Journal of Physics:
Conference Series

PAPER • OPEN ACCESS

Energy Management System for a Smart Grid Including Atmospheric Water Generation

To cite this article: Mario L. Ferrari *et al* 2024 *J. Phys.: Conf. Ser.* **2893** 012027

Energy Management System for a Smart Grid Including Atmospheric Water Generation

Mario L. Ferrari[1*], Lucia Catttani[2] and Anna Magrini[3]

[1] University of Genoa, Genova, Italy
[2] SEAS SA, Société de l'Eau Aérienne, Technical Office, Riva San Vitale, Switzerland
[3] University of Pavia, Pavia, Italy

*E-mail: mario.ferrari@unige.it

Abstract. The aim of this paper regards the development of an Energy Management System (EMS) for a smart grid including water extraction from atmospheric humid air. Special attention is focused on the water demand satisfaction with different generation systems and storage technology. The main innovation of this analysis is the application of the EMS tool, usually developed for energy production machines, to optimize, in real-time mode, their integration with a water-collection system. Starting from component models development and validation, the results obtained with the EMS were successfully compared with a standard management approach showing the cost benefits and the related impact on the environmental side. Moreover, different layouts were analyzed to show the benefits due to component integration, especially for the storage systems. In details, the integration of different technologies focusing special attention of energy storage was able to produce important benefits for exploiting renewable sources. So, this approach, based on an EMS tool, was demonstrated as a promising application for energy transition process, considering the importance and flexibility of optimized air-to-water generation systems (AWGs).

1. Introduction

One of the most challenging issues affecting the sustainable human development concerns with fresh water accessibility and availability. Currently, more than two billion people face water scarcity for at least one month per year [1]. The situation is expected to worsen not only because water consumption is continuously increasing, by 2050 it could be 20% - 30% higher than the current one [2], but also for climate changes, related to global warming, are exacerbating droughts and water issues [3].

Urgent actions are required. Besides better management, use, and re-use of resources, there is a need for new unconventional and sustainable water sources [4]. The research field concerning water extraction from air should be seen from this perspective [5]. In recent years, scientific interest in air as a potential water source has constantly increased, as testified by the trend of scientific paper production, reported in [6]. Water in the atmosphere can be present in the liquid phase, as it happens with fog or mist, or in the gas phase. In this latter form, its presence is almost ubiquitous, thus a large part of the studied solutions for water extraction are based on the principle of vapour condensation. Among the various techniques, three main approaches to dew harvesting can be identified [7], namely: radiative cooling, vapour concentration by means of sorption-desorption cycles, and active cooling.

The first approach consists of collecting natural dew on large panels, placed outdoors and exposed to the sky, exploiting the natural radiative cooling of their surfaces, which can be treated with particular coatings, biologically inspired, to enhance the yield. Solutions based on this principle do not need external energy sources, but require large spaces to collect meaningful water quantities and are totally dependent on environment conditions [5]. Moreover, water quality can be affected by micro and macroscopic pollutants, such as insects, animal dejections, dust particles, bacteria, and so on [8].

Sorption-desorption based solutions embed particular substances able to trap and release water vapour, even if its percentage is no higher than 20%. The used materials, which can range from silica-gel, to hydrogel, comprising also Metal Organic Frameworks, are normally used in a sorption-desorption cycle aimed at increasing the vapour content in a closed volume of air, or in a controlled airflow. After that, to obtain liquid water, a condensation stage is required. Nevertheless, thanks to the enhanced relative humidity and thus the increased dew point temperature, less cooling energy is required to achieve the target. One of the main drawbacks of the existing applications is the low yield, on the order of a few litres a day [9]. Additionally, there are some concerns about the possibility of releasing pollutants into the water.

The third technique is currently the most diffused [10] and applied in market devices [11]. The working principle can be summarised as follows [12]. An airflow is cooled below its dew point by means of a reverse cycle, operated by a compressor. The air, moved by fans, passes through a first heat exchanger. Here a refrigerant, evaporating, removes part of the air thermal energy, causing the condensation of a fraction of its vapour content. The refrigerant is then compressed and releases the heat to the external environment by means of a second heat exchanger. In some cases, dew condensation can be obtained by means of thermoelectric coolers [12]. The active cooling approach can provide production that ranges from tens to thousands litres per day, in a meaningful range of temperatures and relative humidities. The main drawback of this technique is the energy consumption, required by the cycle. Nevertheless, the issue is common to the other techniques when meaningful water quantities are required, except when radiative cooling is employed. This is because the air vapour content is on the order of magnitude of a few grams per cubic meter, even if the relative humidity is high, thus considerable airflows must be moved to obtain litres of water, with a consequent non-negligible energy consumption [13]. Such consumption cannot be avoided if a certain degree of water quality is required, because air must be filtered [14].

