Assessment of Renewable Energy Sources in Morocco using Economical Feasibility Technique

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Abstract- With the growing demand for harnessing renewable energy in the world instead of traditional energies in electricity generation, a diverse assessment of the performance of these energies has become necessary to make the most of them everywhere in the world. This paper addresses the economic assessment of renewable energy resources in different areas of Morocco. The project was implemented to obtain the optimum size and economical cost of the hybrid system at all sites under study in order to assess the available energy sources and find the best components of the system in each region. The Cost, reliability, ecology, and availability are the criteria respected in this study taken into consideration the same power load for all cases. The PSO algorithm was chosen in the proposed research for its effectiveness and simplicity. The results show that the tidal energy is not approved in almost all regions of Morocco for its low speed. The PV/wind is the best configuration that gives a cost-effectiveness system mainly in Dakhla, which comprises the NPC $204467, COE $0.0842/kWh, LPSP 0.05%, Renewable fraction 100% and Availability of 95%. Furthermore, PV panels solar is the best component for production the energy in Morocco because of the high solar irradiation in this region of the world.

Keywords Loss of power supply probability; Microgrid system; Hybrid system; Optimal economic; Net present cost; PSO algorithm; economic assessment.

1. Introduction

The current world is experiencing an increasing rate of energy consumption, which is mostly dependent on traditional energies, while the production of electricity using these conventional energy sources increases the risk of harmful effects of those energies such as greenhouse gas, environmental pollution, and global warming. These problems and crises have made many countries of the world to think carefully to find alternative solutions to these traditional energies based on natural renewable energies [1-3]. Morocco, like any other country in the world, is experiencing a growth in energy consumption due to increasing population growth and energy demand, which has led the state to develop new plans to adopt renewable energy as an essential source of energy in the future. Morocco has excellent and diverse weather, between the sea, stretching from the north to the south-west of the country that characterized by high wind speeds as in mountain regions existed in the north and middle of the country, as well the desert in the south of the state which characterized by high solar radiation. That explains the build of wind parks in the north, precisely on Tangier with six parks around a total of 500 MW and Taza park with 150 MW and the build of PV complex of Noor I, II, and III in the south of the country with a total of 510 MW. Other renewable energies in Morocco are rarely used as sources as the tidal and biomass, whereas in previous studies, a cost-effective system is obtained when multiple resources are combined [4-6].

Many studies treated the sizing of the hybrid system, while the optimal configuration is not a standard size, but it depends on numerous variables such as location, weather, and diverse specification. In [7], the author Treated the energy consumption growth problem by the lighting, where proposed the using of a PV/wind hybrid system with low-power lamps to decrease energy consumption in roads and high ways lights. The optimum design of the hybrid system in this study is solved using the Bat algorithm (BA), while the objective function is both the cost and the reliability presented by the LPSP. In [8], the author investigates the feasibility of the hybrid system to supply a remote rustic school. HOMER was used to evaluate the technical, economic, and environmental factors of the system. A variety of hybrid systems were studied and compared. Finally, a hybrid system consists of PV /wind/battery was optimized by the IWO and IWO-PSO algorithms in [9]. Various methods are used to size hybrid microgrid systems, and the tools are presented mainly by HOMER and algorithm meta-heuristic as PSO, GA, EA, IWO, EMO [10-13]. In the study [14], the authors used Homer software and genetic algorithm to design an isolated hybrid system based on diesel generators, wind, PV, and storage systems composed of a battery and hydro-pumped storage, on the other hand, the author investigates and ensure a level of reliability. The author in [15] studies the pre-feasibility of PV/Wind hybrid system to predict a more cost-effective configuration, be able to cover an energy consumption of 4874 kWh/month and to demonstrate the effect of the geographical features on sizing result. The Homer pro software used for techno-economic optimization based on the net present cost (NPC). Kiymaz et al. performed a techno-economic study of the hybrid renewable energy systems between PV-wind grid-connected and PV-wind-fuel cell stand-alone, taking into account the maximum renewable fraction and lowest cost. This study was investigated using HOMER software [16]. Alaoui Chakib provides an assessment of the offshore energy potential available near the coastline of Morocco and shows the essential offshore wind resources in Mediterranean and the Atlantic coast of this country [17].

In the light of the previous literature, This study focuses on the economic assessment of different renewable energy in various areas of Morocco (Rabat, Dakhla, Tangier, Fez, Oujda, and Agadir) using a smart algorithm (PSO). Besides, the research also aims to study the size of a cost-effective of the hybrid system using PV, wind, tidal, biomass, diesel and battery; this allows the identification of energetic skills and resources in these areas.

