Modelling and Simulation of a Binary Data-Driven Programming Solution for Hybrid Renewable Energy Systems for Residential Buildings

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ABSTRACT

The purpose of this research study is to model and simulate a Binary Data Driven Programming (BDDP) solution for Hybrid Renewable Energy Systems coined AHREPS – Alternating Hybrid Renewable Energy Power System. This research study employed a computational model for the Otokwu-Mmaku Photo-Voltaic (OMPV) and the Otokwu-Mmaku Wind Turbine (OMWT) renewable energy systems (RES) that was data-driven by a synthesis of data from simple curve-fitted models to a generalized polynomial of order 1 for a 4-year duration (2018 to 2021). The results show details of the AHREPS Power generation for the year 2018 through 2021, the dynamic simulation results of AHREPS model for switching between the solar and wind energy on a monthly and daily-hourly basis and the combination state effect of the AHREPS for future referencing. At the end of this research, conclusions were drawn that the model selection and alternating effect of the proposed AHREPS between the OMPV and OMWT RES can meet the expected load demand of the household in the aforementioned location.

(Keywords: Alternating Hybrid Renewable Energy Power System, AHREPS, Otokwu-Mmaku, wind turbine, solar photovoltaic)

INTRODUCTION

The aim of this research study is to model and simulate a Binary Data Driven Programming (BDDP) solution for Hybrid Renewable Energy Power System for residential buildings. The binary data-driving programming solution for hybrid renewable energy systems will be coined AHREPS – (alternating hybrid renewable energy power system) and will aim to alternate power between two renewable energy systems (solar and wind) to provide constant power supply for residential buildings in the aforementioned location without engaging the solar energy systems battery bank.

The binary data-driving programming solution for hybrid renewable energy systems will be coined AHREPS – (alternating hybrid renewable energy power system) and will aim to alternate power between two renewable energy systems (solar and wind) to provide constant power supply for a household in the aforementioned location. The design is to have the solar energy system providing power for the aforementioned household during the daytime and sunny weathers while the wind energy system provides power as an alternate for the same household during the night-time and rainy/windy weathers. This will help achieve the needed constant power supply and also limit the use of the solar energy systems battery bank.

The above individual systems will be set up as stand-alone or off-grid systems. Note that this design is aimed to give the best results for mini-grids and home systems as it utilizes two important renewable energy sources in two different weather conditions; day-time or sunny weather condition which produces good irradiance for Photo-Voltaic cells and night-time or rainy/windy weather condition which comes with an increased flow of wind for optimum functionality of a wind turbine giving an all-round constant power supply to the estimated load. This research study will also observe the combined state of the hybrid renewable energy power system and its power output for future referencing. The demonstration of the AHREPS will be modeled and simulated in the MATLAB software environments.

IDENTIFIED RESEARCH GAPS

In a hypothetical investigation by (Abdilahi, *et al*., 2014), they incorporated a hybrid solar, wind and diesel generating plant into an off-grid power system, this provided two scenarios where either an RE source is supplying or a non-RE source is supplying power while our approach will capture the alternating of while our approach will capture the alternating of hybrid (solar-wind) renewable energy power system.

In research conducted by Vanukuru, *et al*. (2012), an increased wind farm was designed to generate adequate power as a stand-alone system but we are generating adequate power supply with an alternating hybrid (solar-wind) renewable energy power system.

In research conducted by Modukpe, *et al.* (2020), a model of a wind energy conversion system that operates at different wind speed was simulated and Ogoja wind speed data was used to test the simulation performance. The model demonstrated that wind energy could be extracted in the region even at varying wind speed. For our research study, the wind speed data for Otokwu-Mmaku community was generated through NASA site and was used in the modelling and simulation of an alternating hybrid renewable energy system.

In an analysis done by Lao, *et al.* (2017) based on the shortfall of electricity in developing countries where Cambodia was used as a case study, an isolated grid diesel-based system was used for rural electrification. Three scenarios were considered; diesel-only, diesel/PV and diesel/PV with battery system while our novel approach considered the solar-wind energies in an alternating effect for enhanced power supply and reduced engagement of PV systems battery bank.

The influence of existing battery state of charge on PV array power output in a remote location in Hong Kong was investigated by Ma, *et al.* (2014). Results showed that sufficient battery storage capacity can help achieve higher PV power output ratios and maximize PV energy potentials in a PV stand-alone system. Our research study is clearly aiming to reduce the engagement of the PV stand-alone systems battery bank by alternating two renewable energy sources (solar-wind) to produce a more enhanced and stable power output.

