Disadvantages of Replacing Conventional Energy Sources with Renewable Energy Sources

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Abstract: The aim of this paper is to outline technical disadvantages associated with the renewable energy sources. The paper commence by introducing the disadvantages of the of both the wind and solar energy. Since the micro-grid is used to allow maximum energy throughout different seasons , the disadvantages of the micro-grids are outlined and properly discussed as well. It is observed that the micro-grid is prone to faults. It is also difficult to obtain storage for the micro-grid. The results shows that replacing Medupe power plant in Limpopo with wind energy and solar energy will require the size are 31729 and 1270 times greater than Limpopo which is impractical. Therefore the overall results conclude that the RES will never replace conventional energy sources.

Key words: Central Protection Unit (CPU), Distributed Energy Resources, Distributed Generators (DGs), Inverter Interfaced Distributed Generator (IIDG), Point of Common Coupling (PPC), Renewable Energy Source (RES)

1. INTRODUCTION

For many countries, Renewable Energy Sources are slowly becoming the main source. Countries such as Sweden (100% renewable) and Costa Rica (95% renewable) are have completely reached the stage of relying only on renewable energy. This shift comes with a great deal of advantages especially economic and environmental sustainability. However there a plenty of technical problems associated with the usage of renewable energy sources.

The objective of this report is to address the disadvantages that comes with the usage of renewable energy sources for the generation of electricity. The paper will first discuss challenges associated with this energy resources, finally, since the the different RES are integrated together to create an efficient system, this paper will therefore discusses the challenges associated with the usage of the micro-grid.

2. BACKGROUND

2.1 Constraints and Assumptions

- The micro-grid and the DGs on this paper are purely composed on renewable energy sources.
- The most employed RES are wind and solar, therefore this paper will only be limited to them.

2.2 Literature Review

Wind energy is one of the widely used energy resources reduce the emission of carbon-dioxide and to preserve the environment. The generated power from the wind plants is carbon-free, however wind plants produce fluctuating electric power. These variations have negative effect on the quality of wind generated power causes instability in the system [1].

Sohrab Mirsaeidi et al. [2] had suggested that locally replacing conventional power system with renewable energy requires application of micro-grid method in order to attain level energy distribution. This method is achieved through integration of small-scale DERs into MV distribution networks [3]. The study carried out by Sohrab Mirsaeidi et al. [2] has shown that micro-grids lack protection wereby the challenge is to obtain the effective protection mechanism for both grid-connected and islanded mode of operation.

3. DISADVANTAGES OF USING WIND AND SOLAR ENERGY

3.1 Effect of Wind and Solar on the controllability of Wind and Solar Energy Generation

The knowledge of wind variability is essential given view and growth target for wind energy globally []. Two traits arise from the switch of the climate to the produced energy from automation of production techniques and permit the conclusion that wind offers uncontrollable generation. Figure ?, Appendix ? showcases the wind power for varying speed wind generator, it is observed that the power generated varies with speed and the power is uncontrollable since the wind speed is not controllable as well.

3.2 Effect of Wind and Solar Generation on Power Quality

3.2.1 ***Voltage Fluctuation*** The wind distribution network normally experience voltage instability when there is uncontrollable voltage drop after the variation has occurred in the system due to increase in the power demand or the operating conditions of the system changes. Figure ?, Appendix ? shows the wind speed data for two consecutive days in Cape Town. Using the speed varying wind turbines the output voltage will be unstable as well. For constant speed turbines the voltage may vary if the speed variation occurs belong the constant speed set for the generator [4].

Chen et al. [5] performed the experiment to determine the quality of power using the wind turbines with variable speed. His results showed that the operation of wind plant under aforementioned conditions and unity power factor, introduces voltage increase in the PPC, whereby the generated varying power creates the fluctuation. This voltage variation becomes unacceptable for loads to be connected even though the generation is maintained unity power factor.

3.2.2 ***Voltage Sink*** This is a major error inducing factor associated with power quality of the wind turbines as it affects machines that are sensitive especially in industries [6]. It normally occurs when the load is connect to wind generator distribution, when the motor of wind generator commence its rotation, and when faults or overload occur within the distribution network [1]. It results into decoupling of the wind generators, which causes instability of the network because of the lost generation.