The remainder of this paper is structured as follows: Section 2 presents the modeling of all components that used in this study, Section 3 demonstrates economic modeling, Section 4 explains the optimization algorithm, while Section 5 shows the results and discussion.

2. Hybrid system modelling

This section gives a brief description of the studied system shown in Fig.1. The hybrid system composed of Wind turbines, PV panels, tidal turbines, biomass, diesel generators, battery banks, inverters, etc.

2.1. PV modeling

Solar is one of the most important resources of renewable energies, which convert sunlight into electrical energy in the form of a DC current. These cells can be connected in parallel or series to generate the necessary power for the proposed system. The PV power is based on irradiation (*I*), PV efficiency (η_{pv}) and the PV area (A_{pv}). The PV power is expressed as follow [18]:

$$P_{pv} = I(t) \times \eta_{pv}(t) \times A_{pv} \quad (1)$$

The efficiency of PV can be calculated as follow:

$$\eta_{pv}(t) = \eta_r \times \eta_t \times \left[1 - \beta \times (T_a(t) - T_r) - \beta \times I(t) \times \left(\frac{NOCT-20}{800}\right) \times (1 - \eta_r \times \eta_t)\right] \quad (2)$$

Where $NOCT$ is the nominal operating cell temperature (°C), η_r is the reference efficiency, η_t is the efficiency of the MPPT equipment, β is the temperature coefficient of the efficiency, T_a is the ambient temperature (°C), T_r is the photovoltaic cell reference temperature (°C).

2.2. Wind turbine modeling

The wind turbine harnesses the movement of the wind to convert mechanical energy into electrical energy. The generated power of the wind turbine depends on three states as shown [19]:

$$P_{wind} = \begin{cases} 0, \ V(t) \le V_{ci}, V(t) \ge V_{co} \\ a \times V(t)^3 - b \times P_r, \ V_{ci} < V(t) < V_r \\ P_r, \ V_r \le V(t) < V_{co} \end{cases} \quad (3)$$

Where V_{ci} and V_{co} are the cut-in and the cut-out wind speed respectively, a and b are two variables, the rated wind speed is V_r, and P_r is the wind rated power.

$$\begin{cases} a = P_r/\left({V_r}^3 - {V_{ci}}^3\right) \\ b = {V_{ci}}^3/\left({V_r}^3 - {V_{ci}}^3\right) \end{cases} \quad (4)$$

$$P_r = \frac{1}{2} \times \rho \times A_{wind} \times C_p \times {V_r}^3 \quad (5)$$

2.3. Tidal modeling

Tides are more predictable than photovoltaic and wind sources, where the tidal movement is harnessed to produce energy using tidal turbines. Two way to use this technology, the tidal stream (current) which used the kinetic energy of the free-flowing water and the tidal barrage system which makes use of potential energy in height, the second way is the tidal stream energy which is similar to wind energy, except water is denser than air and water flow is much smaller than airflow. The power extracted from the tidal stream system is expressed as follow [12]:

$$P_{tidal(t)} = \begin{cases} 0, \ V_{tidal}(\mathrm{t}) \le V_{ci}^{tidal} \\ \left(\frac{V_{tidal}(t) - V_{ci}^{tidal}}{V_r^{tidal} - V_{ci}^{tidal}}\right)^3 \times P_r^{tidal}, \ V_{ci}^{tidal} \le V_{tidal}(t) \le V_r^{tidal} \\ P_r^{tidal}, \ V_r^{tidal} \le V_{tidal}(t) \end{cases} \quad (6)$$

$$P_r^{tidal} = \frac{1}{2} \times \rho_{water} \times A_{tidal} \times C_p \times (V_r^{tidal})^3 \quad (7)$$

2.4. Biomass modelling

One form of renewable energy is biomass energy. Thermal energy from burning organic materials such as plants and animals is used to produce electrical power. The biomass power P_{BM} can be estimation from the following equation [20]:

$$P_{BM} = \frac{Total_{av} \times 1000 \times CV_{BIO} \times \eta_{BIO}}{8760} \quad (8)$$

Where CV_{BIO} is the calorific value of the organic material, $Total_{av}$ is the total organic material, and η_{BIO} is the biomass efficiency.