METHODOLOGY

The materials include the data source employed comprising the solar and wind data of the proposed site and the energy usage (loading profile). Also, the needed system specifications based on a net power estimate of the energy potentials of the proposed site is presented. It must be emphasized here that the minimum Renewable Energy (RE) potentials possible is used as the baseline estimate such that the Solar Energy or Wind Energy can still provide meaningful power to the household in the aforementioned community. The representative system architecture in the HOMER® PRO software tool depicted in Figure 1 will form the basis of further studies.

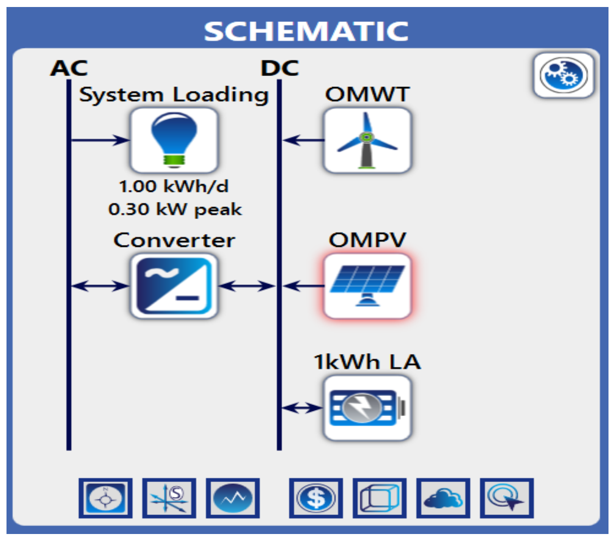

Figure 1: Representative System Architecture in the HOMER ® PRO Software.

LOCATION STUDY

The location for this research study is a household situated at Otokwu-Mmaku Community which is one of the villages at Mmaku, the southern-part of Awgu LGA, Enugu State (https://outravelandtour.com/things-to-know-about-mmaku/) with GPS coordinates 6.121N, 7.454E. The study area is a rainforest and slightly savannah vegetation characterized by high temperature throughout the year (except during Harmattan season), high rainfall with thunderstorms, strong winds and high atmospheric pressures particularly at the Mmaku plateau regions (Egbuna, *et al.*, 2015). This makes it very suitable as a rich source of renewable energy supply.

DATASET DESIGN SPECIFICATIONS

The primary dataset comprises the load profiling data, the solar irradiance data and the wind speed data.

Load Profile

Table 1: Load Profile.

Item Description	Quantity (Qty)	Load (W/Unit)	Total Load (W)	Hourly Utilization (hr/day)
TV	1	80	80	4
Fan	1	75	75	4
Electric bulbs (Lighting)	4	6	24	4
Electric bulbs (Security Light)	2	9	18	12

The load profile data used for this research study is obtained from field studies for a typical rural House-Hold (HH) in equivalent location in Enugu State (Ani, *et al.*, 2015). This data describes a simple power usage pattern comprising several electric bulbs (for lighting and security), a small Television (TV) set, and a small fan. The dataset is as described in Table 1 is entered into the HOMER software tool using the Electric Load component option to generate the HOMER load profile data as shown in Figure 2.

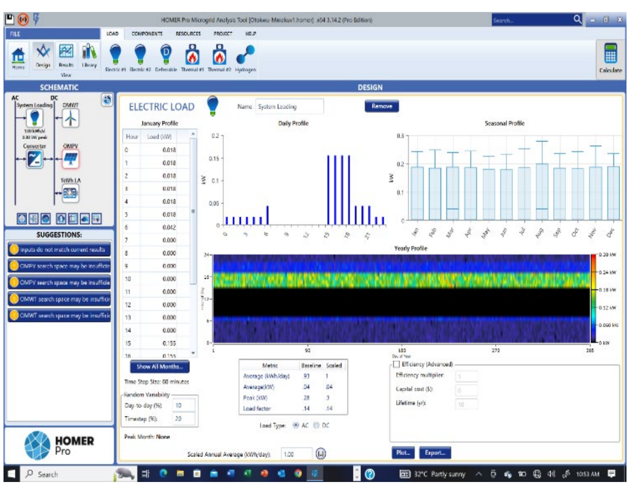

Figure 2: Daily Load Profile in the HOMER® PRO Software Interface.

As can be seen from Figure 2, the average estimated daily consumption is at the baseline of approximately 0.9 kWh/day. This is almost equivalent to a conventional "I better pass my neighbor" generator set.

Solar Irradiance and Wind Speed Data

The monthly direct solar irradiance including the temperature and the wind speed data for the study location in the year 2021 are as provided in Tables 2 and 3, respectively. Previous data for the period of 2018 to 2020 are also considered in this study and are provided in Appendix B.

Table 2: Monthly Average Shortwave Downward Direct Normal Irradiance, Irravg (kWh/m2/day) with temperature, T (°C), 2021.

