m and 12.75 kW/m, while the 10 m and 100 m mean wind power density is respectively 0.08 kW/m2 and 0.16 kW/m2. Based on these results, an environmentally and socio-economically sustainable is constructed As a result, multifunctional structures and multi-use systems, which combine power generation, desalinization and coastal defence, are strongly recommended.	1.To characterize the wave climate around the study area, emphasizing wave power assessment and the involvement of different sea states (e.g., monthly variability and long period swell influence); 2.To provide a comprehensive study of offshore wind resource, provided at a height of 10, 25, 55, 80 and 100 m and referring to three practical utility-scale wind turbines; 3.To draw a preliminary discussion about the realistic perspectives of blue farm installations around the Maldives coastline, also through practical case studies of these innovative technologies.	The present paper provides a preliminary assessment of the electric power generation of offshore wind turbines and wave energy converters along the Archipelago of the Maldives coasts. Both resources are relatively abundant, albeit opposite trends for energy potential have been recognized. The energy patterns suggest that wind and waves are generally uncorrelated, especially during the period of southwest monsoon.
4	https://www.sciencedirect.com/topics/engineering/offshore-wind-energy	"Offshore Wind Energy" by R. Rolfes, M.W. Häckell publised in May 2020 in ScienceDirect.	Offshore wind energy can be defined as the energy generated from the wind at sea. Wind is produced by uneven heating of the earth's surface by the sun. A wind energy turbine can convert the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use: wind blows across the rotor blades, causing them to rotate and to drive a shaft that is connected to the rotor hub	Offshore wind turbines (OWTs) show similarities to onshore designs, although several modifications must be applied to deal specifically with aggressive marine environments. The main components of an OWT are foundation, substructure, tower, and blades–rotor–nacelle.Several floating offshore projects have been fully commissioned and investigated around the world	The harsh offshore environment raises demands on support structures, corrosion protection and climate control in the nacelle, while generally deteriorating working conditions.EAP-based coatings Corrosion protection using EAPs was first suggested by MacDiarmid in 1985.33 EAPs can be synthesized both chemically and electrochemically. It has been observed that most EAPs can be electrochemically produced by anodic oxidation, enabling one to obtain a conducting film directly on a surface. EAPs can go from the insulating to the conducting state through several doping techniques, such as (1) chemical doping by charge transfer, (2) electrochemical doping, (3) doping by acid-base chemistry (only PANI undergoes this form of doping), (4) photodoping, and (5) charge injection
5	https://www.sciencedirect.com/science/article/pii/S1364032111003984	"What is the global potential for renewable energy?" by Patrick Moriartya, Damon Honnery publised in Elsevier on July 2012.	This paper addresses the questions of what energy levels RE can eventually provide, and in what time frame.They try to find that when the energy costs of energy are considered, itis unlikely that RE can provide anywhere near a 1000 EJ by 2050. Also, they try to show that the overall technical potential for RE will fall if climate change continues. Author's conclude that the global shift to RE will have to be accompanied by large reductions in overall energy use for environmental sustainability.	One approach to projecting energy demand is to ask what future energy demand levels would occur if the entire world achieved present OECD levels of per capita energy consumption. At present, energy and electricity consumption values, and CO2 emissions from fossil fuels, all on a per capita basis, vary greatly from country to country. Another approach has been proposed—the 2 kWsociety. Spreng argued that a continuous power of 2 kW (63 GJ/capita/year) for everyone would be sufficient to provide all with a high quality of life, compared with the 2008 level of 77 GJ/capita	The potential reduction in total RE potential is most uncertain, but its existence adds urgency to the shift to renewables; the longer we delay, the lower their technical potential. Unfortunately, since the majority input energy costs for RE must usually be made before any energy is produced, possible growth rates for RE are subject to limits. It is thus important to reduce total energy use.

