OPTIMAL DESIGN ANALYSIS OF STANDALONE STREETLIGHT SYSTEM

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Abstract— **The uncertain nature of renewable energy sources has resulted the system design being unreliable. A hybrid system makes these energy systems more economical and reliable.Optimization of standalone hybrid renewable energy storage (HRES) is done for street light application. We mainly focuses to combine optimization process in supply side of street light..optimization is aimed to get better configuration with minimum loss and minimum cost. In this study, HRES street light uses photovoltaic (PV) as main supply, battery as storage supply and fuel cell (FC) as backup supply. Simulation of the system is done with the help of MATLAB.It is proposed to minimize loss of power supply probability LPSP and cost of energy(COE) to get better configuration**

***Index Terms*—Hybrid standalone street light systems,HRES Optimization,PSO,Street light**

I. INTRODUCTION

The energy which is harvested from the natural resources like sunlight, wind, tides, geothermal heat etc. is called Renewable Energy. As these resources can be naturally replenished, for all practical purposes, these can be considered to be limitless unlike the conventional fossil fuels. Renewable energy can replace these conventional fuels.In earlier days renewable energy is taken as single supply.but the combination of two or more renewable energy can increase their efficiency. combination of renewable energy is called Hybrid Renewable Energy Systems

One of the application of Hybrid Renewable energy system is street light system.The installation of street lamps in a city requires complex and expensive work. Moreover, to supply the lamps, an electrical network is needed. The problem is the same in remote areas where illumination is needed, as for instance on road sides. Stand-alone systems are commonly powered by solar cells with a battery to store the energy. However in regions that are far from the equator, this system cannot work all the yearlong because the solar power is weak and varies significantly according to seasons. Some studies have been conducted in term of HRES implementation.

Bernal and Rudolfo [4] present optimization HRES between PV-Wind-Battery system using simulation and optimization software. The research is aimed to find configuration with desired Net Present Cost (NPC) and Levelized Cost of Energy (LCE) as objective. Bashir and Sadeh [5] conduct the research to optimize standalone hybrid system PV-Wind-Battery using Monte Carlo algorithm. Zou and Sun design the PV -Wind system using multi-objectives optimization algorithm [6]. Optimization process is combined between Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) to optimize cost of system and reliability as objectives. Load management has been proven to enhance HRES optimization. In street light application, load management is implemented to control and optimize lighting intensity and hence lighting power consumption. Poppa [1] has studied intelligent load management that can be implemented to increase efficiency of street light system. Dynamic lighting control [1] is one kind of load management which can be implemented. In this paper, dynamic lighting control is implemented to manage lighting side with dimming method based on traffic flow condition

II. ARCHITECTURE OF THE SYSTEM

A. System Description

HRES standalone streetlight system consists of photovoltaic (PV),battery and fuel cell(FC). The FC should work during critical periods, which occur in winter. when the load is the largest (long nights) and the photovoltaic source is very weak. When the battery SOC reaches a low level (for instance 30 %), the FC starts supplying the load. When the load is switched off (i.e. during the day), the FC and the PV charge the battery simultaneously. In this way, the FC is prevented from starting and stopping each day, which would cause the FC lifetime to decrease rapidly. Finally, when the battery reaches its normal SOC, which can be even different from 100 %, the FC is turned off. The hybrid system layout is shown in fig 1.

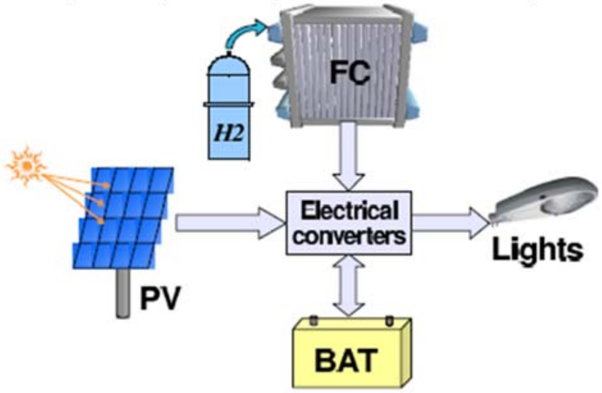

Fig 1:hybrid system layout

B. Photovoltaic model

Photovoltaic generates the power from solar radiation
which is converted into electrical voltage [2]. Generated power from photovoltaic is influenced by kind of photovoltaic cell.For photovoltaic cells, three commercialized silicon technologies are currently available: amorphous, polycrystalline and monocrystalline. There are some parameters which affect the photovoltaic power, where Ins is solar radiation in coverage area of pv (Apv), and power efficiency from pv ..