3.2.3 ***Harmonics*** Harmonics are induced in both wind generation terminal and the terminal of consumption. At the consumption terminal it is found to occur due to non-linear loads such as computers, servers, telecoms and fluorescent lamps [7]. The current induced by non-linear devices link with impedance of the power systems which results into development of harmonics. This harmonics introduces decay in quality of power at the consumption end, increases the loss of generated energy and distortion in the communication network [8]. The level of difference is observed at the PCC, where generation and consumption link. According to IEC61400-21, the harmonics voltage and current of the wind turbines should be within an acceptable and it specifies that the harmonic measurement is required for wind turbines with varying equipped with converters [9]. The measurement of the harmonics at the wind turbine is difficult due to voltage harmonics that natural exist at the grid. The shape of the grid voltage is not sinusoidal and there always 5^{th} and 7^{th}.

3.2.4 ***Flickering*** Wind generation usually generate oscillating output power that result into flickering in the network system. This is another issue associated with power quality of the wind turbines. Flickering is produced by voltage fluctuations as result of load changes.

3.3 Effect of Wind and Solar Generation on the Environment

Another disadvantage of the solar and wind generation is the consumption of land. The power density of conventional energy sources is greater than those of the RES, as such for the RES to achieve the same amount of energy equivalent to the conventional energy, it will require a large amount of space. This relationship can be observe on Table 1 below. The current ESKOM Matimba coal plant produces $6 \times 665MW$ of energy.

Table 1: Area of for different RES power density for a fixed power of 35GW

Renewable Energy	**Power density W/sq.m.**	**Size for 35GW average output**
Biofuel	$\sim 0.2 - 0.4$	87,500-175,000 sq·km
Wind power	$\sim 1 - 2$	17,500-35,000 sq·km
Solar power	~ 25	1400 sq·km
Coal or nuclear power station	~ 4000	8.75 sq·km

3.3.1 ***Replacing Matimba coal plant with wind power*** Using Table 1 and the power produced by Matimba, the proportionality method can be applied to determine the area required to replace the solar Matimba by the solar panels. It will require the area of 3.99×10^9 km^2. This area is 31729 times greater than the area of Limpopo.

3.3.2 ***Replacing Matimba coal plant with solar power*** It will require the area of 1.60×10^8 km^2. This area is 1270 times greater than the area of Limpopo.

4. MICRO-GRID OBSTACLES

4.1 Protection

Figure ?, Appendix ? shows the micro-grid energy system. As shown in the figure, the micro-grid is an integration of energy sources with power bank device operated to satisfy the requirements of the clients [10]. Most of micro-grid distribution system are used in radial mode, which have normally open switches that closes only when faults occur [11]. The power flow within the micro-grid can function in two directions due to connection of DGs at different locations. This implies the protective devices used in the conventional power system will fail in micro-grid. Development of protective measures is required due to failure of protective mechanism used in conventional system.

4.2 Existing Micro-grid Protection Solutions

The operational notion of the micro-grids shows that under normal conditions the micro-grid functions in the grid-connected mode. It should then smoothly disconnect from the utility grid at the PCC and continue to operate as an island during a disturbance in the utility-grid [12]. Appropriate protection to protect the micro-grid should be capable of responding to faults for both the utility-grid and the micro-grid. Figure ? below shows different kinds of protections used in the micro-grid. This protection will be described in detail.

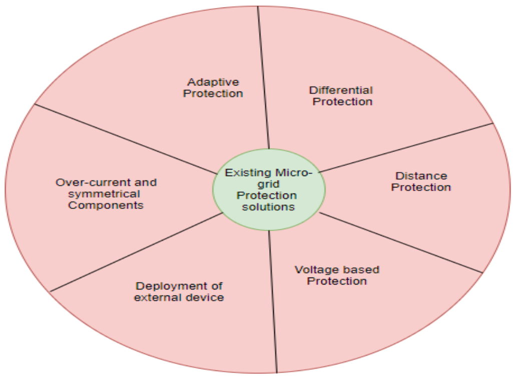

Figure 1: Micro-grid energy system

4.2.1 ***Adaptive protection and their problems*** Ustun et al. [13] provided an adaptive protection which uses communication platform that employs the CPU to control and update the settings of the micro-grid. The tripping settings of the relay are determined anytime an interrupt is captured for either connection or disconnection of the DG. The challenges obtained in this scheme are as follows.

- It requires a large-scale communication framework installation since each DG and relay should connect to the CPU via the communication network.
- The CPU requires a fast processing unit to determine new settings for the tripping whenever the call for interrupt is detected.