It can be said that, considering the various possible techniques, the main issues related to water extraction from air can be summarised as: quantity, energy consumption and quality. In order to address the said issues, advanced integrated Air to Water Generator (AWG) machines were designed [15]. A short description of such a solution is reported in section 2.2. Here it is enough to anticipate that this kind of machines is able to exploit all the useful effects of the reverse cycle applied to the extraction process, providing, beside condensed water, cooling energy, by means of a cooled and dry airflow, and heating energy at low temperature. All those effects can be obtained at the same time with the same energy input. Such a kind of machines can be a mean to improve existing Heating, Ventilation, Air Conditioning (HVAC) systems, while providing drinking water [16].

An important aspect to be investigated for these HVAC systems regards management optimization during operations in integrated mode. Although this topic is investigated or under investigation in different studies for smart grids [17][18][19][20], the integration of resource management (or EMS technology) is innovative for the AWG side. Especially in case of grids with different useful energy forms (e.g. heating, cooling) and water, the complexity could reach a level requiring real-time tools for management optimization. This is also very important if the system is equipped with generators based on renewable sources and/or storage devices for water and/or energy. Considering that the state-of-the-art of AWG technology is mainly related to the component performance and its application for supplying water, the integration in a smart grid is an important innovation. Especially the development and application of devoted innovative EMS tools has important potentiality of generation cost decrease, producing positive impact on the environment side (CO_2 emission decrease due to energy savings and integration with renewable sources). So, the aim of this work is the development and the application of a new EMS for optimizing the water management in a grid including an AWG system. Special attention is focused on the variable cost decrease obtained with the application of the EMS tool against a standard solution (water demand fully satisfied by the aqueduct).

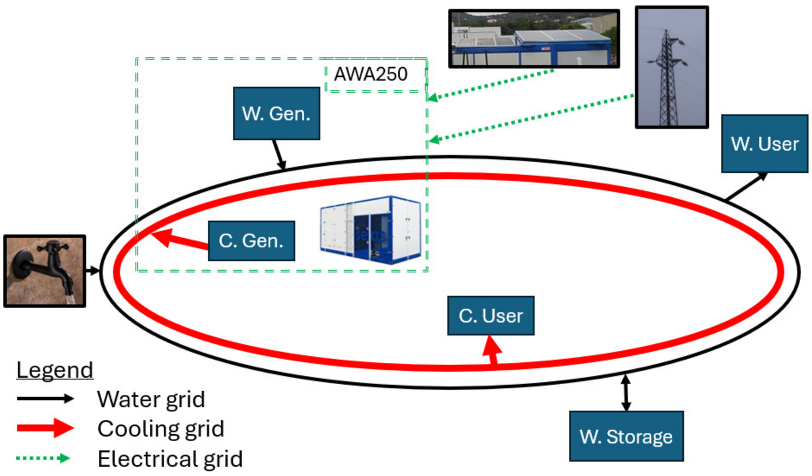

Figure 1. System layout including three different grids (water, cooling air, electricity), water and cooling energy users, water vessel for storage, an advanced integrated AWG machine (AWA250 [21]), photovoltaic panels and the connections to the supply grids for water and electricity.

2. System layout and component description

To study the management optimization for systems including an advanced integrated Atmospheric Water Generator (AWG) machine, a layout including both water and cooling demand was considered. Moreover, a storage tank was also included to exploit the benefits of storing water when profitable or in case of generation excess.

2.1 System layout

The system considered in this work is presented in Fig.1. It is based on two grids for distributing both water flow and cooling energy (in the form of chilled air) to satisfy the related demands. Although it could be representative of a residential or a commercial building, similar applications could also regard small industrial sites. The water quality obtained from the integrated AWG system is not a topic considered in the work. However, the considered device is built with a particular attention to such an aspect, as described in section 2.2.