2.5. Diesel generator modeling

In this paper, the diesel generator was used as an auxiliary source to support the system and increase its efficiency. The fuel consumption F_{dg} of any diesel generator can be estimated as [21]:

$$F_{dg}(t) = B_g \times P_{dg} + A_g \times P_{dg,out} \quad (9)$$

Where $P_{dg,out}$ is the output power generated, P_{dg} is rated power of the generater, and A_g and B_g are parameters of generator.

2.6. Battery storage modeling

An essential component of the hybrid system components is the battery. It operates on the storage of the surplus power of hybrid power system and uses it if the hybrid system is not able to meet the load demand. The capacity of any battery can be estimated by the following equation [21]:

$$C_{bat} = \frac{E_l \times AD}{DOD \times \eta_{inv} \times \eta_b} \quad (10)$$

Where E_l is the electric load, AD is the daily battery autonomy.

3. Economic and optimization model

3.1. Net present cost

The net present cost (*NPC*) is an important factor in any hybrid system design. NPC for any project is the sum of the total cost of establishing, operating and maintaining the system during its lifetime (*N*) as the capital cost (*C*), the operation & maintenance cost (*OM*), the replacement cost (R), besides the fuel cost for the diesel (FC_{dg}). To improve the precision of the economic estimates there are the critical parameters to consider such as the inflation rate (δ), the rate of the interest (i_r), and the escalation rate (μ). The *NPC* is represented as [11, 18, 22, 23]:

$$NPC = C + OM + R + FC_{dg} \quad (11)$$

The capital cost of any component of the system C_{com} (PV, wind turbine, tidal turbine, battery, inverter, diesel generator) is calculated as:

$$C_{com} = \lambda_{com} \times A_{com} \quad (12)$$

Where λ_{com} is the component initial cost, OM_{com} is the operation & maintenance cost of that components of the system which calculated as:

$$OM_{com} = \theta_{com} \times A_{com} \times \sum_{i=1}^{N} \left(\frac{1+\mu}{1+i_r}\right)^i \quad (13)$$

The replacement cost of any component R_{com} can be calculated as follows:

$$R_{com} = R_{co} \times P_{con} \times \sum_{i=7,14}^{N} \left(\frac{1+\delta}{1+i_r}\right)^i \quad (14)$$

Where R_{co} is the cost of the unit component, P_{con} is the capacity of the replacement units. In addition, fuel cost FC_{dg} can be calculated as follows:

$$C_f(t) = p_f \times F_{dg}(t) \quad (15)$$

$$FC_{dg} = \sum_{t=1}^{8760} C_f(t) \times \sum_{i=1}^{N} \left(\frac{1+\delta}{1+i_r}\right)^i \quad (16)$$

3.2. Levelized cost of energy

The Levelized cost of energy (*LCOE*) is a measure of the energy source that allows comparison of various techniques of electricity production on a consistent basis. it is a very important factor that estimates the cost of each kilowatt per hour. The *LCOE* is calculated by this formula [21]:

$$LCOE = \frac{NPC \times CRF}{\sum_{t=1}^{8760} P_{load}(t)} \quad (17)$$

The capital recovery factor (*CRF*) is calculated to convert the initial cost to an annual capital cost by the following formula [21]:

$$CRF(ir, R) = \frac{i_r \times (1+i_r)^R}{(1+i_r)^R - 1} \quad (18)$$

3.3. Loss of power supply probability

Loss of power supply probability (LPSP) described the reliability of the system. The value of LPSP determines the state of the electrical load is it satisfied or not satisfied by the hybrid system. Which can be calculated as [21]:

$$LPSP = \frac{\sum_{t=1}^{8760}(P_{load}(t) - P_{pv}(t) - P_{wind}(t) + P_{dg,out}(t) + E_{bmin})}{\sum_{t=1}^{8760} P_{load}(t)} \quad (19)$$

3.4. Renewable energy Fraction

The renewable fraction (*RF*) is the fraction of the energy given to the electric load that generated from renewable resources, The RF is formulated as follow [21]:

$$RF = \left(1 - \frac{\sum_{t=1}^{8760} P_{dg,out}(t)}{\sum_{t=1}^{8760} P_{re}(t)}\right) \times 100 \quad (20)$$

Where P_{re} is the sum of hybrid system powers.

