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Minimization of Operational Cost for an Islanded Microgrid using a Real Coded Genetic Algorithm and a Mixed Integer Linear Programming Method

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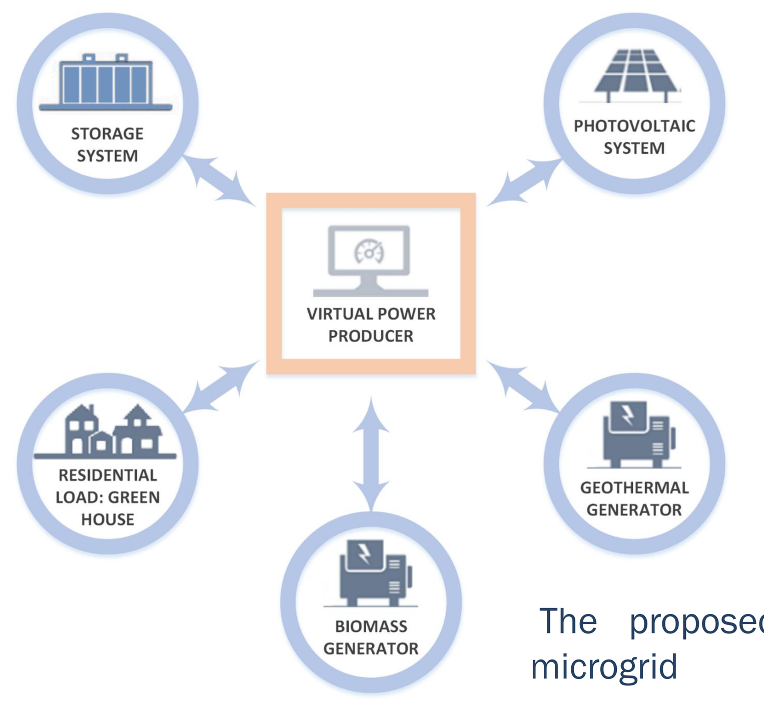
1. Introduction

Two different algorithms were applied to achieve the optimal scheduling of a PV panels-geothermal-biomass smart microgrid. Both methods, the **Genetic Algorithm (GA)** and the **Mixed-Integer Programming (MILP)** solution, are widely used to solve single-objective multi-variable constrained optimization problems.