The system core is an advanced integrated AWG machine that in this case is the AWA250 [21], able to produce in nominal conditions 2500 litres/day of water and 100 kW of cooling power. This component needs 30 kW of electrical power (in nominal conditions), that, as shown in Fig.1, can be obtained from the electrical grid and/or from locally-installed photovoltaic (PV) panels. From the water grid point of view, the system also includes a connection with the general supply system (from the aqueduct) and a 2000 l water tank for a local storage.

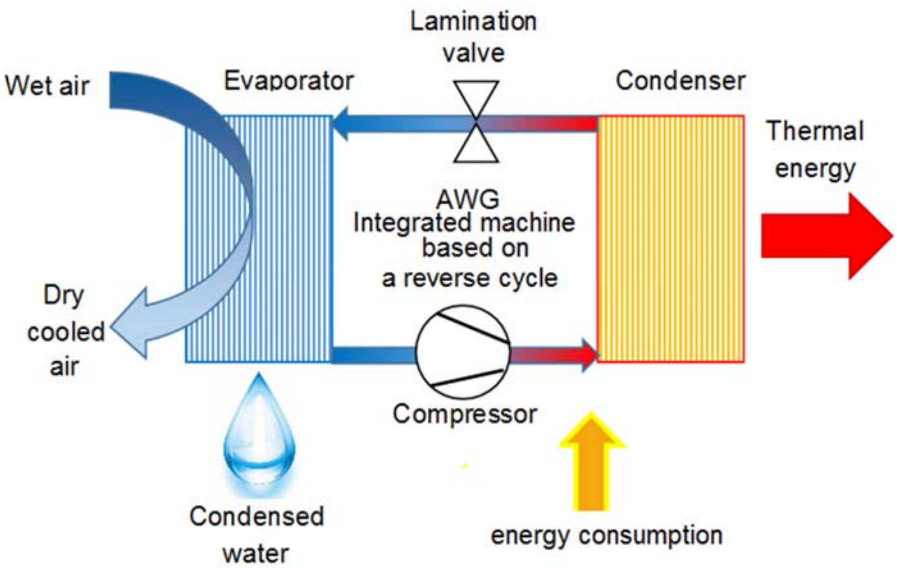

Figure 2. Advanced integrated machine working scheme, image adapted from [15].

2.2 Description of components

The working principle of the advanced integrated AWG machine considered in this work is shown in Fig.2. The difference between a traditional AWG, based on a reverse cycle powered by a compressor, is that the proposed advanced machine is expressly designed to fruitfully employ the useful effects related to the water extraction process.

Even in this case, an external airflow is moved inside the machine, by means of fans, and is cooled below its dew point, after a mechanical filtration. It must be observed that, beside the condensate production, the effect of the process is an airflow characterized by a temperature and humidity lower than those of the environmental air. Advanced integrated AWG machines are designed to let an integration with building plants, and the treated air can be used to assist the cooling system, as demonstrated in a study case where the airflow was employed to cool the laundries of a hotel [22]. At the same time, in such a kind of AWGs, the heat extracted from the air is made available for domestic water heating, by means of a plate exchanger. In the example cited in [22] the heating power, provided by the advanced integrated AWG, was enough to heat all the domestic water required by the hotel customers. The existing boiler did not operate, resulting in a meaningful fuel saving. Thus, with only the energy required to produce water it was possible to provide both cooling and heating, achieving significant savings, calculated in about 80 thousand dollars a year for the application described in [22]. Such an integrated approach bypasses the energy issue related to water extraction from air. Regarding quantity, this type of technology allows for yields ranging from hundreds to thousands of litres per day, as also reported in [16]. Atmospheric water quality is of the utmost importance, as remembered in [23]. The advanced integrated machines are equipped with air filters and are built with materials certified for food contact [22]. Moreover, the condensate is treated by a tailored system to achieve the required water quality, as demonstrated in [24], where the produced water was tested and found comparable with high-rated bottled waters.

The advanced integrated machine (AWA250), considered in the current work, is similar to that described in [16] and [22]. It works with R134a fluid and it is composed of:

- a 30 kW screw compressor;
- an air treatment unit equipped with a fine and tube heat exchanger and a heat recovery system, for a cooling capacity of 100 kW;
- a plate heat exchanger, as condenser, for the domestic water heating;
- a backup fin and tube heat exchanger for the refrigerant condensation by external air, in case domestic water heating is not required, with a heating capacity 120 kW;
- evaporator fans and back-up condensation fans.