Month	Irravg (kWh/m2/day)	T(°C)
Jan	5.350	26.130
Feb	5.250	26.430
Mar	4.810	26.570
Apr	**5.610**	26.970
May	4.860	26.440
Jun	4.710	25.750
Jul	4.160	25.080
Aug	4.230	25.120
Sep	**4.140**	25.180
Oct	4.840	25.690
Nov	4.940	26.120
Dec	5.050	24.870

Table 3: Monthly Average Wind Speed, Wspeed (m/s), 2021.

Month	Wspeed (m/s)
Jan	3.500
Feb	3.800
Mar	4.130
Apr	4.200
May	4.060
Jun	3.730
Jul	**4.870**
Aug	4.410
Sep	4.300
Oct	3.990
Nov	**3.230**
Dec	4.070

From the Tables 2 and 3, we can see that the maximum average solar irradiance and wind speed for the given year (2021) is 5.61

kWh/m^2/day and 4.87 m/s, respectively; the maximum values for the solar irradiation and wind speed also fall on April and July respectively. Correspondingly, the minimum average values obtainable for the solar radiation and wind speed is 4.14 kWh/m^2/day and 3.23 m/s respectively and they fall on September and November, respectively.

DETAILED MATHEMATICAL MODELLING OF THE SOLAR PV SYSTEM

The detailed mathematical modelling of the PV system is presented in equations (1) - (11) as described in Wang, *et al*., (2017).

$$I = I_{pv} - I_o\left[\exp\left(\frac{V + IR_s}{aNkT / q}\right) - 1\right] - \frac{V + IR_s}{R_p} \quad \textbf{(1)}$$

Eq (1) computes the current-voltage statistic or I-V curve of the Photo-Voltaic (PV) module; this is necessary to determine the short-circuit current (Isc) obtained when the loading causes the voltage across the PV terminals to drop to zero. The open circuit voltage which is obtained by disconnecting the parallel loading when the current levels is almost zero and the maximum power point which is found by tracking the peak of the I-V curve is seen in Figure 3. Knowing this statistic will help determine Safe Operating Area (SOA).

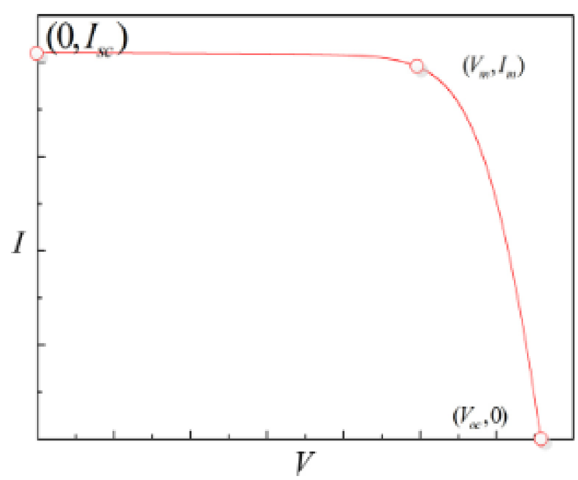

Figure 3: I-V Characteristic of the PV Model Module illustrating Short Circuit (Zero-Voltage) Current, Maximum Power Point (Maximum Voltage-Current) and Open Circuit (Zero-Current) Voltage. (Hart 2010).

$$\left.\frac{dP}{dV}\right|_{V=V_{m.n},P=P_{m.n}} = \left.\frac{dIV}{dV}\right|_{V=V_{m.n},I=I_{m.n}} = I_{m.n} + V_{m.n}\left.\frac{dI}{dV}\right|_{V=V_{m.n},I=I_{m.n}} = 0 \quad \textbf{(2)}$$

Eq (2) indicates that at the maximum power point, the derivative of power with respect to voltage is zero.

$$\left.\frac{dI}{dV}\right|_{V=V_{m.n},I=I_{m.n}} = \frac{\frac{-I_{o.n}}{a_n V_{t.n}}\exp\left(\frac{V_{m.n}+I_{m.n}R_{s.n}}{a_n V_{t.n}}\right) - \frac{1}{R_{p.n}}}{1 + \frac{I_{o.n}R_{s.n}}{a_n V_{t.n}}\exp\left(\frac{V_{m.n}+I_{m.n}R_{s.n}}{a_n V_{t.n}}\right) + \frac{R_{s.n}}{R_{p.n}}} \quad \textbf{(3)}$$

Eq (3) computes the change of current with voltage at the Maximum power point.

$$I_{o.n} = \frac{I_{sc.n}}{\exp(V_{oc.n}/a_n V_{t.n}) - 1} \quad \textbf{(4)}$$

Eq (4) computes the reverse saturation current from the short circuit current at the STC (Isc.n), the open circuit voltage at the STC (Voc.n) and the thermal voltage of the shunted model (internal) diode of the PV module at the STC (Vt.n)

$$\left.\frac{dP}{dV}\right|_{V=V_A,P=P_A} > 0$$
$$\left.\frac{dP}{dV}\right|_{V=V_B,P=P_B} = 0$$
$$\left.\frac{dP}{dV}\right|_{V=V_C,P=P_C} < 0 \quad \textbf{(5)}$$

