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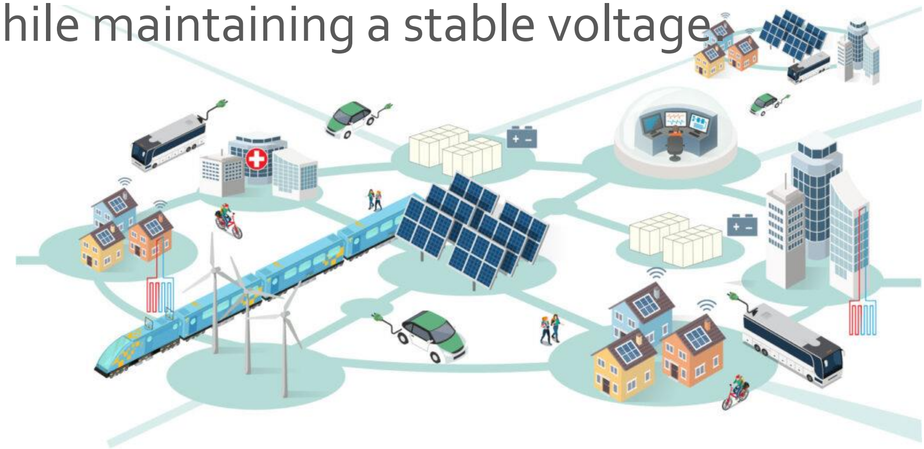
Modified Genetic Algorithm for Unit Commitment of Grid-connected Microgrids Under Real-time Pricing Conditions

Natasha Dimishkovska Krsteski* and Atanas Iliev
Ss. Cyril and Methodius University, Faculty of Electrical Engineering and Information Technologies
Skopje, Republic of North Macedonia

Introduction

- Microgrid - a system consisting of microgenerators of electrical energy and consumers that operate as a single unit .
- The complexity of today's microgrids requires an energy management system that can optimize the energy consumption and production
- This paper proposes a modified genetic algorithm to solve the unit commitment problem in a grid-connected microgrid with photovoltaic and wind generators, with connected consumers and prosumers, equipped with photovoltaic generators and a battery storage system that serves both the consumers and the prosumers. The microgrid trades with the local power grid under real-time pricing conditions, while maintaining a stable voltage.



Problem Definition

- The microgrids' optimization is mostly based on production and distribution costs' minimization or the maximization of the profit from trading with the local grid.
- The stochastic nature of power consumption and generation from renewable energy sources complicates the optimization process. Additionally, it is essential to maintain voltage within specified levels to ensure stable frequency and prevent interference with the local distribution network.

Proposed Algorithm

- The proposed algorithm unites two optimization functions. The first one minimizes the operational costs of the microgrid, and the second one limits the voltage drop to the generators to ±5%, and to the consumers to ±10%.

$$F_1(P_i) = \max\left\{\sum_{i=1}^{T}\left(B_{DER,i} - C_{grid,i}\right)\Delta t\right\} \quad (1)$$

$$F_2(P_i) = \max\left\{\left(\frac{P_\Sigma}{V_n}\cdot r + \frac{Q_\Sigma}{V_n}\cdot x\right)\cdot l - \Delta V\right\} \quad (2)$$

$$P_\Sigma = P_{pv} + P_{wind} + \sum_{m=1}^{N_{prosumers}}\left(P_{pv\_res,m}\right) + P_{bat\_dis} - P_{bat\_ch} + P_{buy} - P_{sell} - \sum_{i=1}^{N_{consumers}}\left(P_{load,i}\right) \quad (3)$$

$$Q_\Sigma = Q_{wind} + Q_{buy} - Q_{grid} \quad (4)$$

- The optimization functions take into consideration the costs for buying power from the local grid when there is a shortage of power in the microgrid, as well as the profit for selling power to the grid when there is an excess, under defined technical constraints and the voltage levels in the connection points.