The proposed plans and suggestion are can solve long term energy needs of the Maldieves and also make them energy self-relient and also help the nation tackle there beach erosion problem which is also taking away the key selling point the tourist economy based nation.	The use of a single source of energy does not fit with energy security strategies, addressed to ensure the uninterrupted physical availability of energy products and to balance and diversify the various sources of supply.Also,visual impacts of onshore and nearshore wind facilities represent one on the major concern considering the high value of Maldive’s natural seascapes.	For a large turbine, the yearly energy could arise in average 4.33 GWh on the west side and 5.11 GWh on the eastern part of the nation. This represents an important result because about 100 wind generator of 2.3 MW could provide the approximately 480 GWh of the whole electricity sector, moving the Maldives towards energy self-sufficiency using offshore wind power.
1.Helps extend the life of the ofshore wind energy by providing sutable suggerstion and ways to combat rust and to prevent the ware and tear of the offshore wind tubines.	Requires a lot of Energy to keep the system rust free by using the Cathodic Ressitance method. Hard to maintain in marine conditions. Regular maintaince is required to keep the initial results and prevent the deterioration of the wind farm over time.	Given the ambitious Paris climate goal, offshore wind is expected to continue to grow strongly over the coming years. Next to the main growth area in the European Union, also the United States and China are expected to invest increasingly in offshore wind parks. For the near future (2030), it is expected that global installed capacity will reach 130–140 GW (IEA, 2018), compared to less than 20 GW installed at the end of 2018.
Renewable Sources of energy can provide Fuel Supply That Never Runs Out. Unlike the mining of coal, oil, and natural gas – which requires extensive networks of heavy machinery, processing stations, pipelines, and transportation – renewables convert natural resources directly into electricity. Perhaps the most significant benefit of renewable energy is that there are no greenhouse gases or other pollutants created during the process. Whereas coal power plants create around 2.2 pounds of CO2 for every kilowatt-hour of electricity – solar panels and wind turbines	While renewable energy systems need no fuel and can deliver substantial long-term savings, their up-front costs can still be prohibitive. On a larger scale, wind farms, solar parks, and hydropower stations require significant investment, land, and electrical infrastructure, resulting in some projects being delayed, altered, or even cancelled. Due to the intermittent nature of renewables, they need forms of energy storage to capture and release electricity in a consistent and controlled way. The efficiency of renewable energy systems also depends on their location and surrounding environment. For example, wind turbines are only effective in large, open areas with strong and consistent	By 2050, the world may need 1000 EJ of primary energy, if business-as-usual projections of global economic growth are to be realised. Given the problems facing both fossil and nuclear fuels, within a very few decades, RE will have to account for most energy production. Yet pervasive uncertainty surrounds estimates of technical potential for all renewable energy sources except hydro, both at the national and global levels

6	https://www.sciencedirect.com/science/article/abs/pii/S0141118717306338	"Novel piezoelectric-based ocean wave energy harvesting from offshore buoys" by Seyedeh, Fatemeh Nabavi, Anooshiravan ,Farshidianfar, Aref Afsharfard publised on July 2018 in	Ocean wave energy is one of the huge energy sources, which easily wasted around us. Because of low frequency of the ocean waves, less attention has been paid on vibration-based energy harvesting from this energy source. In this study, a novel beam-column piezoelectric-based energy harvesting system is studied, which can be optimally used as an Ocean Wave Energy Harvester . In doing so, the electromechanical equations of motion for the energy harvesting system are accurately derived. The presented novel system opens new field of research that helps to use the ocean wave energy in a proper way.	• In this study, a beam-column piezoelectric-based energy harvesting system is presented as an ocean wave energy harvester. • The electromechanical equations of motion for the energy harvesting system are derived and experimentally validated. • The buoys are considered as the ocean wave energy absorber systems. • Energy harvesting from the buoy, which is subjected to large wave height and low frequency, is more efficient.	This method converts mechanical wave energy directly to electrical energy, so energy loss due to friction from moving parts is greatly reduced. This method was mainly used in oscillating body systems. The downside of this method is that the requirement of using heavy magnets causes increase in mass of the whole system and reduction in efficiency due to the low velocity of wave oscillations.