Eq (5) defines the conditions of parameter estimation and updates.

$$I_{sc.n} = I_{pv.n} - I_{o.n}\left[\exp\left(\frac{I_{sc.n}R_{s.n}}{a_n V_{t.n}}\right) - 1\right] - \frac{I_{sc.n}R_{s.n}}{R_{p.n}} \quad \textbf{(6)}$$

$$I_{pv.n} = I_{sc.n}\frac{R_{p.n} + R_{s.n}}{R_{p.n}} \quad \textbf{(7)}$$

$$I_{m.n} = I_{pv.n} - I_{o.n}\left[\exp\left(\frac{V_{m.n}+I_{m.n}R_{s.n}}{a_n V_{t.n}}\right)-1\right] - \frac{V_{m.n}+I_{m.n}R_{s.n}}{R_{p.n}} \quad \textbf{(8)}$$

Eq (8) describes the current relations due to diode ideality factor (an) and the series resistance component, Rs.n (second term of R.H.S); the series resistance, Rs.n, and parallel resistance, Rs.n (third term of R.H.S); and the light generated current, Ipv.n.

$$R_{p.n} = \frac{I_{sc.n}R_{s.n} - V_{m.n} - I_{m.n}R_{s.n}}{I_{m.n} + I_{o.n}\left[\exp\left(\frac{V_{m.n}+I_{m.n}R_{s.n}}{a_n V_{t.n}}\right)-1\right] - I_{sc.n}} \quad \textbf{(9)}$$

$$R_{s.nr} = \frac{a_n V_{t.n}\ln\left(\frac{I_{sc.n}-I_{m.n}}{I_{o.n}}+1\right) - V_{m.n}}{I_{m.n}} \quad \textbf{(10)}$$

$$R_{s.n} = R_{s.n1} + \left(R_{s.n2} - R_{s.n1}\right) \times dP/dV_1/\left(dP/dV_1 - dP/dV_2\right) \quad \textbf{(11)}$$

DETAILED MATHEMATICAL MODELLING OF THE WIND TURBINES

The aerodynamic power characteristics of a wind turbine depends on air density(ρ) kg/m^2, coefficient of power (Cp), wind turbine swept area (A) m^2 and wind speed (V) m/s. The coefficient of power is a function of tip speed ratio (λ) and blade pitch angle (β). The equation for power (Pw) can be written as:

Pw= 0.5ρAV3Cp (β, λ). **(12)**

On theoretical basis the maximum value of coefficient of power (Cp) is 0.59. The Cp is a fraction of upstream wind power and is captured by the wind turbine rotor blades while the remaining power is discharged to the downstream. To achieve maximum torque for the wind turbines the blade pitch angle (β) is always kept to zero. (Naik, *et al.*, 2014).

TECHNO-ECONOMIC SPECIFICATIONS

The techno-economic dataset including pricing details for generic generating plants of a Solar-PV system and Wind Turbine Generators are provided in Tables 4 and 5, respectively.

TECHNO-ECONOMIC SPECIFICATIONS

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Parameter	Function	Value	Unit
Capacity	Technical	1	kW
De-rating Factor (DF)	Technical	16	%
Capital (C)	Economic	242	$
Replacement (R)	Economic	215	$
Operation and Maintenance (O&M)	Economic	25	$
Life Time	Techno-Economic	5	Years

Table 4: Techno-Economic Data for Solar-PV System.

Parameter	Function	Value	Unit
Capacity	Technical	5	kW
Hub-height (H)	Technical	50	M
Capital (C)	Economic	5,000	$
Replacement (R)	Economic	5,000	$
Operation and Maintenance (O&M)	Economic	500	$
Life Time	Techno-Economic	15	Years

Table 5: Techno-Economic Data for Wind Turbine Generator.

The above Tables 4 and 5 showcasing the techno-economic data of the solar PV and wind turbines shows a low capital and replacement costing for the solar PV system but a very high costing for the initial capital needed to set up the wind turbine system. Also, the replacement cost for the wind turbine system is equally high but it has a longer life span of 15 years than the solar PV system of 5 years.

The considered height of the wind turbine is 50 meters and the capacity is 5kW. The de-rating factor of the solar PV is 16% with a capacity of 1KVA. Both systems have an acceptable operations and maintenance cost.

MODELLING AHREPS – ALTERNATING HYBRID RENEWABLE ENERGY POWER SYSTEMS

To achieve the desired alternating effect, a model that will enable for proper switching will be created and embedded into the Energy-Mix Controller module (Figure 4).