The photovoltaic panels considered in this work refer to the installed ones in the Innovative Energy Systems laboratory (in the campus located in Savona, Italy). They are 6 elements based on single-crystal silicon (185 kWp each) for a total maximum producible power of 1.1 kWp at 14.5% efficiency (in nominal conditions) [17]. However, due to the component aging (they were installed more than 10 years ago) their performance is lower than the nominal one.

3. Component models and Energy Management System

For performing system optimal management in real-time mode, it is necessary to develop software tools for the involved components. Considering the necessary simulations to be performed before applying the energy management tool to a real plant, the transient models were implemented using Matlab-Simulink environment. Due to simulation real-time performance requirement, essential to have a management system ready to operate in a real plant, simplified modelling approaches were used for the plant components. In general, as performed in previous works (e.g. in [17] or [25]), the component models are simulated with 0-D approaches (input-output balances) or interpolating performance maps for the steady-state behaviour followed by first order delay tools for the transient response. For this reason, the model validation against experimental or literature data is essential to have the necessary model reliability.

3.1. Component models

The modelling core for this system is related to the AWA250 machine. Starting from the design data available in the manufacturer's web site [21], literature data [22] and further confidential simulations/results related to specific off-design conditions, the steady-state tool section was implemented. It is based on the interpolation of maps used to calculate produced water, cooling power and consumed electrical power at different operating conditions (as functions of ambient temperature and relative humidity). The time-dependent response is obtained implementing two subsequent first order delay blocks based on time constants to be set with experimental data.

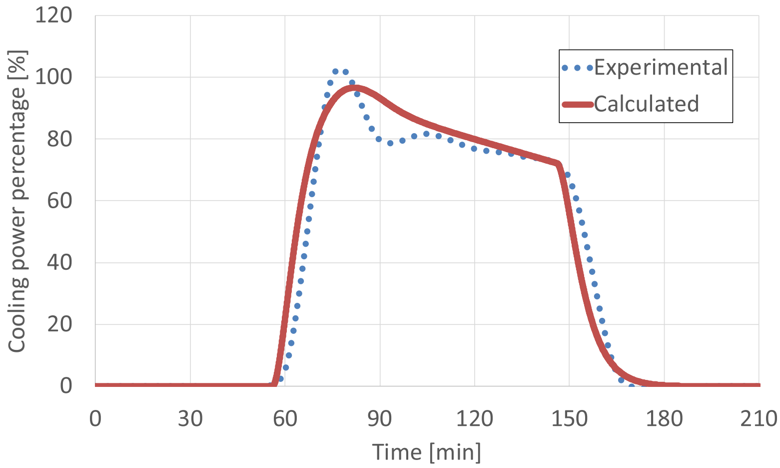

Figure 3. Time-dependent validation for the AWA250 model (accuracy of the experimental data: ±3%).

The validation of this model is reported in Fig.3 showing start-up and shutdown phases for the cooling power point of view. Since no specific transient data are available for publication, the validation was performed considering (and scaling-up) the evaporator side of and heat pump available in the Innovative Energy Systems laboratory at the University of Genoa [17]. In detail, Fig.3 shows a good matching between the calculated results and the experimental data. The minor differences in time-dependent mode (few seconds in the transient response) are negligible considering the accuracy of experimental data and the optimization time scale of this type of work (several hours or days).

The other important model regards the water storage tank. However, this is a very simple tool based on an integrator to calculate the changes in the mass of stored water on the basis of the inlet/outlet balance. The model also calculates the component state of charge (SoC), as a number in the 0-1 range.