The proposed smart microgrid

2. Microgrid Description

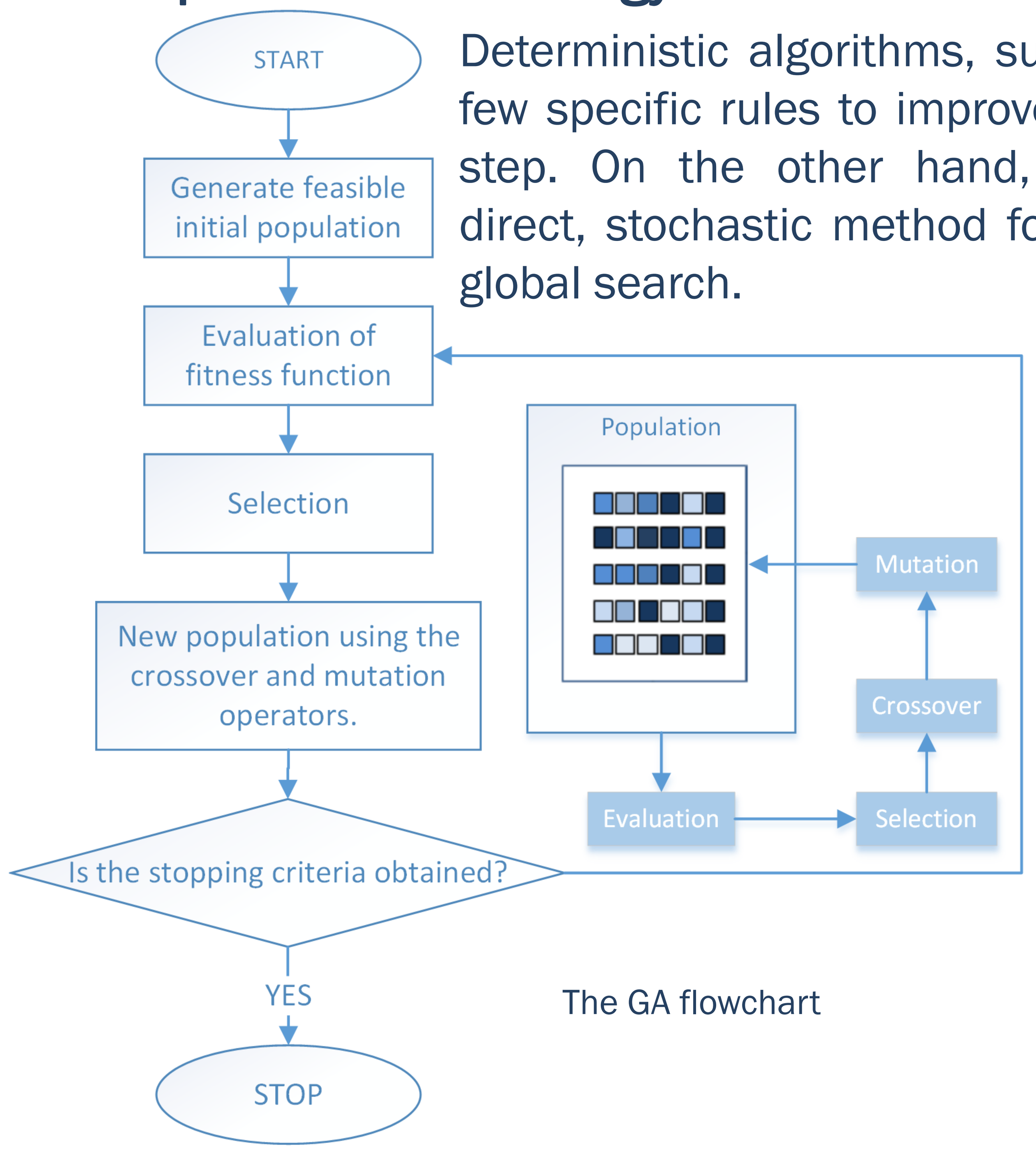
The proposed microgrid contains two generators (geothermal – 3kW and biomass – 3kW) and a PV system (14 panels, 250 kWp/each). A storage system is also required (8 batteries, 250Ah, 12V). The consumer is a vegetable greenhouse. The sizing of the proposed microgrid takes into consideration the meteorological and geographical data of the city Oradea, in Romania.

The Virtual Power Producer is a vital part of the Supervisory Control and Data Acquisition System (SCADA) which is responsible for the communication and control.

All presented units are connected; they communicate with the SCADA through an RS-485 network.

3. Proposed Methodology

Deterministic algorithms, such as MILP, use a few specific rules to improve solutions step by step. On the other hand, GA represents a direct, stochastic method for optimization and global search.