3.5. Availability

The availability index *A* defines the quality of the suggested system design which provides the satisfaction of the electric load. The availability can be calculated as follows [23]:

$$A = 1 - \frac{DMN}{\sum_{t=1}^{8760} P_{load}(t)} \quad (21)$$

$$DMN = P_{bmin}(t) - P_b(t) - \left(P_{pv}(t) + P_{wind}(t) + P_{dg,out}(t) - P_{load}(t)\right) \times u(t) \quad (22)$$

3.6. Inequality constraints

The system is fully controlled and satisfied with the economic and environmental aspects, furthermore, this provides high reliability and excellent availability of the hybrid system, some of those conditions can be described as follows:

$0 \le A_{pv} \le A_{pv}^{max}$,
$0 \le A_{wind} \le A_{wind}^{max}$,
$0 \le P_{dgn} \le P_{dgn}^{max}$,
$0 \le P_{Cap\_bat} \le P_{Cap\_bat}^{max}$,
$LPSP \le LPSP^{max}$,
$RF^{min} \le RF$, $A^{min} \le A$,
$AD^{min} \le AD$

4. Particle swarm optimization algorithm

The Particle Swarm Optimization The Particle Swarm Optimization (PSO) is a metaheuristic algorithm, inspired by the social behavior of some nature organisms like birds and fishes. Each particle characterized by its placement and velocity, which are initialized by zero and updated each iteration to find the best fitness inside the search space. The optimal fitness can be local or global, which requires a comparison of each iteration to define the best global [11]. All steps of the PSO algorithm present in the flowchart in Fig.1.

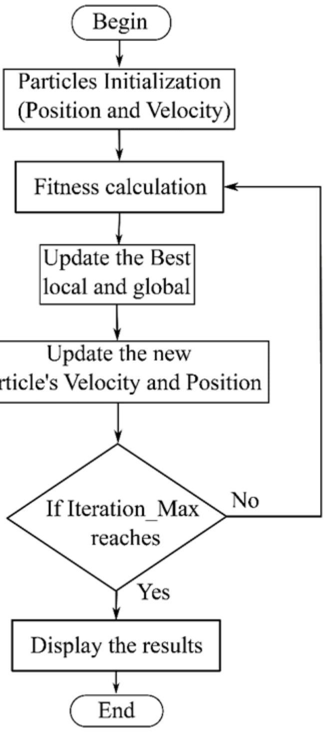

Fig. 1. Flowchart of the PSO algorithm.

5. Results and discussed

This study presented an economic assessing of renewable energy resources in Morocco. Where six cities are chosen in various regions in Morocco, marine, steppe, mountain, and coastal areas are taking to be a diverse and comprehensive study. The cities under study are Rabat (33.943, -6.8504), Dakhla (23.6985, -15.9116), Tangier (35.703, -5.8008), Fez (33.9855, -4.9823), Oujda (34.5767, -1.8951) and Agadir (30.3504, -9.5993) as shown in Fig.2.

The economic feasibility of hybrid energy microgrid systems consisting of PV/wind/diesel/battery/tidal and biomass been studied. The results showed that the three best economically hybrid systems are (PV/wind/diesel/battery), (PV/tidal/biomass/battery), and (PV/biomass).

Figure.3 describes an overview of available components and electrical load which considered in this work. The load is composed of the electric of houses, street lighting, and a traditional shower that consumed the dumped energy. The load peak is 70.2 kWh, all data of load power and meteorological are calculated per hour (as the tidal data shown in Fig.4).

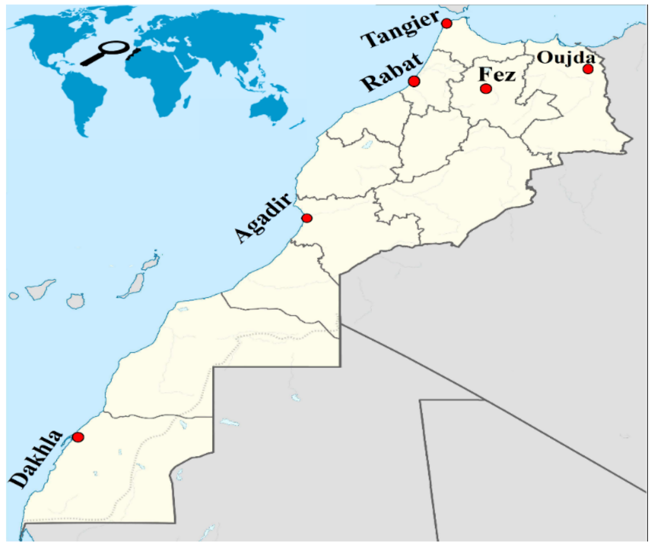

Fig. 2. Morocco maps.