Proposed Algorithm

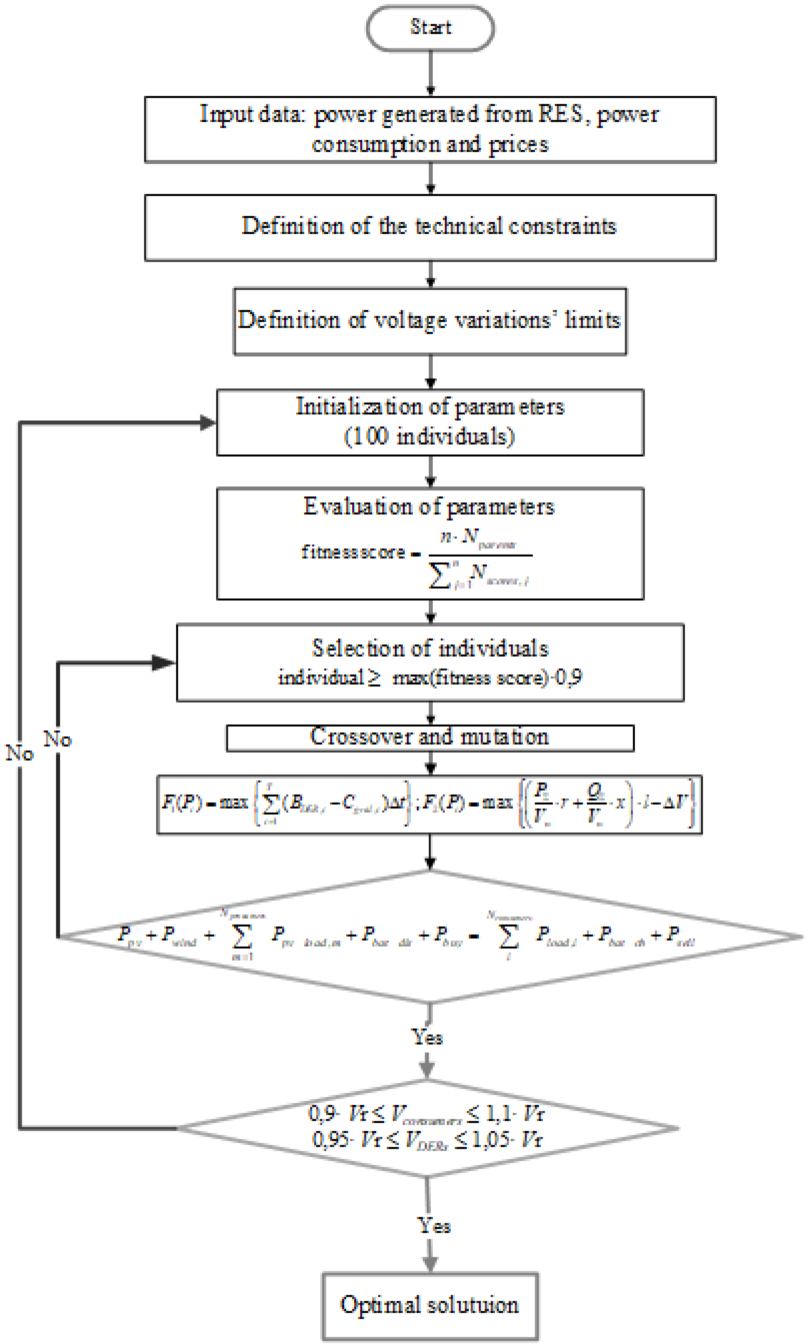


Fig. 1. Flowchart of the proposed modification of the genetic algorithm

Simulation & Results

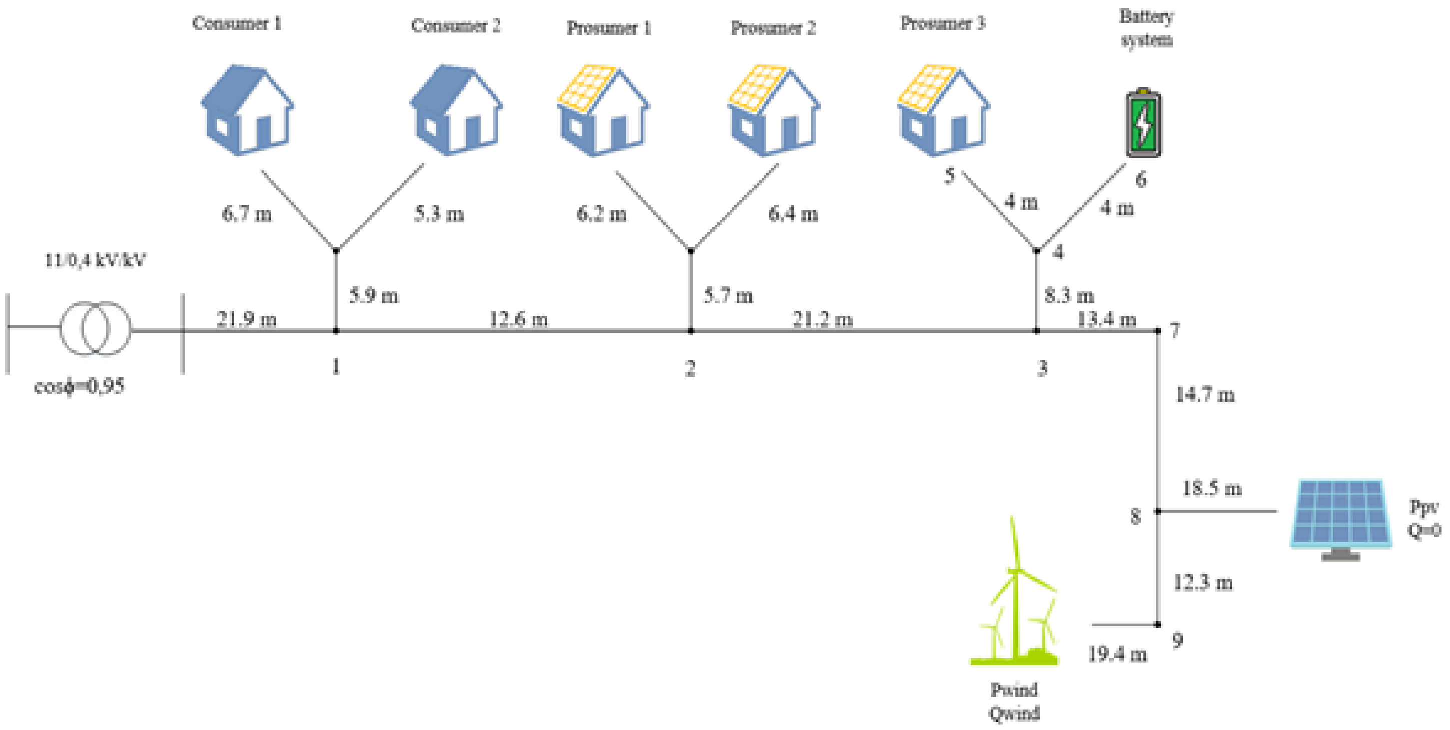


Fig. 2. Diagram of the analyzed microgrid according [9]

Simulation & Results

Table 1. Technical constraints of the installed equipment.

Parameter	Meaning	Value	Unit
P_{pv}	Installed capacity of the photovoltaic generator	10	kW
P_{wind}	Installed capacity of the wind generator	3	kW
P_{pv_rez}	Installed capacity of the photovoltaic generators installed on the residential objects	7	kW
P_{bat_ch} P_{bat_dis}	Maximal charge power Maximal discharge power	2	kW
P_{buy_max}	Maximum power bought from the grid	20	kW
P_{sell_max}	Maximum power sold to the grid	35	kW
C_{bat}	Battery's capacity	20	kWh
SoC_{bat_min}	Minimal battery state of charge	10	%
SoC_{bat_max}	Maximal battery state of charge	100	%
η_{ch} η_{dis}	Efficiency coefficient of charge/discharge	95	%

Table 2. Comparison of the obtained results using different selection methods

Method	GA with Tournament selection	Standard GA with uniform selection	Modified GA
Total profit(€ct)	224.0605	224.0685	**224.0877**
P_{buy} (kW)	0.513	0.513	**0.513**
P_{sell} (kW)	13.817	13.816	**13.814**

Simulation & Results

Table 3

Comparison of the obtained results using different selection methods

Method	**Roulette Wheel**	**Remainder selection**	**Tournament selection**	**SUS**	**Uniform selection**	**Improved GA**
Total profit(€)	135,29	135,29	135,32	135,32	135,3317	**135,3328**
P_{buy} (kW)	642,527	642,527	642,885	642,885	642,885	**642,885**
P_{sell} (kW)	703,138	703,174	703,195	703,202	703,2724	**703,2795**