3.2. Energy Management System

The Energy Management System (EMS) implemented for this activity is focused on the water resource for minimizing the related variable costs. Although a further optimization level can be performed for the component sizing (as in [25]), the target of this activity regards the development of a real-time tool able to manage the system during operations. Considering that the simulation is not based on a real site, water demand value was defined scaling real data [26] to have a reasonable load for the AWA250 machine.

$$J_{cost} = c_W \cdot m_{W_{grid}} + (c_{O\&M} + c_{el}) \cdot P_{el_{AWA250}} - c_{cool} \cdot P_{cool_{AWA250}} \quad (1)$$

$$P_{el_{AWA250}} = f\left(m_{W_{AWA250}}, WET_{AWA250}, RH_{amb}, T_{amb}\right) \quad (2)$$

$$P_{cool_{AWA250}} = f\left(m_{W_{AWA250}}, WET_{AWA250}, RH_{amb}, T_{amb}\right) \quad (3)$$

Water Energy Transformation (WET) is the indicator of atmospheric water extraction efficiency. Its formulation can be found in [12]. Conceptually, the indicator represents the ratio between the theoretical energy needed for the vapour condensation and the energy consumed by

Journal of Physics: Conference Series **2893** (2024) 012027 doi:10.1088/1742-6596/2893/1/012027

the actual machine to achieve the condensation effect. Its formulation was developed on the same concept as the Coefficient of Performance (COP), which is the ratio between the wanted useful effect and the energy needed to achieve it. In the WET case, the useful effect is the atmospheric water vapour condensation.

The cost minimization is performed by an optimization algorithm on the cost function reported in Eq.1. The optimizer (a Matlab tool) calculates in real-time mode the values of two decision variables to minimize the variable costs. These variables are: water obtained from the general grid and water produced with the AWA250 ($P_{el_{AWA250}}$ and $P_{cool_{AWA250}}$ are mainly dependent on $m_{W_{AWA250}}$ with a non-linear trend, as in Eqs.2-3). Since the optimization approach is constrained by the necessity to satisfy the water demand and the constrains in Tab.1, the optimization tool used in this work was selected to perform non-linear constrained cost minimization [27]. However, it is important to highlight that the innovative aspect of this work regards the application of EMS technology to such integrated systems, not the development of a new algorithm.

The EMS includes also the management of the water storage tank on the basis of the cost forecast. As discussed in previous works (e.g. in [17]), an optimization step by step without a prediction is not useful. For instance, a water tank discharge when the water price seems low could be an error (for the optimization process) in case of low SoC or in case of a further cost decrease. So, in the work the same approach presented in [17] was considered: the tank is charged at its maximum (depending also on the available flow following the demand satisfaction) if the electricity cost is lower than its daily average and if the AWG is active. In case of electricity cost higher than this average value, the tank is discharged. Moreover, to maintain a reserve in case of generation missing or excess, the charging is limited to the 90%, while the discharging limit was set to 10%.

Finally, since the PV panels produce electricity at zero variable cost, the renewable-based generation is taken into account for a recalculation of the electricity cost performing a weighted average with the variable cost for the electrical energy obtained from the grid.

Table 1. Constraints for the optimization process.

Parameter	Minimum value	Maximum value	Unit
Water from the grid	0.00	0.03	kg/s
Water from the AWA250	0.0	0.06	kg/s
Water from the storage tank	-0.02	0.02	kg/s

4. Simulation results

For the simulation results presented in this section, the considered input values for 24-hour electricity cost and ambient conditions are reported in Fig.4. These data are typically representative of a location with a double-peak trend for the electrical cost point of view (e.g. as in [17]) and a typical summer day at intermediate latitude. Moreover, the following input data were considered: 2 €/m^3 for the aqueduct water, 10 €/MWh for Operation and Maintenance (O&M) activities and 45 €/MWh for the cooling energy selling. The water cost is representative of Barcelona (Spain) [28] and the O&M cost is in agreement with the values proposed in [29] (since the AWG system is more complex than a compression chiller and no specific data are available, the O&M cost was increased to take into account water treatment devices). The PV panel generation is significant between 9 to 16 with a continuous curve. The maximum PV generation was obtained at 12 for an amount of about 650 W (laboratory measurements).

