Study Committee 6

ACTIVE DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCES

Paper ID_10700

A Hybrid Heuristic Optimization Algorithm for the Rolling Day-Ahead Scheduling of Non-Interconnected Islands in Greece

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Motivation

- Several Greek Non-Interconnected Islands' (NII) electrical systems (ES) constitute isolated microgrids and HEDNO provides for the establishment and implementation of the Rolling Day-Ahead Scheduling (RDAS)
- Resolution of the RDAS on isolated microgrids presents certain unique features: higher operating costs (fuel transportation costs and diesel/mazut units as base load), technical requirements (spinning reserves, reserve in the event of outage of any generating unit, unpredictable load fluctuations), maximization of Renewable Energy Sources (RES) penetration, minimization of production costs and CO_2 emissions of conventional thermal units.
- Aim is to determine the day-ahead hourly dispatch schedule of the Dispatchable Units (i.e. thermal units and Hybrid Power Stations - HPS), in order to meet the load demand of each NII ES and simultaneously adhere to the above principles and restrictions, a multi-objective optimization problem is established.

Approach

- The proposed approach employs a heuristic algorithm to initially synthesize all possible combinations of the conventional dispatch units per dispatch hour and removes those combinations that do not meet pre-selected criteria. Based on the above combinations, a set of candidate solutions for the RDAS is algorithmically created, which are ranked based on weighted criteria regarding the maximization of RES penetration, the minimization of production costs, the minimization of the number of unit dispatches and the number of conventional dispatchable units utilized in the RDAS. From the set of candidate solutions, the one that receives the best score is eventually chosen.

Objects of investigation

- The proposed methodology has been applied to the NII Limnos, which is a medium-sized NII with a peak load of 14.3 MW (in 2020) and its ES includes one thermal power station with 9 conventional thermal units, two WFs with a total licensed capacity of 2.34 MW and 1.9 MW of installed PV power.

Methodology

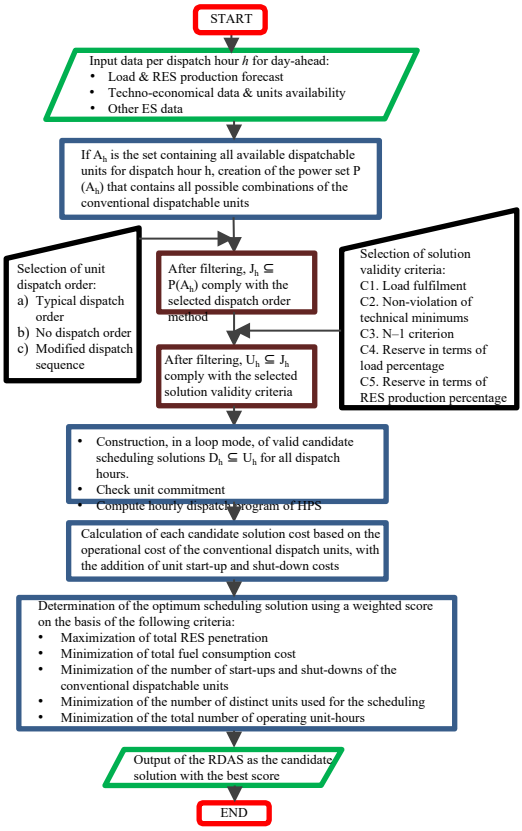

Figure 1: Methodology flow chart

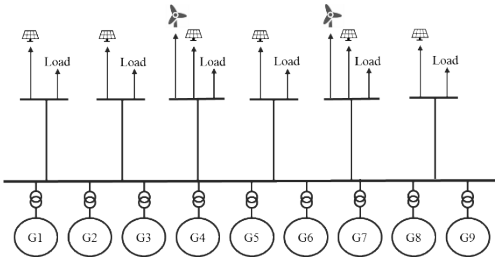

Figure 2: Topology of the Limnos ES network

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Method overall results

- The implementation period that has been considered for the present analysis includes months August to October 2021 and performance comparisons have been made to the respective months for the year 2020, when the scheduling dispatch was prepared not via optimization but in an empirical manner.

Table 1: WF operating hours (setpoint normalized)

Month	*Operating hours (SP normalized)*	
	WF1	*WF2*
Aug. 2020	591.34	646.83
Aug. 2021	694.44	684.20
Sept. 2020	359.59	508.19
Sept. 2021	470.03	525.77
Oct. 2020	371.31	380.36
Oct. 2021	453.60	397.96

Table 2: WF penetration

Month	*WF total energy production (kWh)*	*ES total energy produced (kWh)*	*Total WF production penetration*
Aug. 2020	468 914	6 748 639	6.95%
Aug. 2021	495 857	7 849 092	6.32%
Sept. 2020	483 382	5 116 659	9.45%
Sept. 2021	495 131	4 892 511	10.12%
Oct. 2020	298 077	4 324 027	6.89%
Oct. 2021	689 725	4 463 956	15.45%