Simulation & Results

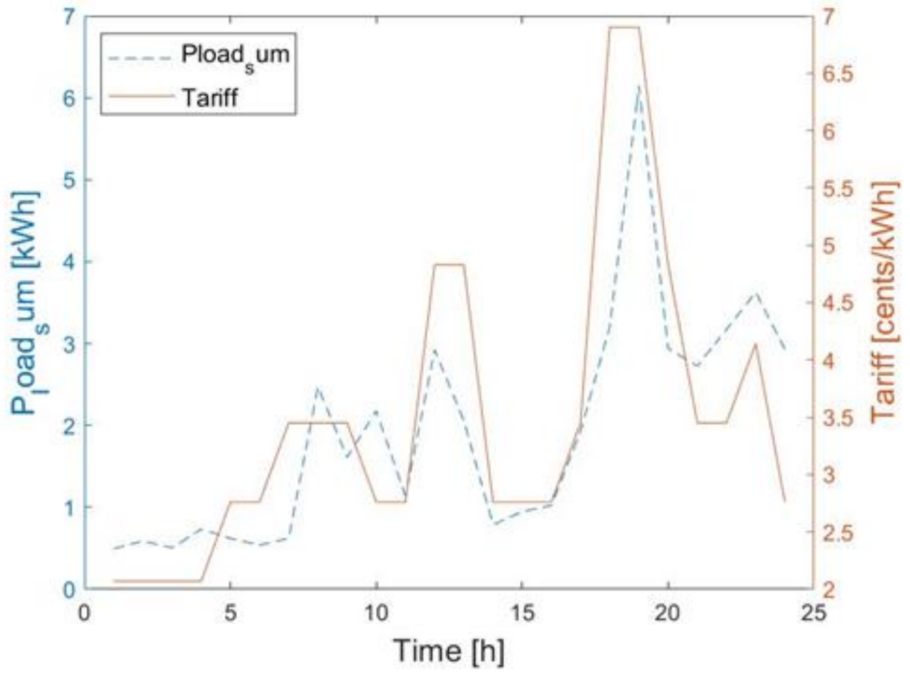


Fig. 3. Power price variations and load curve over one day (24 hours)

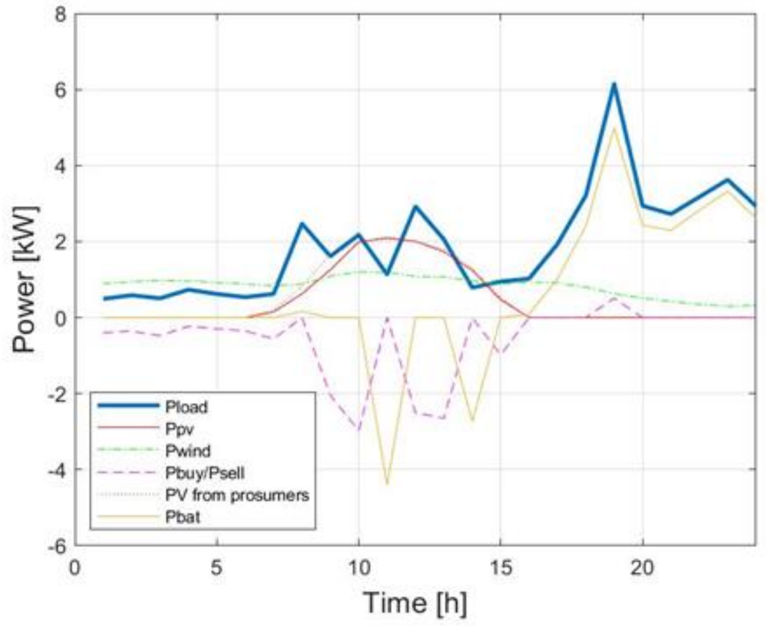


Fig. 4. Optimal unit commitment using modified genetic algorithm for α=0,9

Conclusion & Future Work

- In this paper, the optimization of a grid-connected microgrid with connected prosumers and consumers was analyzed. The optimization functions include the unit commitment and voltage regulation in the critical nodes.
- The paper proposes a modification of the genetic algorithm to obtain better results in the optimization process. The modification is in the selection process, and although some of the potentially good individuals are lost during this type of selection, the results show that the proposed modification provides better results than the standard selection algorithms. This validation of the improvement paves the way for further enhancement.
- In future work, the research could include the usage of different types of backup systems and could analyze the demand response in real-time pricing conditions.

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Thank you for your attention

Please send your questions at
dimishkovskan@feit.ukim.edu.mk

MSc Natasha Dimishkovska Krsteski