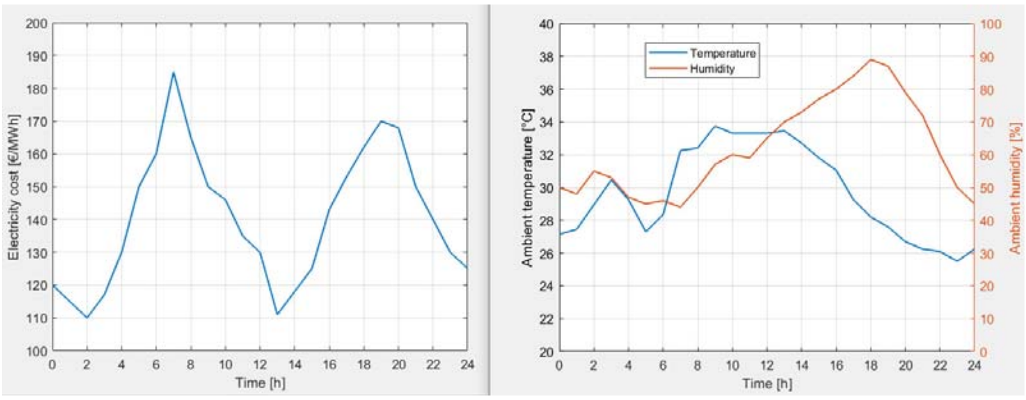

Figure 4. 24-hour electricity cost and ambient conditions considered for these simulations.

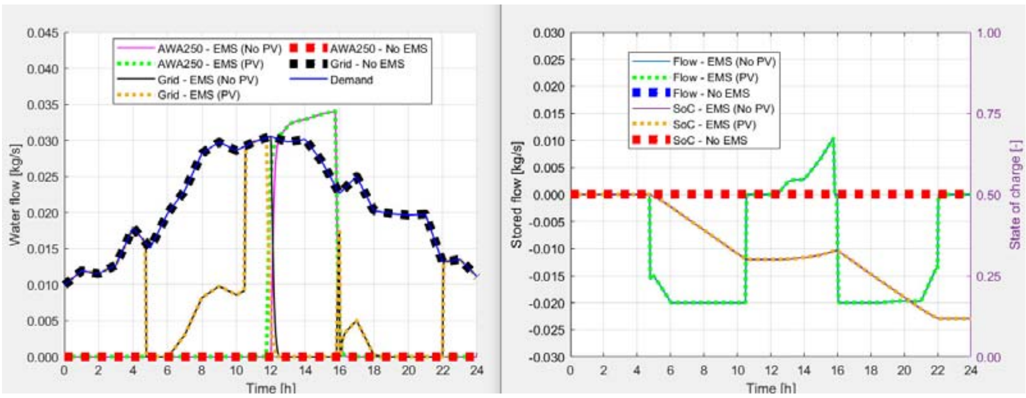

Figure 5. 24-hour simulation. Comparison between the “No EMS” and the “EMS” cases.

For assessing the obtained performance, the simulation results obtained with the EMS were compared with the “No EMS” case (a sort of simple approach based on water demand satisfaction fully with aqueduct flow). The EMS activated the AWG system when its utilization produced a cost decrease. This happened in the central hours of the day with electricity cost significantly lower than the average. Even if the electricity cost is also low in the night, in this period the AWG was not activated due to the interaction of ambient conditions with the other costs and the low water demand. PV generation, although not too much important (less than 1 kW in comparison with electrical power consumption in the 30 kW range), produced an anticipation of the AWA250 activation of about 15 minutes.

Moreover, Fig.5 shows that the EMS used the stored water for a couple of periods affected by high electricity costs. Due to a high water demand in the AWG activation period, the re-charging phase is quite limited. This produced a significant decrease of the water storage State-of-Charge (SoC). No differences were produced on the water storage side with the application of the PV panels. This is because the water flow to/from the storage was null when the PV panels produced an anticipated activation of the AWA250 machine.

The effectiveness and the impact of the EMS application is shown by the global cost related to this 24-hour analysis (Fig.6). Also considering the cost associated with the energy storage re-charging operation (if the final SoC is lower than its initial value), the global cost decrease obtained with the real-time optimization was significant: -40.2% without the PV panels and -51.7% including the electricity cost decrease coming from the locally produced solar energy. Therefore, the PV panel application, although not significant from an initial evaluation, was important to produce global cost decrease. Although this analysis was performed considering cost decrease objective, an important environmental benefit can be produced for the CO_2 emission decrease, especially in case of grid water managed with fossil-fuel based energy.