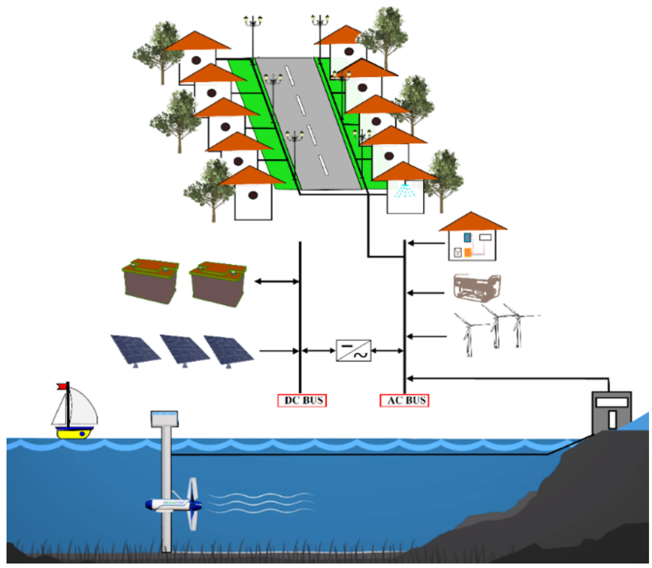

Fig. 3. Microgrid projects; components and loads.

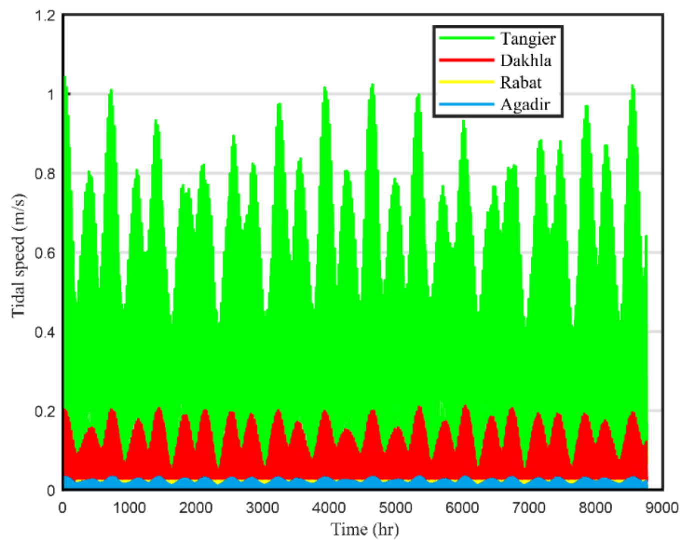

Fig. 4. Tidal currents of the sites under study.

The input parameter economic data is tabulated in Table1, while the PV, wind, tidal, battery, diesel, biomass, and converter data are listed in Table [2-7], respectively. Table 8 represents the limits of the constraints, which help to get high availability of power and excellent reliability of the system, all with a high penetration of renewable energy. The sizing and power management strategies of the hybrid systems are investigated using the PSO algorithm that choosing for its simplicity and effeteness. The algorithm has been coded using the MATLAB editor. The algorithm used ten populations with a variable inertia weight and a maximum iteration of 100.

Table 9 indicates that the hybrid PV/wind/diesel/battery is the economic system in Rabat with 545935 $, while in Dakhla is 204467$, Tangier is 362063$, Fez is 427454$, Oujda is 401064$ and finally in Agadir is 393499 $. Note that in the Dakhla city, the project has the best NPC over the country, while the LCOE is the least expensive with just 0.0842 $/kWh. These results show the high source of irradiation and wind speed on parallel in this area. Table 10 shows the optimal sizing of this hybrid system is 368.7 and 227.633m² for the PV and wind area, respectively, which confirmed the high availability of these renewable sources in those regions. Figures [5-7] show the Matlab simulation results for the optimal three hybrid systems in all Moroccan regions under study, Fig.5 shows the PV/wind/diesel/battery system, which is the best choose found in the Morocco case. The convergence results refer to three categories; the first has a high project cost as Rabat, the second has an excellent project cost as Dakhla, while the third location has medium project cost like most cities in Morocco. Those cities converged in the project cost despite the diverse geography and the meteorological between each other.