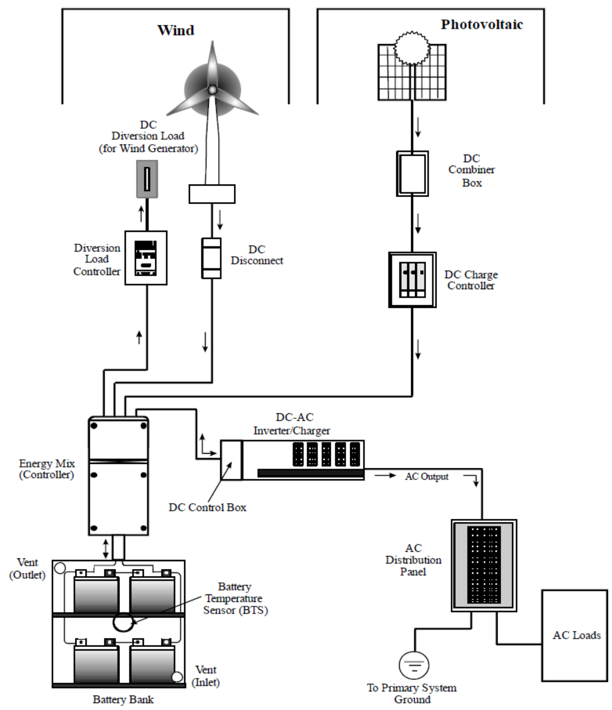

Figure 4: Existing System Architecture (Adejumobi, *et al*. 2011) for which an Improvement is Sought.

The proposed system model implements a generalized control algorithm to solve the minimum energy entry (mee) barrier problem where the Solar Photovoltaic (Solar PV) system is used as the primary renewable energy source and the Wind Turbine (WT) is used as the secondary renewable energy source. Also, the model will analyze the combination state effect for future referencing. In this research study, a binary data-driven logic (pseudo-code) is implemented in the energy mix controller as follows in Listing 1:

Listing 1: The AHREPS Computational Program

MATLAB Codes

A1.1 Main Program (PV_L_model1.m)

```
%% Power-Velocity-Linear Model:
clc;
clear all;
 %% Input Year:
year_input = 2021;
 %% Load data:
Load (['wind_speed_data_' num2str(year_input)]);
Load (['solar_data_', num2str(year_input)]);
 %Coefficients (with 95% confidence bounds):
%% Kinetic Model:
rho = 1.225; % Standard air density kg per m3
Cpmax = 0.40; % Wind Power Coefficient (Utilization Ratio)
A = 32.17; %m^2
Pmwn_theor = (0.5*rho*A*(v.^3)*Cpmax)/1000; %Theoretical Wind Power in kW
%% Updated Power Model - Power-Velocity-Linear (PVL) Model:
Pmwn_theor_updated = (0.3579*v - 0.9002);
%% Solar:
%% Solar-PV:
%constant data
KT = -0.0037;
Isc_stc=5.56;
Voc_stc =45.43;
Ki=0.03;%A/K
Kv=-0.37; %V/K
FF = 0.776;
 %% Fitness section:
%[rcount,cz] = size(x);
%for i=1: rcount
%% Optimization Parameters:
Ns = 2;
Np = 1; %N
%% Peak PV Computation:
%Ppv_pk = (TL/(0.1+((5000/1000)*0.95*0.93)));% == Rated PV power
%% SolarPV Panel Power:
%Voc_n = 2*Ns;
%Voc = Voc_n - (T*kV);
%Isc = Isc_n + Ki*(T - T_n)*(G);
%%
Tc = Tamb + (0.0256*G);
%Ppv = Ppv_pk*(G/Gr)*(1+KT*(Tc-Tr)); %PV Pannel in Watts(W)
Isc = (Isc_stc + (Ki*(Tc - 25)).*G);
Voc = Voc_stc - Kv*Tc;
Ppvout = (Ns*Np*Voc.*Isc*FF)/1000; %PV Pannel in Watts(W)
```

```
bar([Pmwn_theor,Ppvout])
xlabel('Months');
ylabel('Monthly-Daily Power Generation (kWh)');
title (['Monthly-Yearly Power Generation for Year ', num2str(year_input)]);
legend('OMWT','OMPV');
%% AHREPS switching criteria:
[mode_selcet_WT_SolarPV, modes_contribution] = AHREPS (Pmwn_theor_updated, Ppvout)
modes_contribution = modes_contribution.*1;
```

A1.2 Functional Program (AHREPS.m)

```
function [mode_selcet,modes_contribution] = AHREPS(Pmwn_theor_updated, Ppvout)
In = length (Ppvout)
for i = 1: In
if (Pmwn_theor_updated(i,1) > Ppvout(i,1))
mode_WT(i,1) = 1;
mode_PV(i,1) = 0;
else
mode_WT(i,1) = 0;
mode_PV(i,1) = 1;
end
end
mode_selcet = [mode_WT mode_PV];
modes_contribution = (Pmwn_theor_updated + Ppvout) > 1; % > 1kW/hr - Daily-hourly Load
end
```

The essence of the AHREPS as demonstrated in Listing 1 is to identify firstly the winning renewable energy system based on the state representations of Solar PV module system (modePV) and Wind Turbines (modeWT). This state representations are subsequently concatenated and represented as the mode select parameter in their alternating state.