Han et al. [14] presented the auto-instant overcurrent protection algorithm. It uses the voltage and fault current to determine the micro-grid and main-grid impedances in the real time manner. It then compares the main-grid and micro-grid impedances and uses the information to update the settings of the relay. Challenges with this method are as follows:

- The method is found to be valid for development of faults within two cycles. When the cycles increase the system is no longer able to offer protection.
- This technique only operates for IIDG micro-grids.

4.2.2 ***Differential protection and their problems*** The model operates under the phenomenon that the current entering the feeder should be equal to the current leaving the feeder. Reference [] presented differential protection to protect the micro-grids. This method managed to observe and prevent the single line-to-ground faults within the micro-grid.

The challenges with this methodology on the micro-grid are as follows:

- The system requires a back-up protection since the communication system can fails.
- The scheme does not function properly with unbalanced load.
- Implementing a communication framework for this scheme is too-expensive.
- The short time during connection and disconnection of DGs courses problems.

4.2.3 ***Distance protection and their problems*** This scheme employs either the admittance or impedance measurement to identify faults and remove the faults from the micro-grid. They key scheme in this field was proposed by Dewadasa et al [15], of which it uses the admittance relay with inverse time tripping characteristics. This relay was able to detect and separate faults from the grid-connected and islanded mode.

The challenges with this methodology on the micro-grid are as follows:

- The measured impedance is negatively affected by the fault resistance, which can lead to mis-calculation of admittance.
- The quality and accuracy of extracting fundamentals is affected by harmonics and transient of the current.
- It is difficult to measure the impedance and admittance for short lines.

4.2.4 ***Voltage-base protection and their problems*** Voltage-based protection employ the voltage of the micro-grid and process it to protect the micro-grid. The main scheme was first developed by Al-Nasseri at al. [16], in which the output voltage of the DG power source are constantly observed and changed into direct current by employing direct-quadrature reference frame. The system is capable of protecting the micro-grid from out and in-zone faults for which it also employs the communication framework. Ho et al. [17] also introduced another method on this field based on positive sequence of voltage.

The key problems linked with the scheme are as follows:

- The protection device malfunction may occur whenever the voltage drop within the micro-grid occurs.
- These methodologies aforementioned cannot identify HIFs (High Impedance Faults).
- The methodologies are designed for a specific micro-grids settings and their zones, as such they are not applicable for micro-grids with different settings.
- The protection device is found to be more sensitive in island mode of operation while it has some defects in the grid connected mode.

4.3 Existing Storage Technologies and their Problems

In order to utilize renewable energy without having problems related to variability and intermittency of energy and also instability of electricity, a properly designed storage system must be implemented in a local power system containing big amount of small-scale RES. Implementing storage for micro-grids is challenging. The disadvantages of potential utility scale storage technologies are described below.

4.3.1 ***Pumped Storage*** Pump storage is one of the storage widely employed globally. However it is found to be benefit economically only in large installations (100MV) [] since it is found to have major environmental effects due to its size and its dynamic behaviour as well. Further more most of places do not have suitable sites for accommodating storage reservoir. Even though the environmental effect of underground pump reservoir storage is minimal, they installation is costly.

4.3.2 ***Battery Storage*** Another possible candidate storage is the battery. Even though the plant capital cost is low, the storage capital cost is always high and the installation for advanced batteries is more costly. Further, the extra volume required for material use in facility scale raises the environmental issues that are difficult to surpass. The battery system cost does not include the replacement cost. The use of batteries in a utility scale storage system is not realistic.

4.3.3 ***Superconducting Magnet*** Large scale superconducting magnets are still under development for energy storage. Small scale systems are already employed for short term dropout protection on electrical equipment such as computers. The high storage cost ($300/kWh) for the for superconducting magnetic makes it economically impractical for the utility scale systems.

4.3.4 ***Flywheels*** Flywheels store energy in rotating machines. The flywheels storage capital cost ($300/kWh) shows that it is impractical to use it in utility scale system especially when the return of investment is not achievable with it.

5. FUTURE RECOMMENDATIONS

In order to improve the quality of power from renewable energy resource and with the hope that they may replace the conventional energy sources the following recommendations can be considered.