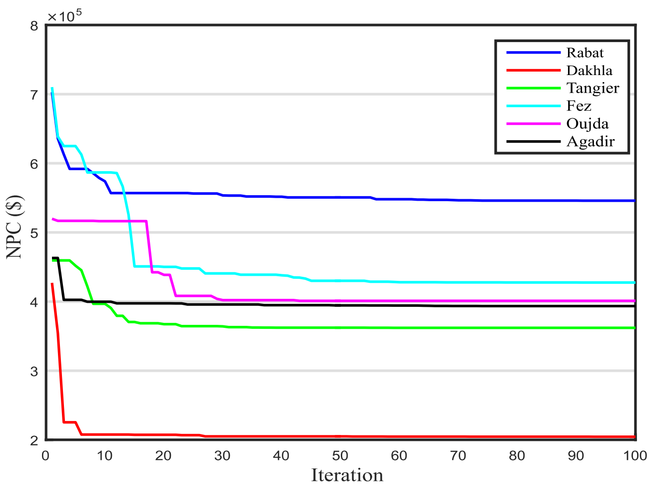

Fig. 5. The Cost of PV/wind/diesel/battery system.

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Figure 6 presents the PV/tidal/biomass/battery system, and the convergence results are almost the same, Fig.7 shows the convergence results of the PV/biomass system, indicate that the PV is the pillar source. The project cost of each location is dependent on its solar irradiation capacity.

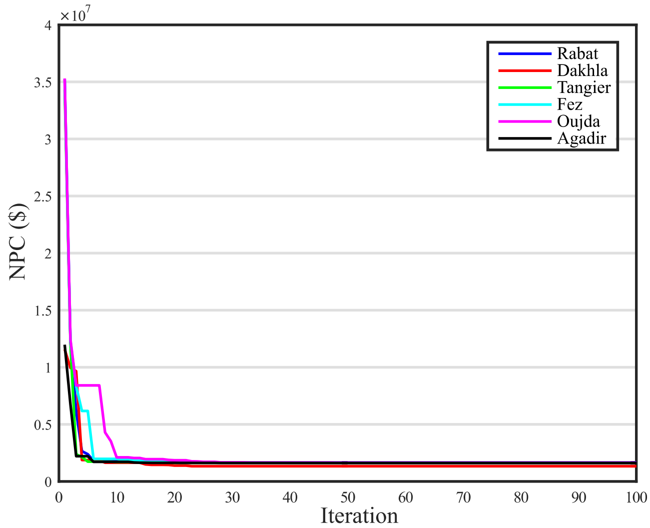


Fig. 6. The Cost of PV/tidal/biomass/battery system.

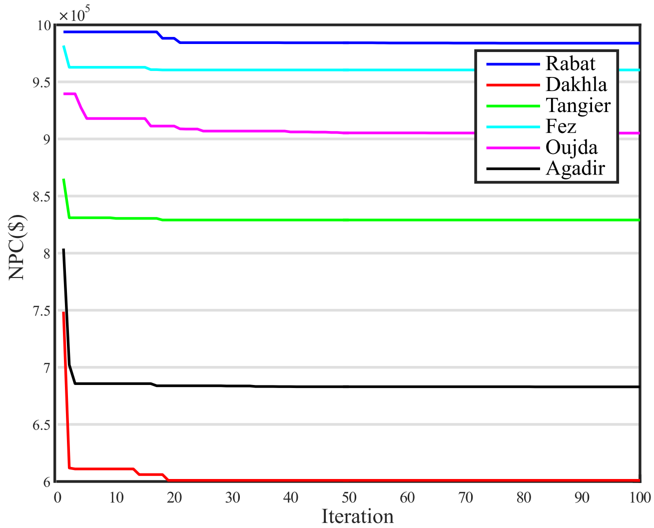


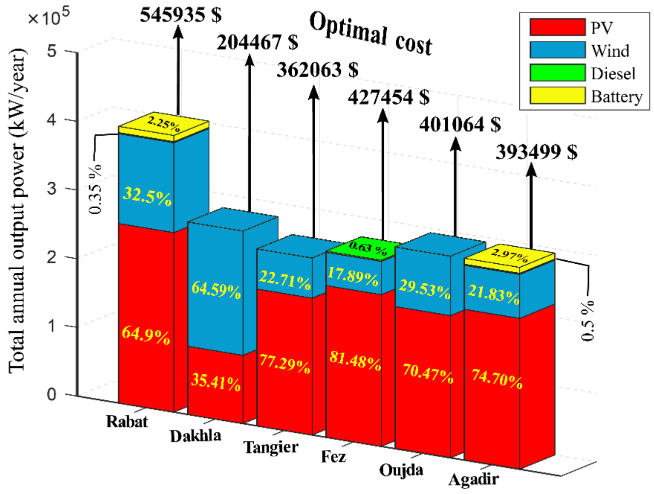
Fig. 7. The cost of PV/biomass system.