Secondly, the AHREPS program will also evaluate the combined state of the hybrid renewable energy system for future referencing. In the considered dual logic as described in Listing 1, states may either take a value of 0 or 1 and this makes for a Binary-Data-Driven Programming (BDDP) solution.

SIMULATION RESULTS AND DISCUSSIONS

This chapter presents the simulation results of the Alternating Hybrid Renewable Energy Power System (AHREPS) model for constant power supply to a household in Otokwu-Mmaku, Awgu, Enugu State. The results show:

- The electricity production of AHREPS for the aforementioned location.
- The feasibility report of AHREPS
- The power generations of AHREPS
- The switching effect of AHREPS on a monthly and daily-hourly basis.
- The combination effect of AHREPS for future referencing.

HOMER ® PRO SIMULATIONS

Electricity Production of AHREPS

In Table 6 the Otokwu-Mmaku Photo-Voltaic (OMPV) plant and Otokwu-Mmaku Wind Turbine (OMWT) generator electricity generations are 1782 kWh/yr and 1828 kWh/yr respectively; this effectively powers a primary load of 363k Wh/yr. In Figure 5 it can be seen that a large excess electricity of 3200 kWh/yr was obtained.

Table.6: Simulation Results of Electricity Production.

Component/System/Parameter	Electricity Quantity (kWh/yr)
OMPV	1782
OMWT	1828
Primary Load	363

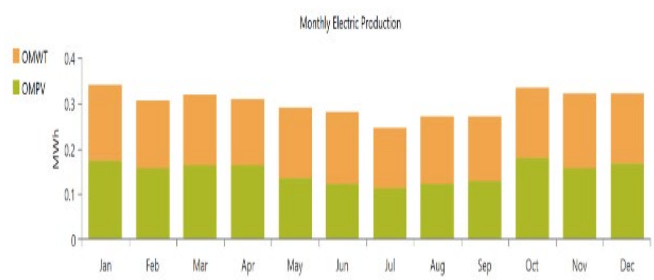

Figure 5: Monthly Production of the Hybrid Solar-Wind Energy.

Feasibility Report of AHREPS

Using the HOMER®PRO software tool, a total of 648 solutions were simulated out of which 502 were feasible and 146 were infeasible due to capacity shortage constraint; a similar simulation reporting can be found in (Ani et al. 2014).

A sample reporting in HOMER software tool is as shown in Figure 6.

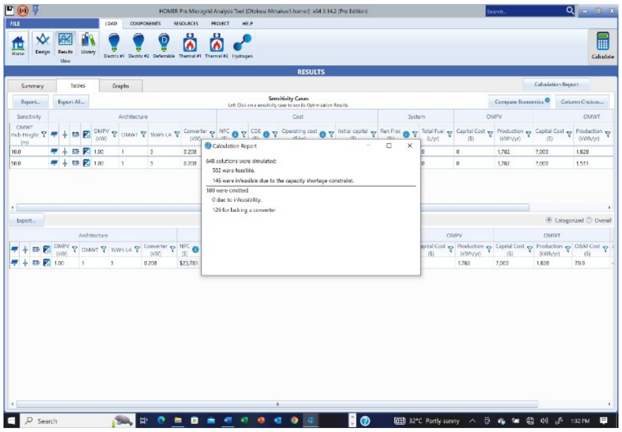

Figure 6: Simulation Report of Hybrid Solar-Wind System in HOMER® PRO Tool/

As can be seen in the pop-up calculation report, 180 solutions were omitted from which 126 were omitted for lacking a converter but there was 0 infeasibility condition due to the omitted solutions. Also, from the simulation report, it can be seen that the HOMER® PRO software tool separated the hybrid Renewable Energy (RE) power systems clearly. The combination state effect in the simulation report also shows that the hybrid renewable energy system can be combined to maintain the required load demand.