5.1 Wind Plant

- The PPC voltage fluctuations can be reduced by the application of inverters on the wind plant to produce reactive power when the voltage of the system is low and absorb the reactive power when the voltage of the system is high. Interfaces such as CC-VSI (Current Controlled Voltage Source Inverter)
- To meet the system harmonic requirements, techniques such as high frequency switching PWM used simultaneously with a harmonic filter can be employed.

6. CRITICAL ANALYSIS

It is observed that replacing Matimba power plant alone requires the area greater thousands times greater than the area of Limpopo for both the solar and wind energy. This results shows that the Wind energy and solar will never replace the conventional energy generators.

Protection is very important when it comes to power system equipment. It is observed from protection section that the micro-grid, which composed of pure RES, fails to be protected by all of the protection schemes introduced in that section. The difficulty in protection occurred as a result of factors such as requirement of back-up of protection, difficulty in measuring the impedance and admittance for short lines, etc. The untripped faults damages the electrical equipment.

The control of voltage fluctuations of the micro-grid requires storage to harness power when the voltage dips and to store power when the voltage increases above the operating point. From the storage section different type of storage technologies where provided, whereby it was observed that they all fail. Most of failure was cost due to the battery not being able to pay itself back overtime.

7. CONCLUSION

The disadvantages associated with the wind energy, solar energy and the micro-grid has been presented. The results shows that RES require a huge area of space to create the equivalent amount of power obtained from the conventional system. This results shows that the is no possibility that the renewable energy sources can replace the conventional system. The micro-grid purely made of RES is found to be vulnerable to faults for which it will cause problems when it is connected to main grid and can also damage the electrical equipment during island mode.

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APPENDIX A

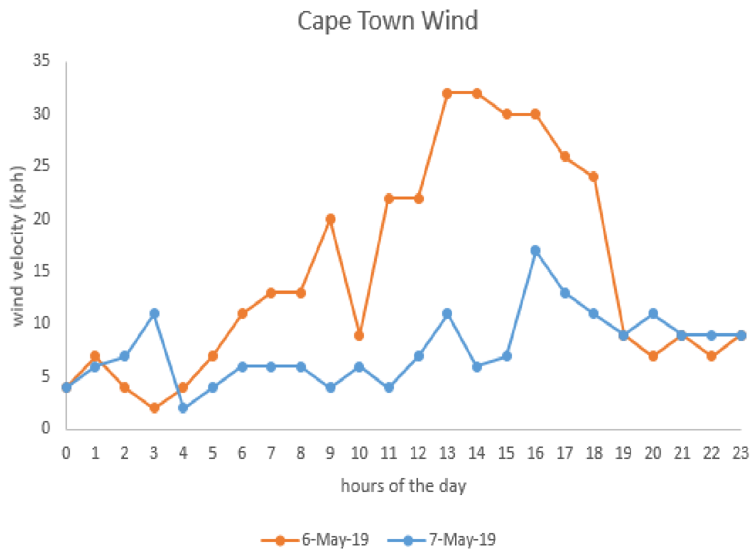

Figure 2: Wind for consecutive days in Cape Town.

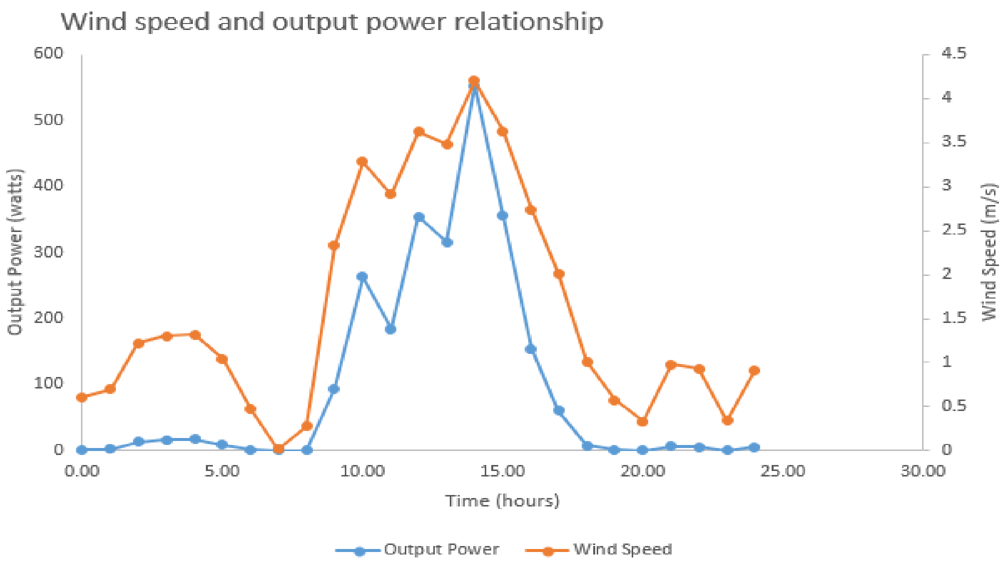

Figure 3: Wind power for given wind speed.