Concerning the assessing of renewable energy sources in Morocco, the tidal speed is almost useless except in some specific places because of its low tide speed, which is inferior to 2m/s. In general, the feasible tidal energy project requires regions with spring tides stronger than 2 m/s and neap tides stronger than 1 m/s, and contrarily the tidal energy will be useless. The PV solar is considered as pillar sources in all hybrid systems in these cities, which means Morocco has suitable solar irradiation that could help to build PV cost-effective projects anywhere in the country. As for wind energy, the wind speed is a perfect across the country with a total of 30000 m/s in the year mean 4 m/s on middle, while in Dakhla city that has an excellent wind speed with a total of 58000 m/s per year; it around 6.7 m/s in the middle and 12.55 m/s in max.

Figure 8 demonstrates a summary of this study, which shows that Dakhla city has perfect meteorological data to obtain the best project cost with 204467 $ and 0.08 $/kWh

with the percentage of each source's participation in the hybrid system.

The results demonstrated that Morocco has excellent and diverse weather all through the country, where the PV and wind system found is the best hybrid system to overcome the fluctuating weather, raising the reliability, and increasing efficiency of the system. Also, the PV solar produces energy always more of other components, except in Dakhla location where wind turbine produces 64.59% from total energy while the PV panels produce the rest of energy. Finally, the results showed the ability of the PSO algorithm to achieve the optimal solution with high precision and fastness.



PV/wind/diesel/battery hybrid system

Fig. 8. The optimal hybrid system in the cities under study.

6. Conclusion

Morocco has plans to meet its energy needs by the full exploitation of renewable energies, mainly with solar energy parks and wind farms. The fertile climate in this region explains the country's tendency to build and evaluate such systems. This research focuses on assessing renewable energy sources in Morocco using the economical feasibility technique based on the optimization of NPC. The optimal sizing and power management strategies of the hybrid systems are achieving used a smart algorithm (PSO). The proposed technique has been programmed with MATLAB. Subsequently, the economic feasibility of the project was compared among many Moroccan regions with a diverse climate, and many factors were considered and mainly the reliability. The results show that Morocco has excellent climate data, especially in Dakhla city, where the high solar irradiation and wind speed both. However, the hybrid PV/wind system is optimal economic with 0.0842$/kWh and ecologic, which should take him seriously by the state instead of the PV parks or wind farms only.

In future work, the focus is on looking at the evaluation of new hybrid microgrid energy systems in the areas under study. As well as the evaluation of renewable energy in other regions of Morocco, in addition to developing small domestic wind turbines, mainly in northern Morocco, which is interesting because of the high wind speed In these areas.

Table 1. Input parameter economic data

PV initial cost	325	$ /m²
Annual O&M cost of PV	0.01× λ_{pv}	$ /m²/year
Reference efficiency of the PV	15	%
Efficiency of MPPT	100	%
PV cell reference temperature	25	°C
Temperature coefficient	0.005	°C
Nominal operating cell temp.	47	°C
PV system lifetime	20	year

Table 2. PV parameters

Project lifetime	20	year
Interest rate	6	%
Escalation rate	7.5	%
Inflation rate	8	%

Table 3. Wind and tidal parameters

Initial cost	λ_{wind}	85	$ /m²	λ_{tidal}	125	$ /m²
Annual O&M cost	θ_{wind}	0.01× λ_{wind}	$ /m²/y	θ_{tidal}	0.01× λ_{tidal}	$ /m²/y
Max. power coeff.	C_{p_wind}	0.4	%	C_{p_tidal}	0.4	%
Cut-in wind speed	V_{ci_wind}	3	m/s	V_{ci_tidal}	0.7	m/s
Cut-out wind speed	V_{co_wind}	25	m/s	V_{co_tidal}	5	m/s
Rated wind speed	V_{r_wind}	11	m/s	V_{r_tidal}	2.4	m/s
Wind system lifetime	N_{wind}	20	year	N_{tidal}	20	year

Table 4. Biomass parameters

Biomass initial cost	400	$ /kW
Annual fixed O&M cost of the biogas system	0.05× λ_{bg}	$ /kW/year
Annual variable O&M cost of the biogas system	0.0042	$ /kWh/year
Biomass fuel cost of the biogas system	45	$ / ton /year
Tidal system lifetime	20	year

Table 5. Diesel parameters

Diesel initial cost	260	$ /kW
Annual O&M cost of diesel	0.05	$ / h
Replacement cost	210	$ /kW
Fuel price in Rabat	1.04	$ /L
Diesel system lifetime	7	year