The GA flowchart

4. Mathematical Formulation

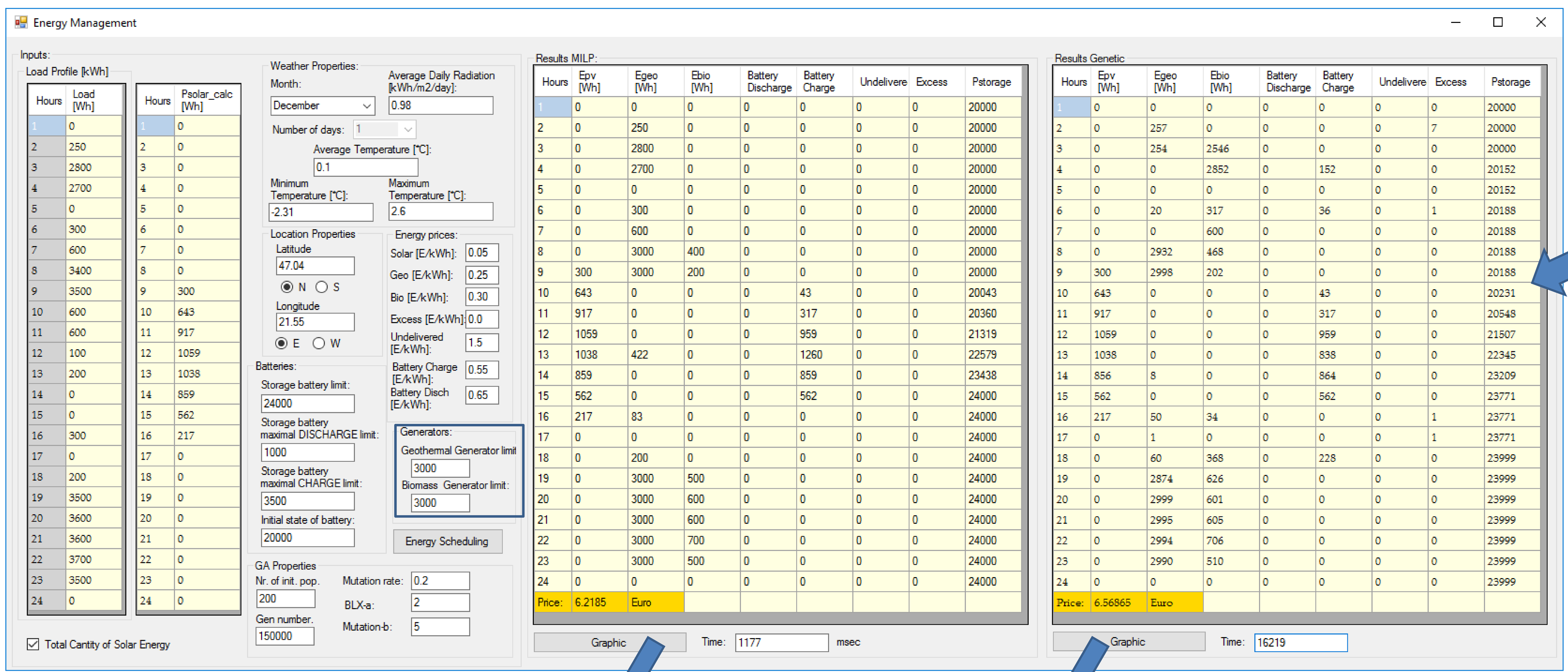
The economic dispatching and optimal scheduling of the connected units in power systems is a fundamental issue. The aim is to minimize the operation cost considering the limitations and restrictions of the system.

In this paper, this issue is handled as a multi-variable single-objective constrained optimization problem which can be solved using GA or MILP methods.

Objective function:	$C_{min} = \sum_{t=1}^{24} \left(E_s(t) \times C_s + E_{geo}(t) \times C_{geo} + E_{bio}(t) \times C_{bio} + E_{bat} \times C_{bat} + E_{un}(t) \times C_{un} - E_{ex}(t) \times C_{ex} \right)$
Power balance:	$E_s(t) + E_{geo}(t) + E_{bio}(t) + E_{bat}(t) + E_{und}(t) - E_{ex}(t) - E_L(t) = 0$
Solar, geothermal and biomass energy limits:	$0 \le E_s(t) \le E_{s\_max}(t),\ 0 \le E_{geo}(t) \le E_{geomax},\ 0 \le E_{bio}(t) \le E_{bio\_max}$
Charge- and discharge limit of batteries:	$-3500 \le E_{bat}(t) \le 1000$
The batteries' state balance:	$P_{storage}(t) = P_{storage}(t-1) - E_{BDsch}(t) + E_{BCh}(t),\ 0 \le P_{storage}(t) \le P_{S\_max}$

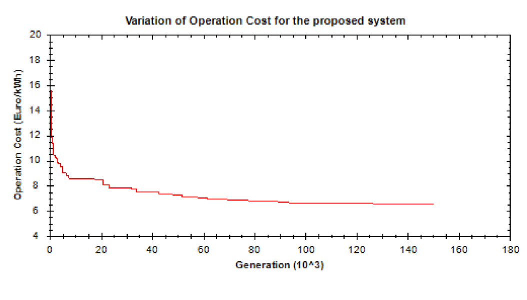
Where E_s, E_{geo}, E_{bio}, E_{bat}, E_{un} and E_{ex} are, respectively, energy generated by PV panels, geothermal- and biomass generators, power discharged and charged in batteries, the undelivered and excess energy. E_L represents the hourly demand by loads. $P_{storage}$ and P_{s_max} are the actual storage power and the maximum allowed storage power. C_s, C_{geo}, C_{bio}, C_{bat}, C_{ex} and C_{un} are the cost coefficients.