APPENDIX B

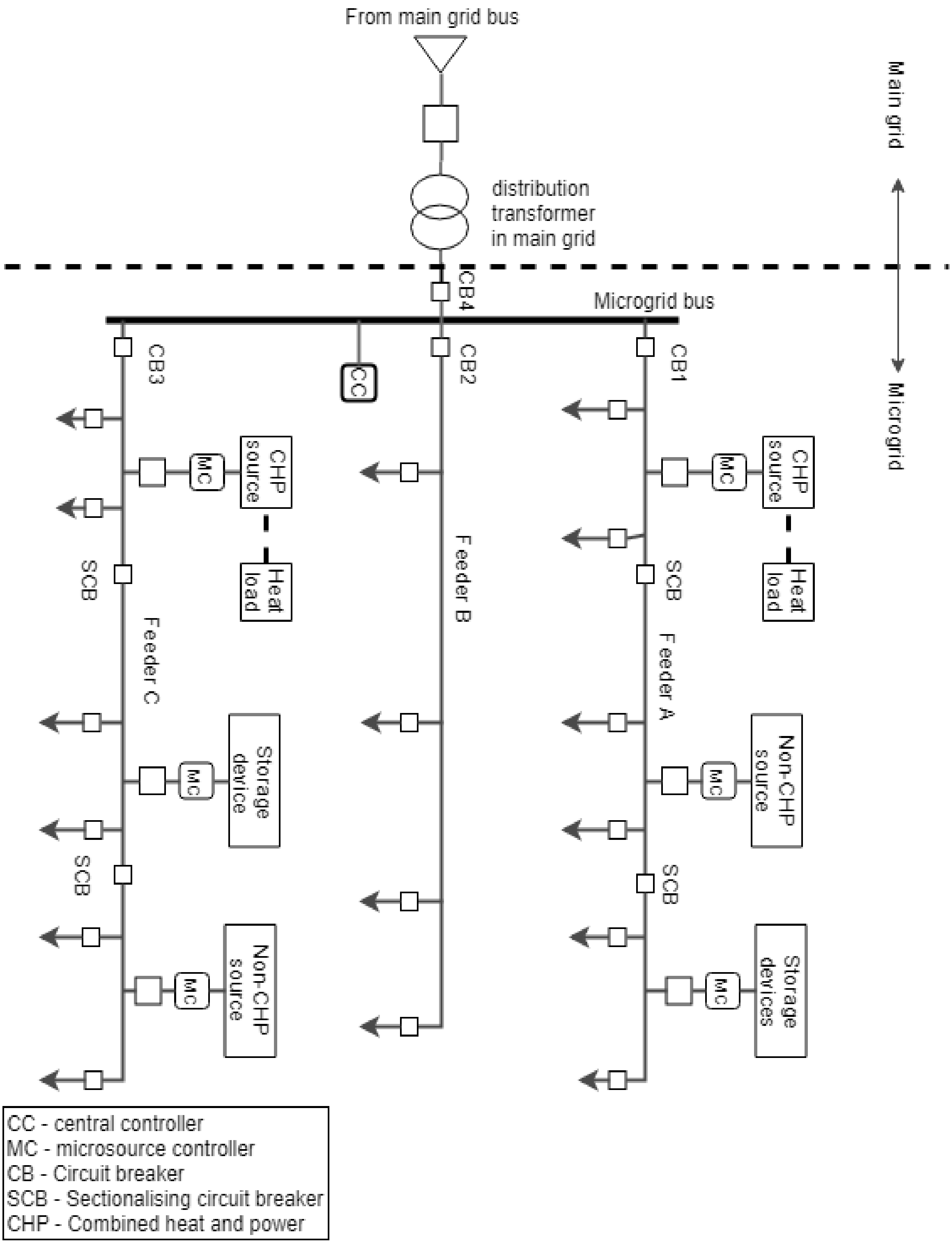

Figure 4: Micro-grid energy system