AHREPS SWITCHING RESULTS

The AHREPS simulation results using the MATLAB software environment captured the AHREPS switching effect between the solar and wind energy on a monthly and daily-hourly basis and the combination state effect of the hybrid renewable energy power system for future referencing. The switching of AHREPS is automated based on a minimum energy entry baseline set at 0.7 kWh/day as minimum rated and 0.9 kWh/day as maximum rated. The AHREPS selects the higher producing hybrid renewable energy system (solar or wind) that falls within or above the baseline. Basing on the minimum energy entry baseline set, the AHREPS switching time follows the rated inverter switching time policy of less than 300 ms (milliseconds) to determine the hybrid renewable energy system (solar or wind) to select at all times. The battery bank though not aimed to be engaged retains power if there is a shortfall of the hybrid renewable energy system.

Using the mode select criteria based on greater than or less than the load demand, the AHREPS will select using the 0:1 ratio the chosen hybrid renewable energy power system needed to supply the estimated load. The simulation experiments with the AHREPS program revealed that a 1 kVA solar energy system was adopted along with the corresponding Hummer series H6.4-5 KW wind turbine generator; The model select states are as shown in Figures 7 through 9 for the model select state analysis for the years 2018 through 2021.

AHREPS Model Select State Results

The Model Select State analysis for the years 2018 through 2021 are as shown in Figures 7-9.

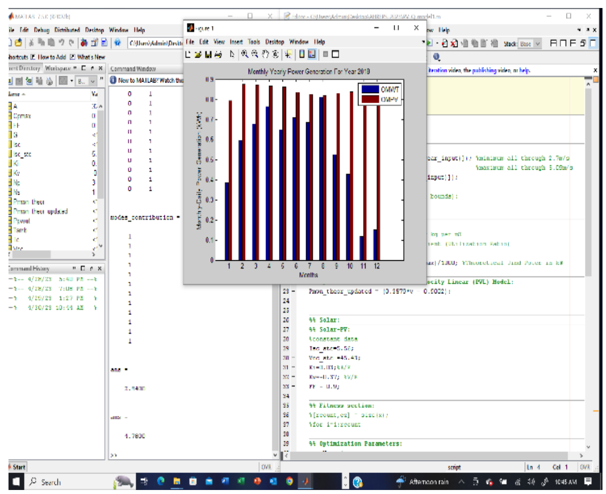

Figure 6: Model Select State (2018).

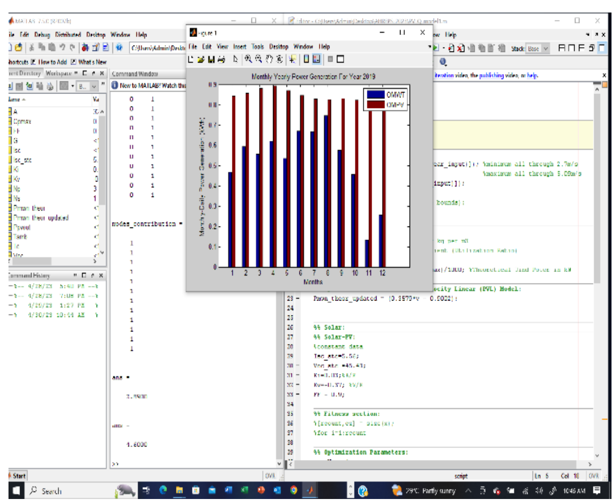

Figure 7: Model Select State (2019).

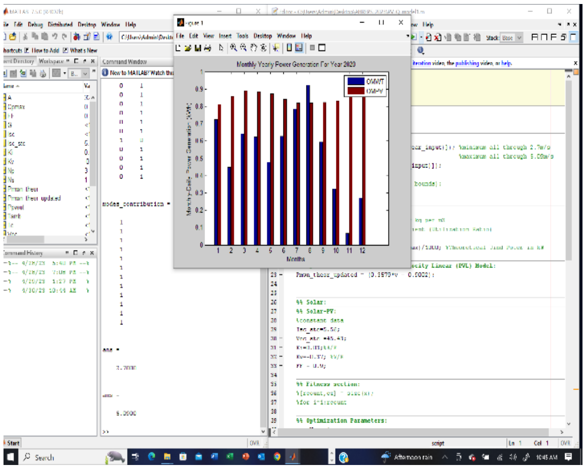

Figure 8: Model Select State (2020).

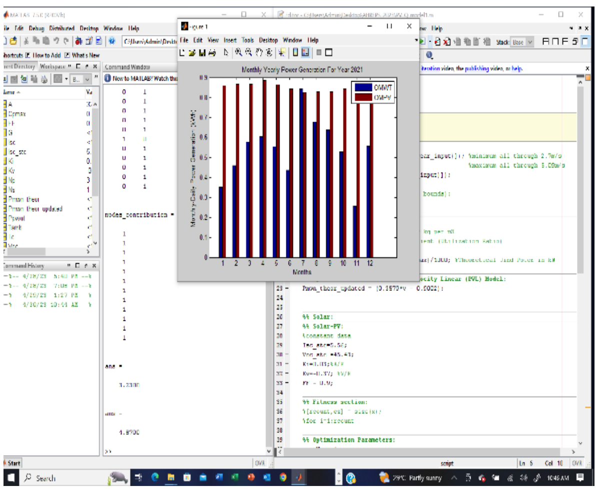

Figure 9: Model Select State (2021).

