Short Term Scheduling of Desalination Loads in Hybrid Systems

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Abstract

The objective of this paper was to present a methodology for the short-term scheduling of reverse osmosis desalination modules in autonomous systems. The principles of this wind-diesel-desalination hybrid system were integrated and tested through a simplified simulation model, similar to the autonomous system of Kythnos Island. The study aims to provide a rough estimation of the benefits expected by unifying the scheduling functions of the power system and the desalination modules, in a "common operator" scheme.

The implementation described in this paper assumes the presence of a supervisory controller in the power system, which performs short-term economic scheduling functions based on the uncertainties of load and wind forecasts. In the proposed scheme, the desalination modules are powered by the system's surplus generating power. Their schedule is based on an adaptive algorithm, the main goal of which is to ensure the proper operation of the RO modules and minimize cost, by avoiding the startup of an additional diesel unit. The proposed scheme could present an interesting investment scenario for new and existing reverse osmosis installations; the results of this study should provide enough motives for further investigation.

I. Introduction – Scope of the Study

- Wind energy curtailment in autonomous systems - major hindrance for wind park investments in non-interconnected island systems.
- Main reasons: seasonal variance of electricity demand, intermittency of wind energy, dynamic penetration limits, penetration limits due to operating minima of diesel generators. Proposed solutions (better forecasting tools, advanced monitoring and control systems, energy storage, load management strategies) often difficult and/or costly to implement .
- Dispatchable Loads: an interesting concept both for operators and investors. The energy that would otherwise be dumped or curtailed can be "stored" and sold as a service or product. Example: variable thermal loads in cold climate hybrid systems – studied and implemented in the past.
- Reverse osmosis (RO) desalination: An interesting study case for the autonomous systems of the arid Aegean Sea Islands.
- Current status: installation and operation independent of the power system, despite the modularity and size of their load.
- Suggested alternative: A more centralized operational scheme, able to yield substantial *water production savings* as well as an *increased utilization of wind energy*, leading to *lower operational costs for the power system*. The idea could, alternatively, present an interesting investment scenario, by combining the installation of a new wind turbine, with the operation of reverse osmosis units, operated and scheduled centrally.

II. Implementation

- Desalination modules: Variable, dispatchable load of known size – do not contribute to additional spinning reserve.
- Basic implementation goals when unifying the RO plant and the power system scheduling functions:
  - *Increase wind energy utilization* by increasing system load when consumer demand is low and wind energy availability high.
  - *Minimize fuel consumption* for the RO plant's operation: 1) by adapting its schedule to avoid a long term increase of additional diesel startups and 2) by prioritizing plant operation when low specific fuel consumption units are scheduled to provide power to the grid.
  - *Ensure secure operation* of the power system's primary loads by disconnecting RO modules from the grid during critical/unforeseen occurrences.
- Study Case - Preliminary assessment: Simulation loosely based on Kythnos Island's power system. Supervisory control capabilities were assumed. A 10 minute scheduling and dispatch cycle was used, with a short term forecast horizon of 1 hour, divided in 10 minute intervals.
- Power supplied to the RO plant only limited by adapting its schedule so as to avoid additional diesel unit startups for its operation.
- Adaptive scheduling algorithm ensures consecutive operation of each module for at least one hour.

III. Simulation

- *Scenario (1)*: Power system operation without desalination plant.
- *Scenario (2)*: Desalination modules centrally scheduled and operated. Scheduling algorithms unified under a single operator.
- *Scenario (3)*: Same water output as (2), but independent RO plant operator. Schedule of operation is assumed constant and known to power system operator.

Yearly Simulation Results

Scenario	Primary Load (MWh)	Wind Energy Available (MWh)	RO Load (MWh)	Diesel Units Prod. (MWh)	Wind Energy Prod. (MWh)	Wind Energy Dump (MWh)
1	5642	1020	-	4698	891	129
2			1372	5972	988	32
3				5968	992	28

Scenario	Wind Energy Dump (%)	Wind Energy Penetration (%)	Fuel Cost (000€)	Load Increase (%)	Cost Increase (%)	Water Cost (€/m^3)
1	12.7	15.8	768.5	-	-	-
2	3.1	14.1	895.0	24.3	16.5	0.37
3	2.7	14.2	940.2		22.3	0.50

IV. Simulation Results

- Desalination plant accounted for a 24.3% increase in system load.
- Wind energy dump is minimal both in (2) and (3). Difference in cost between (2) and (3) results not from increased wind energy use, but reduced fuel cost.
- Produced water: 343500 m^3. Operational cost difference: 45.000 EUR/year – more than 5% of the total power system costs. Water production energy cost reduced by 25%.
- Tests showed that when desalination operation is constrained, optimized utilization of wind energy becomes significant in achieving a much lower yearly water production cost. In this case, the proposed scheme, simulated in scenario (2), becomes even more attractive.

V. Conclusions

- Preliminary study has shown that the use of RO modules as dispatchable loads is possible. The benefits expected by a centralized scheduling and operation scheme of such a desalination plant are tangible.
- Possible issues preventing application in existing infrastructure (separate operators): Modifications required in the power system (components, scheduling functions, availability of forecasts), legislative issues.
- However, the results presented confirm the potentially increased viability of new investments that combine wind energy and with RO desalination (or other dispatchable loads) in autonomous systems, especially in cases where the owner and operator of the power system is the same.
- Considering the high cost of water transport to the arid islands of the Aegean Sean (often as high as 9 EUR/m^3), new RO installations in the region are already on the increase – the framework regarding their operation within the respective autonomous systems is expected to become a matter of great interest.

V. Acknowledgements