Table 3: Thermal dispatchable units results

Month	*Unit-hours of operation*	*Number of start/stop operations*	*Diesel fuel consumption (kl)*	*Mazut fuel consumption (kTn)*
Aug. 2020	1 813	230	18.45	1334.54
Aug. 2021	2 467	313	28.92	1558.86
Sept. 2020	1 633	211	17.38	982.54
Sept. 2021	1 533	179	17.55	920.65
Oct. 2020	1 376	196	19.98	845.48
Oct. 2021	1 251	161	16.03	769.48

Wind Farms operation results

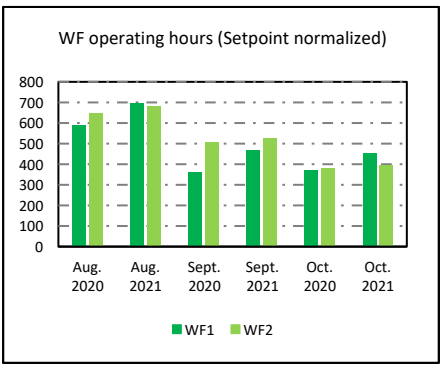

Figure 3: WF operating hours (setpoint normalized)

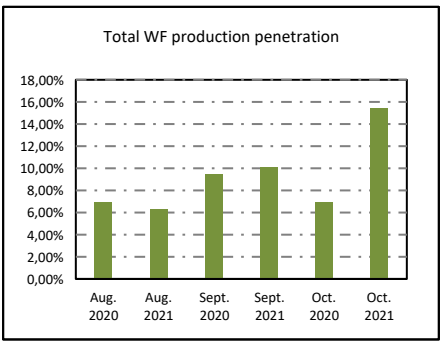

Figure 4: Total WF production penetration

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Thermal units operation results

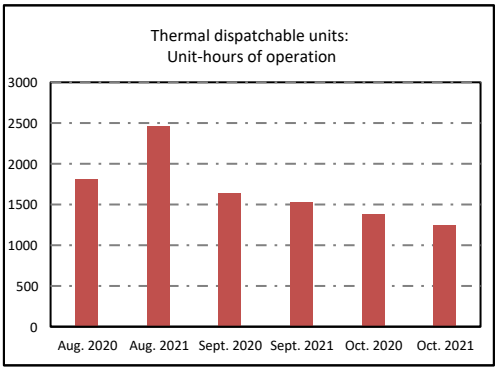

Figure 5: Unit-hours of operation

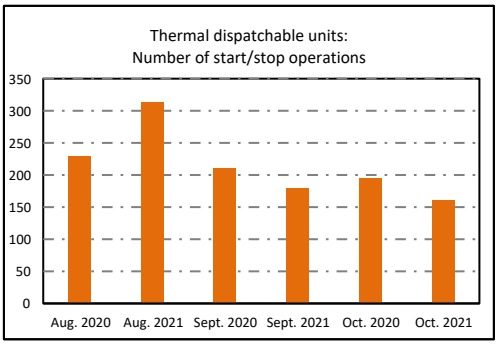

Figure 6: Number of start/stop operations

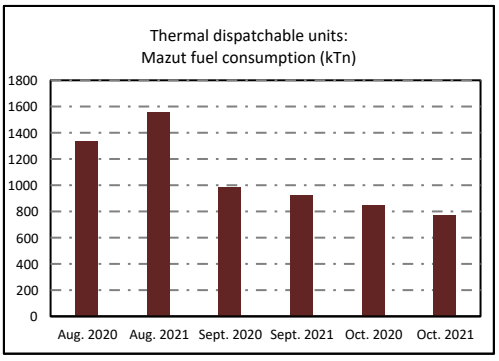

Figure 7: Mazut fuel consumption

Discussion

- An increase has been observed in all WF normalized operating hours (NOH), a fact that gives more "space" for the WFs to produce energy when the wind conditions are favourable.
- When comparing August 2021 to August 2020, the total WF penetration is slightly reduced, despite the rise in raw WF production, a fact attributed to the highly increased ES loads during August 2021 due to very high temperatures in Limnos.
- In September 2021 an increase of 0.67% in WF penetration takes place, in spite of the lower ES loads compared to September 2020.
- The total thermal dispatchable unit-hours present a clear decrease from 2020 to 2021, with the exception of August 2021 where the ES loads are significantly higher. The same pattern applies to the number of unit start/stop operations and fuel consumption.

Conclusion

- The proposed RDAS implementation method has lead to improved island ES management, as well as expanded renewable energy production and economic operation of thermal units
- Optimal RDAS has contributed aid in achieving NII management and operation targets, in accordance with the Greek NII Code objectives. Among others, the necessary input data, as well as the mandatory requirements and limitations of each NII ES are utilized in an algorithmical and mathematical manner to produce valid and optimal RDAS output.
- Optimal scheduling offers better thermal unit dispatch and has the potential to lessen the necessary thermal unit operation and maintenance costs. In particular, the thermal dispatchable unit-hours, the number of start-stop operations and the fuel consumption may be significantly decreased.