7	https://www.sciencedirect.com/science/article/pii/S187661021735124X	"Comparative Study of Small Hydropower Turbine Efficiency at Low Head Water"by PiyawatSritramRatchaphonSuntivarakorn publised on October 2017 in ScienceDirect.	The purpose of this research was to study and compare a small hydropower turbine efficiency at low head water by making a comparison between the Water Free Vortex Turbine and the Small Under Shot Water Wheel. The experiment and analyze were carried out to find the torque and energy of the turbine, as well as the overall efficiency of both types of turbines at the flow rate of 0-950 l/min and at the head water of 0-0.5 m.	Currently the generation of electricity in the low head water sources has been based conventionally on different forms of generating turbines which include: horizontal spiral turbine, small under shot water wheel, Kaplan hydro turbine and gravitational vortex power plant. Electricity generation in the low head water sources is appropriate for application in remote areas which the expansion of the distribution system is not possible.	Moreover, this small under shot water wheel can be conveniently used on highland with ease of transportation, maintenance, and fix. The average efficiency of this water turbine is observed at 35-40 % . Despite the fact that several types of water turbines are available for electricity generating in low head water setting, the potential diversity in electricity production among these existing turbines had never been investigated. Accordingly, it was proposed in this research that the electricity generating capacities of the traditional turbine, small under shot water wheel, and its more modern and widely used counterpart, water free vortex turbine, should be investigated.
8	https://www.sciencedirect.com/science/article/pii/S036054420600301X	"Renewable Energy Strategies for Sustainable Development " by Henrik Lund published in Elsevier Aalborg Universitet on 2015.	This paper discusses the perspective of renewable energy in the making of strategies for a sustainable development. Consequently, large-scale renewable energy implementation plans must include strategies of how to integrate the renewable sources in coherent energy systems influenced by energy savings and efficiency measures.	The aim of the analysis is to see if a 100 percent renewable energy system is a possibility for Denmark and hereby to identify key technological changes and suitable implementation strategies. All changes have been carefully calculated on the EnergyPLAN energy system analysis model. Consequently, the energy balance of each system has been calculated for each hour of the year taking into account the intermittent nature of RES, limitation in capacities of flexible technologies as well as demands for ancillary services.	The tendency in the results is an increase in the fuel consumption rather than a decrease. This is because, such technological changes lead to a substantial increase in the electricity excess production. More CHP, better efficiencies, less demand and more intermittent resources all lead to higher excess production unless something is done to prevent such problems.

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From the experiment, it was found that at a flow rate of 950 l/mim, the highest amount of generated energy of the Small Under Shot Water Wheel, was at 7.51 W, the torque was 4.78 N-m and the highest efficiency was 13.96 % at the rotational speed of 15 rpm. As for the Water Free Vortex Turbine, the highest amount of generated energy was 14.5 W, the torque was 2.77 N-m and the highest efficiency was 35.92 %	1. The higher cost is required for the construction of Hydropower Turbine at Low Head Water 2. Huge amount of magnetic field is required which needs a special design, higher cost and magnetic shielding in some cases. 3. Plasma or ionized fluid velocity must be high for large amount of energy generation. 4. Heat losses of plasma is also a porblem	The potential of hydro power plants for storage is a particularly powerful concept when we consider several plants operating in harmony no research has yet been conducted on this topic, there is scope for optimizing the scheduling (both generating and pumping) of several tidal range schemes to resolve some of the issues associated with temporal variability. Similarly to tidal elevations, tidal streams are also predictable, and so complementary phasing of sufficiently large tidal stream arrays, in conjunction with tidal lagoons, offers the potential for power production.
By implementing the three key technological changes the analyses show that the Danish energy system can be converted into a 100 percent renewable energy system when combining 180 TJ/year of biomass with 5000 MW photo voltaic and between 15 and 27 GW of wind power. In the reference 27 GW wind power is necessary, while in combination with savings and efficiency improvements the necessary capacity is almost only 15	Reaching a stage of a high share of intermittent resources in combination with CHP and savings the making of sustainable energy strategies becomes a matter of introducing and adding flexible energy technologies and designing integrated energy systems solutions.	Oil for transportation must be replaced by other sources. Given the limitations in Danish biomass resources solutions based on electricity become key technologies. Moreover, such technologies raise the potential of including wind power in the ancillary services of maintaining voltage and frequency in the electricity supply dd electrolysers to the system and at the same time make possible for wind turbines further to be included in the voltage and frequency regulation of the electricity supply.