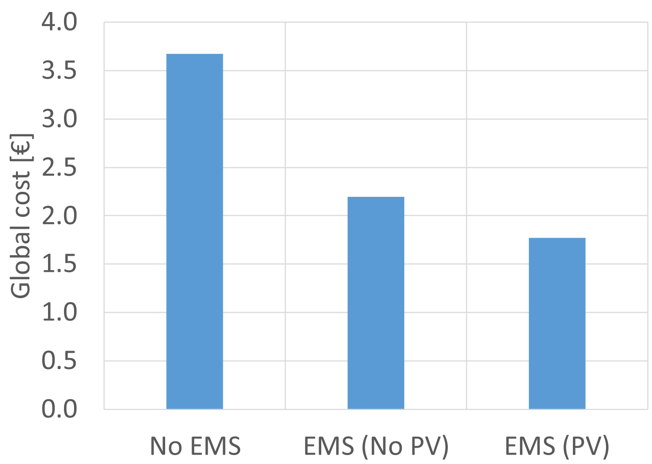

Figure 6. 24-hour simulation. Global cost comparison between the “No EMS” and the “EMS” cases.

5. Conclusions

This paper shows the EMS development for a smart grid including an advanced integrated AWG system. An important innovation regards the application of the EMS technology to a water supply grid. The main results obtained in this work are summarized in the following points.

- The component models were developed using 0-D approach based on performance maps and first order delay tools. Special attention was focused on the AWG machine model that was successfully validated against experimental data (considering a system scale-up) obtaining few seconds of difference in the transient response.
- An EMS was developed to minimize system variable costs in real-time mode.

- The management of the water storage tank was developed on the basis of a scheduling: the tank is charged at its maximum if the electricity cost is lower than its daily average and if the AWG is active (in case of electricity cost higher than this average value, it is discharged).
- The simulation results performed with typical input data of a summer day produced significant global cost decrease (-40.2% without the PV panels and -51.7% including the electricity cost decrease due to solar energy utilization).

The results produced here are important for the further activities in the WISHeR PRIN2022 project, which will include also laboratory tests for completing the EMS assessment.

5. Acknowledgment

This work has been funded by the EU in the Next Generation EU program (Finanziato dall'Unione europea – Next Generation EU) - PRIN2022 project (n. 2022YSR9LM, CUP UNIGE D53D23004380006) titled "WISHeR - Water-collection and Improvement of Sustainability in the HVAC Retrofitting".

References

[1] https://www.who.int/news-room/fact-sheets/detail/drinking-water (accessed on 10 June 2024).
[2] Boretti A., Rosa L., 2019, Reassessing the projections of the World Water Development Report, npj Clean Water, 2, 15, 1-15.
[3] https://www.unicef.org/stories/water-and-climate-change-10-things-you-should-know (accessed on 10 June 2024).
[4] Karimidastenaei Z., Avellán T., Sadegh M., Kløve B., Haghighi A.T., 2022, Unconventional water resources: Global opportunities and challenges, Science of the Total Environment, 827, 154429, 1-15.
[5] Zhang M., Liu R., Li Y., 2022, Diversifying Water Sources with Atmospheric Water Harvesting to Enhance Water Supply Resilience. Sustainability, 14, 7783, 1-17.
[6] Ahrestani Z., Sadeghzadeh S., Motejadded Emrooz H.B., 2023, An overview of atmospheric water harvesting methods, the inevitable path of the future in water supply, RSC Advances, 13, 10273-10307.
[7] Tashtoush B., Alshoubaki A., 2023, Atmospheric water harvesting: A review of techniques, performance, renewable energy solutions, and feasibility, Energy, 280, 128186, 1-22.
[8] Algarni S., 2018, Assessment of fog collection as a sustainable water resource in the southwest of the Kingdom of Saudi Arabia, Water and Environment Journal, 32, 301–309.
[9] Zhang C., Guo H., Li C., Wang F., Guo X., Li A., Gong S., Zhang H., Zhang X., Qin X., 2023, Atmospheric water extraction - a review from materials to devices, Journal of Material Chemistry A, 11, 22041-22057.
[10] Raveesh G., Goyal R., Tyagi S., 2021, Advances in atmospheric water generation technologies, Energy Conversion and Management, 239, 114226, 1-19.
[11] https://www.atmoswater.com/manufacturers-and-suppliers-of-atmospheric-water-generators--water-from-air-machines.html (accessed on 27 May 2024).
[12] Cattani L., Magrini A., Cattani P., 2021, Water Extraction from Air: A Proposal for a New Indicator to Compare Air Water Generators Efficiency, Energies, 14, 224, 1-21.
[13] Milani D., Abbas A., Vassallo A., Chiesa M., Al Bakri D., 2017, Evaluation of using thermoelectric coolers in a dehumidification system to generate freshwater from ambient air, Chemical Engineering Science, 66, 2491-2501.