Table 6. Battery parameters

Battery initial cost	85	$ /kWh
Annual operation & maintenance cost of Battery	0.03× λ_{bat}	$ /kWh/year
Depth of discharge	80	%
Battery efficiency	85	%
Minimum state of charge	20	%
Maximum state of charge	80	%
Battery system lifetime	5	year

Table 7. Inverter parameters

Inverter initial cost	400	$ /m²
Annual O&M cost of inverter	20	$ /year
Inverter efficiency	97	%

Table 8. Limits of constraints

Maximum PV area	A_{pv}^{max}	1350	m²
Maximum wind swept area	A_{wind}^{max}	1350	m²
Maximum tidal swept area	A_{tidal}^{max}	1350	m²
Maximum biomass swept area	$A_{biomass}^{max}$	1000	Ton/year
Maximum rated power of diesel generator	P_{dgn}^{max}	30	kW
Maximum nominal capacity of battery	$P_{Cap\_bat}^{max}$	35	kWh
Maximum loss of power supply probability	$LPSP^{max}$	5	%
Minimum renewable fraction	RF^{min}	70	%
Minimum Availability	A^{min}	95	%

Table 9. hybrid system factors result

Location	Hybrid system	NPC ($)	LCOE($/kWh)	LPSP (%)	Av (%)	RF (%)	AD (h)
Rabat	PV/wind/diesel/battery	545935	0.224	0.05	97.23	99.6	32
	PV/tidal/biomass/battery	1648063	0.678	0.046	96.68	//	12
	PV/biomass	983898	0.405	0.05	95	//	//
Dakhla	PV/wind/diesel/battery	204467	0.0842	0.05	95	100	0
	PV/tidal/biomass/battery	1333175	0.549	0.0427	97.179	//	12
	PV/biomass	600992	0.2475	0.05	95	//	//
Tangier	PV/wind/diesel/battery	362063	0.1491	0.05	95	100	0
	PV/tidal/biomass/battery	1625988	0.6696	0.047	97.648	//	32
	PV/biomass	829040	0.3414	0.05	95	//	//
Fez	PV/wind/diesel/battery	427454	0.176	0.05	95.421	99.363	0
	PV/tidal/biomass/battery	1634504	0.6731	0.0411	97.055	//	12
	PV/biomass	960450	0.3955	0.05	95	//	//
Oujda	PV/wind/diesel/battery	401064	0.1652	0.05	95	100	0
	PV/tidal/biomass/battery	1644383	0.6772	0.0429	96.96	//	12
	PV/biomass	905184	0.3728	0.05	95	//	//
Agadir	PV/wind/diesel/battery	393499	0.1621	0.05	97.322	99.464	32
	PV/tidal/biomass/battery	1612908	0.6642	0.0388	98.173	//	32
	PV/biomass	682984	0.2813	0.0489	95.109	//	//

Table 10. hybrid systems sizing results

Location	Hybrid system	PV(m²)	Wind(m²)	Tidal(m²)	Biomass(ton/year)	diesel(kW)	battery(kWh)
Rabat	PV/wind/diesel/battery	966.64	564.463	//	//	0.5831	35
	PV/tidal/biomass/battery	1350	//	0	2.68	//	13.16
	PV/biomass	1286.8	//	//	937.25	//	//
Dakhla	PV/wind/diesel/battery	368.7	227.633	//	//	0	0
	PV/tidal/biomass/battery	699.8	//	0	2.6835	//	13.1783
	PV/biomass	643.58	//	//	1000	//	//
Tangier	PV/wind/diesel/battery	735.07	207.110	//	//	0	0
	PV/tidal/biomass/battery	1350	//	0	2.68348	//	35
	PV/biomass	998	//	//	1000	//	//
Fez	PV/wind/diesel/battery	826.4	238.78	//	//	0.5367	0
	PV/tidal/biomass/battery	1350	//	0	2.6835	//	13.1627
	PV/biomass	1161	//	//	1000	//	//
Oujda	PV/wind/diesel/battery	770.4	345.82	//	//	0	0
	PV/tidal/biomass/battery	1350	//	0	2.6835	//	13.1627
	PV/biomass	1227.2	//	//	957.53	//	//
Agadir	PV/wind/diesel/battery	713.03	321.1495	//	//	0.5675	35
	PV/tidal/biomass/battery	1350	//	0	2.6835	//	35
	PV/biomass	808.83	//	//	1000	//	//

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