The results presented thus far show a monthly and daily-hourly analysis and indeed shows the advantage of the binary data-driven technique in the solution process of an alternating hybrid renewable energy power system basing on the AHREPS model. In particular, for the years 2020 and 2021 in Figures 8 and 9 above, it is evident that any one of the hybrid renewable energy power systems (OMPV or OMWT) can attain either a 1 (selected) or 0 (non-selected) state but not both states at the same time. It is also evident that the AHREPS Binary Data Driven Programming (BDDP) solution employed the OMPV REPS for the months of January through June and the months of September through December all through the 4-year duration (2018-2021) but in the months of July and August in (2018) and (2019), the AHREPS program employed the OMPV. In the year (2020), the AHREPS program employed OMPV in July but switched to OMWT in August and in the year (2021) the AHREPS program employed the OMWT in July and switched to OMPV in August and continued with OMPV all through the remaining months of the year as earlier stated above. This proves that the AHREPS has the potential to switch among the hybrid renewable energy power systems to provide continuous power supply for the estimated load. This clearly shows that considering the model selection and alternation of the hybrid (solar-wind) renewable energy power system, the proposed AHREPS model can effectively meet the estimated load demand of the household in the aforementioned location.

Combined AHREPS Simulation Result

The combined (Solar and Wind) numerical presentation of the monthly and daily-hourly generation at Otokwu-Mmaku for the initial aforementioned duration of 4 years is also shown in Figure 10 below and this was also evaluated for future referencing.

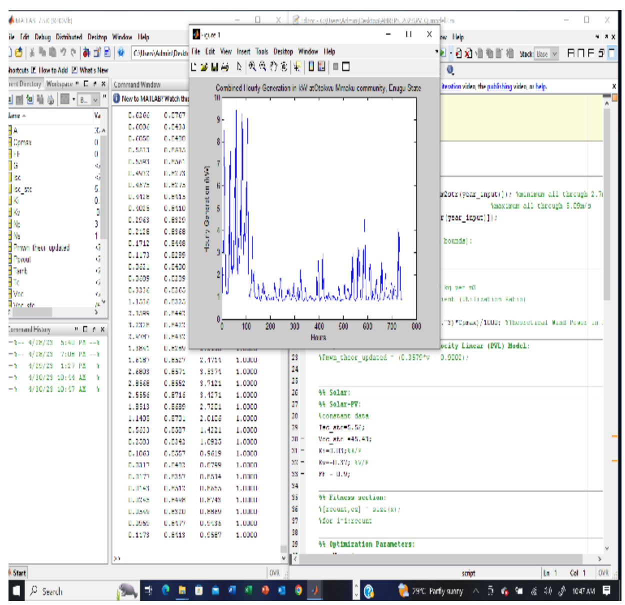

Figure 10: Combined Select State (2018).

The combination state effect as investigated on a monthly and daily-hourly basis in Figure 10 above for future referencing shows clearly that the combined hybrid renewable energy power system on a monthly and daily-hourly basis has the potential to also supply adequately the estimated load demand of 0.7-0.9 kWh/day for the household in the aforementioned location.

CONCLUSIONS

The areas of possible use are primarily centered on the energy sector; particularly in remote and rural locations where access to power grid is almost non-existent. This research study will also be specifically useful in RE planning and optimization operations in the research labs and field. Also, it will be desirous to exploit the benefits of some sort of dynamic optimization program in the AHREPS routine to further enhance the robustness of the AHREPS solution.

CONTRIBUTIONS TO KNOWLEDGE

Strengths

1. The valuation and simulation of a house-hold electricity requirement in Otokwu-Mmaku Community, Awgu, Enugu State.

2. Development of a new Binary Driven Data Programming (BDDP) approach to prioritizing RE systems called the Alternating Hybrid Renewable Energy Power System (AHREPS).

3. The combination effect of a AHREPS for the household in the aforementioned location for future referencing.

4. AHREPS reduced drastically the engagement of the solar systems battery bank.

Limitations

1. The techno-economic analysis conducted shows an increased costing of the wind turbine for the aforementioned location.

2. AHREPS did not completely eradicate the use of the solar systems battery bank.

3. The system takes into consideration the irradiance, temperature and wind speed data of an area/location to function at optimal capacity. This aids system design and sizing. In a case where any of the above conditions are not met, the system may not function optimally.

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