[14] Cattani L., Cattani P., Magrini A., Figoni R., Dondi D., 2023, Dhanalakshmi Vadivel, Suitability and Energy Sustainability of Atmospheric Water Generation Technology for Green Hydrogen Production, Energies, 16 640, 1-20.

[15] Cattani L., Cattani P., Magrini A., 2021, Air to Water Generator Integrated Systems: The Proposal of a Global Evaluation Index—GEI Formulation and Application Examples, Energies 14, 8528, 1-21.

[16] Cattani L., Cattani P., Magrini A., 2023, Air to Water Generator Integrated System Real Application: A Study Case in a Worker Village in United Arab Emirates, Applied Sciences, 13, 3094, 1-27.

[17] Ferrari M.L., Gini L., Pascenti M., 2025, Laboratory Tests in Cyber-Physical Mode for an Energy Management System Including Renewable Sources and Industrial Symbiosis. Journal of Engineering for Gas Turbines and Power, 147(1), 011020_1-9.

[18] Raggio M., Ferrari M.L., 2023, Compressed air energy storage with T100 microturbines: Dynamic analysis and operational constraints, Journal of Energy Storage, 73, 109093_1-15.

[19] Bellotti D., Rivarolo M., Magistri L., 2022, A comparative techno-economic and sensitivity analysis of Power-to-X processes from different energy sources. Energy Conversion and Management, 260, 115565, 1-15.

[20] Ferrari M.L., Gini L., Di Barba P., Mognaschi M.E., Sieni E., 2024, Multi-objective optimization of a polygeneration grid including thermal energy storage system, Journal of Energy Storage, 97, 112963, 1-12.

[21] https://seas-sa.com/project/awa-modula-250/ (accessed on 06 June 2024).

[22] Cattani L., Magrini A., Cattani P., 2018, Water Extraction from Air by Refrigeration - Experimental Results from an Integrated System Application, Applied Sciences, 8, 2262, 1-21.

[23] Kaplan A., Ronen-Eliraz G., Ratner S., Aviv Y., Wolanov Y., Avisar D., 2023, Impact of industrial air pollution on the quality of atmospheric water production. Environmental Pollution, 325, 121447, 1-9.

[24] Mandal C.S., Agarwal M., Reddy V., Kudapa V.K., 2021, Water from air—A sustainable source of water, Materials Today Proceedings, 46, 3352–3357.

[25] Barberis S., Rivarolo M., Bellotti D., Magistri L., 2022, Heat pump integration in a real poly-generative energy district: A techno-economic analysis. Energy Conversion and Management: X, 15, 100238, 1-10.

[26] Norouzi F., Karimi H., Jadid S., 2023, Stochastic electrical, thermal, cooling, water, and hydrogen management of integrated energy systems considering energy storage systems and demand response programs. Journal of Energy Storage, 72, 108310, 1-23.

[27] Audet C., Dennis Jr. J.E., 2003, Analysis of Generalized Pattern Searches, SIAM Journal on Optimization, 13, 889–903.

[28] https://www.holidu.it/magazine/indice-prezzi-acqua (accessed on 06 June 2024).

[29] Ancona M.A., Bianchi M., Biserni C., Melino F., Salvigni S., Valdiserri P., 2019, Optimum sizing of cogeneration plants by means of a genetic algorithm optimization: A case study. Case Studies in Thermal Engineering, 15 (2019) 100525, 1-13.

Nomenclature

Acronyms

AWG	Air to Water Generator
C.	Cooling
EMS	Energy Management System
Gen.	Generator
HVAC	Heating, Ventilation, Air Conditioning
PV	PhotoVoltaic
W.	Water

Variables

c	cost [€]
COP	Coefficient of Performance [-]
J	cost function [€]
m	mass flow rate [kg/s]
P	Power [W]

Journal of Physics: Conference Series **2893** (2024) 012027 doi:10.1088/1742-6596/2893/1/012027

RH	Relative Humidity [%]
SoC	State of Charge [0-1]
T	Temperature [K]
WET	Water Energy Transformation [-]

Subscripts

amb	ambient
AWA250	AWG machine considered here
cool	cooling
el	electrical
O&M	Operating & Maintenance
W	Water