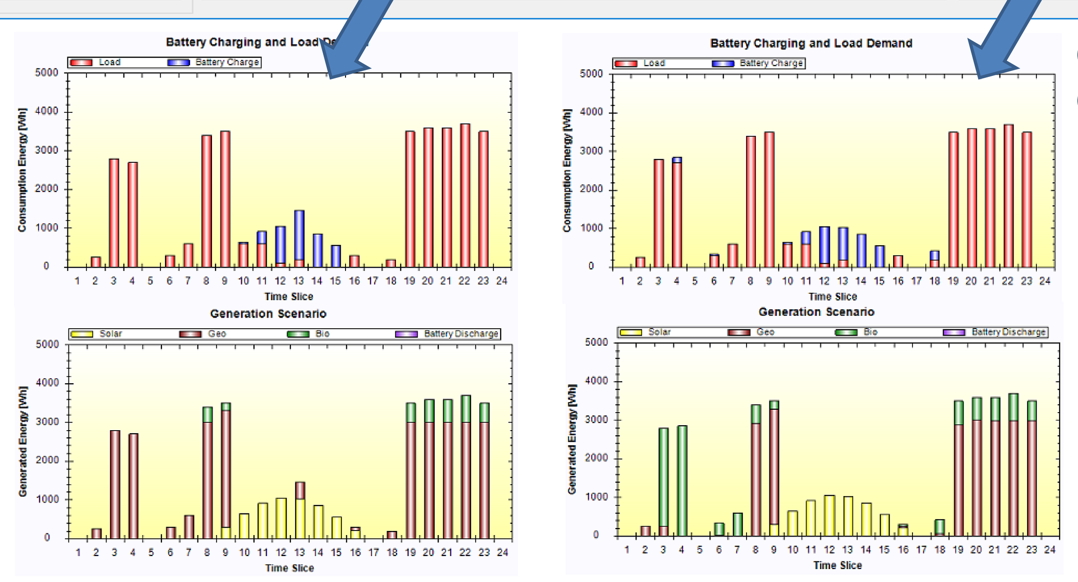
5. Results & Conclusion



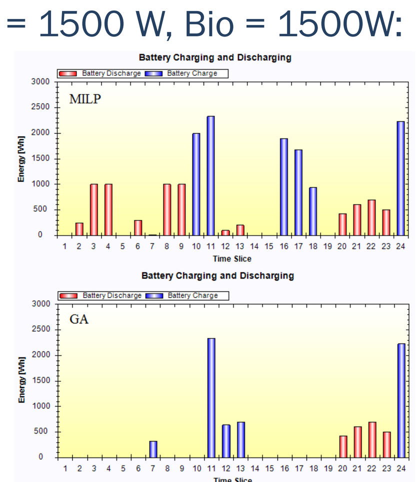
The optimal scheduling – Graphical User Interface (GUI).

Cost function – GA method:





Charging and discharging of batteries, Geo = 1500 W, Bio = 1500W:



Month	Geo [W]	Bio [W]	MILP [€/day]	GA [€/day]	MILP [sec]	GA [sec]
December	0	0	36.59	36.59	1.3	16.4
	1500	0	17.36	17.36	1.1	15.8
	1500	1500	7.11	7.14	3.7	15.6
	3000	0	6.39	6.50	3.7	15.8
	3000	3000	6.21	6.56	1.1	16.2
March	0	0	32.19	32.10	1.1	16.2
	1500	0	14.85	14.90	3.2	15.9
	1500	1500	5.98	6.70	5.0	15.7
	3000	0	5.55	5.94	6.8	16.0
	3000	3000	5.34	6.04	0.8	15.7
July	0	0	27.52	27.47	5.9	16.3
	1500	0	12.47	12.62	5.9	15.8
	1500	1500	5.19	5.74	12.7	15.9
	3000	0	4.75	5.13	13.2	16.0
	3000	3000	5.64	5.19	1.2	15.9

The aim of the present paper was to compare different optimization and global search methods. Clearly, further studies are needed to examine the functioning of this algorithm using other software and to also introduce other methods. Furthermore, it should be examined whether the traditional and metaheuristical procedures are trapped in local minima.

The results presented in this paper might be valuable for future research in energy management systems.

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