C. Battery

A lead-acid battery is commonly associated with stationary
solar systems. In this application, this type fits well with the system: a very fast response time is not necessary since the load is always constant, and the large weight of this battery has no influence in stationary applications. The battery efficiency ηb is assumed to be 80 %.Battery capacity is determined by the state of charge (SOC).

$$SOC(t) \quad = 1 - \frac{Ibatt * t}{C}$$

D. Fuel cell

Power is generated from hydrogen and convert it to electric power.FC power is controlled by battery condition.it will start when battery is low and will be stop when its capacity is high.

E. Lighting model

Street light uses lamp as load. For enhancement, lighting system is controlled to reduce power consumption with dimming method. Maximum power wattage from lighting system is 112W

F. Cost Analysis

The output energy is calculated as the sum of photovoltaic, fuel cell and battery. Loss of Power Supply Probability (LPSP) is used as objective function of optimization related with reliability of system. Loss system will be calculated for each time (t) to get probability loss from the system.

$$LPSP = \frac{\sum_{t=1}^{T} Pload - Ptot}{T}$$

Cost of energy (COE) means the total cost of the system which includes cost of PV,cost of FC and cost of battery.

G. Sizing optimization

The proposed study uses particle swarm optimization in order to obtain the optimal system. The particles in PSO algorithm continuously update the knowledge of the given searching space based on their current position, memory and cooperation of the social behaviour of the swarm. Basically their position and their velocity. Optimization process is started by selection initial configuration and its power generation

PV Capacity, FC Capacity, Battery Capacity, SOC min and SOC max are the parameters that are used for the PSO optimization. These parameters are the state variables for the search space and thus characteristics of the potential solution.

H. Optimization results

ALGORITHM:

Begin: *input the weather data*

Initialize the PSO parameters

Randomly generate an initial population

While *max iteration is not reached* **do**

Calculate the fitness value for the Particles.

Obtain the next generation by updating the velocity and position

→*Update the pbest and gbest in each iteration*

→ ***Return*** *global best individual in the population*

Fig 2: algorithm for pso

The main parameters of the optimization model are:

□ Maximum Number of Iterations (Max. Iter) : 50,000

□ Number of Particles: 20,000

□ Inertia Weight, w: 0.729

□ [c1,c2]: [1.495,1.495]

The typical performance of PSO in finding the optimal configuration of the hybrid system is shown in Fig. 3. The graph clearly shows that the swarm of particles converge to the fitness value of €506.605. Due to space limitation, the evolution trends of individual parameters have not been presented in this work, however the optimal solution set corresponding to these parameters is meticulous in Table 1.

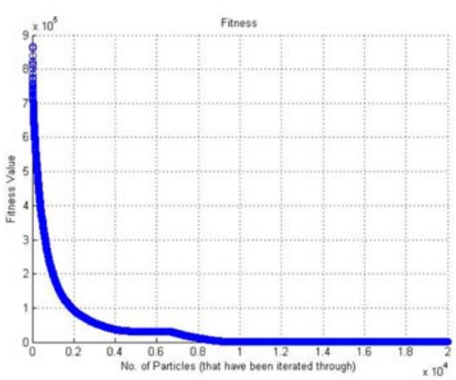

Fig 3:PSO convergence to the gbest

The optimization results without load management is given

Table 1: optimization parameters

	PV(W)	Battery(kWh)	FC(W)	COST
Value	88	2.12	237	
	SOC max(%)	SOC min(%)	LPSP	507
Value	90	40	0	

In Table 1

III. SUMMARY

This paper presented a methodology for optimal sizing of a hybrid standalone system by PSO method. The optimal energy system configuration comprise of 88W PV module, 237W fuel cell and 2.12 kWh battery that can power a LED street light application all the year at a total annualised lifetime system cost of €506. The methodology of optimisation is based on PSO using five optimization parameters to enhance the search space. Moreover, reliability constraint such as sizing penalty factor is taken into account with control parameters like the battery SOC, starting or stopping FC cycles in the optimization algorithm. The results of the proposed algorithm are validated with more economical and reliable system sizing . Moreover, PSO require lower number of convergence cycles to reach the best solution

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