ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

Publisher
http://jssidoi.org/esc/home

DIGITAL INNOVATION GOVERNMENT: ORGANIZATIONAL AND ENERGY ANALYSIS IN ITALIAN HOSPITALS*

Alfonso Marino [1], Paolo Pariso [2]

[1,2,] *Università degli Studi della Campania "L. Vanvitelli" – Dipartimento di Ingegneria, Via Roma, 29 – Aversa - Italy*

E-mails:[1] alfonso.marino@unicampania.it; [2] paolo.pariso@unicampania.it

Received 18 November 2022; accepted 12 March 2023; published 30 March 2023

Abstract. Analyzing the complex structures of 1062 Italian hospitals, the present research aims at evaluating the performance relating to the sustainable energy management. The monitoring activities were carried out both to analyze the building and structural context and to analyze the energy consumption of Italian hospitals during the period 2016-2022. Furthermore, the paper elaborates a comparative analysis the other European countries, highlighting how is possible to improve the energy efficiency of Italian hospitals. The energy analysis concerned the breakdown of electricity consumption, analysis of the consumption of the last six years derived from the monthly bills of hospitals, the consumption now, distribution of electricity consumption, and air conditioning needs; the organizational analysis concerned the plant characteristics of the structure, the age of the building and building maintenance over the last 6 years. In the discussion, possible solutions emerge, operational interventions, to make the energy management of hospitals, more efficient. The presence of different services provided highlight different profiles of energy consumption linked to two main categories: hotel-type consumption for the well-being of patients and staff and consumption more closely related to health functions supported by treatment and diagnosis equipment. In recent years, numerous opportunities for energy upgrading of buildings have not been implemented by creating energy profiles of obsolete and inefficient hospital facilities. In this context, the role of the energy manager and the presence of structures dedicated to energy management emerge as the main bottlenecks for achieving better energy efficiency. After the introduction, the paper elaborates a conceptual background focused on sustainable energy management. The section 3 show the methodology applied, the main results are included in section 4 and the discussion section have been developed in section 5. Finally, the conclusion highlights that the sustainable energy management is an open question and the output of discussion linked to the research suggest that the hospitals' energy efficiency must be seen as under constant development and re-interpretation.

Keywords: energy policy; digital technologies; government; health

Reference to this paper should be made as follows: Marino, A., Pariso, P. 2022. Digital innovation government: organizational and energy analysis in Italian hospitals *Entrepreneurship and Sustainability Issues*, 10(3), 214-230. http://doi.org/10.9770/jesi.2023.10.3(15)

JEL Classifications: I18, P46, O33, O32, M12, C54, C30

* *This research was supported by the project, SSCeGov VALERE which has received funding from the University Studie of Campania – Luigi Vanvitelli, Italy*

ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

1. Introduction

In recent years, modern society is increasingly interested in the energy issue (Clarke et al, 2015), understood as sources of supply (Russo et al, 2021), consumption (Su et al, 2022), and distribution (Patil et al, 2021) of energy. The comparison concerns the economic systems (Liu et al, 2022), the technological evolution (Wen et al, 2022) and the environmental situation (Alola et al, 2021) of the individual States (Yang et al, 2020) and the entire Planet (Smol, M, 2022). The growing energy demand highlights the need for individual states and the internal Planet to pay attention to the economic and environmental costs arising from the use of different energy carriers, shifting attention to the issue of energy efficiency (Economidou et al, 2022). In this context, the total use of energy in Italy, related to the hospital sector is about 35% of the total (OEDC, 2020). Hospital facilities are a very complex structure (Mavrotas et al, 2008), not only for the size and the different technologies that coexist within it (Baltussen et al, 2019; Zavadil et al., 2020) but above all because it is the only public building (Marino, 2001), that must maintain a constant service every day of the year, 24 hours a day (Ai et al, 2022). Energy is one of the fundamental elements for the functionality of healthcare facilities and the different sources converge and interact with each other to ensure patients, employees and users, a safe, comfortable and continuous service (Szczygielski et al, 2021). Nevertheless, it is one of the contexts where there is the greatest margin of difficulty for the implementation of efficient energy strategies. The difficulties relate to a series of elements such as buildings that do have not modern structures and are difficult to maintain and innovate (Yu et al, 2022). It should also not be forgotten that an improvement in energy efficiency must not necessarily result only in an economic advantage detectable in the bill, but can also be used to increase thermo-hygrometric well-being and the health of the environment, all the more reason given the very purpose of the buildings under consideration and the particular condition in which its users are located. Some studies (Bellini et al, 2020) have thoroughly analyzed the general situation of the Italian health heritage about Europe (Lal et al, 2021), to evaluate investment policies and the definition of appropriate intervention strategies. The monitoring activities were carried out both to analyze the building and structural context (Martinez et al, 2022) and to analyze the energy consumption of Italian hospitals. This comparison with the other realities of Europe, highlights what will be evaluated in our research issue, following this research stream, the research question (RQ) will be: how is it possible to improve the energy efficiency of Italian hospitals? In this work, the introduction is followed by the literature review, after the methodology, we present the results of the research, followed by the discussions, and finally the conclusions of the work. In the next paragraph, concerning the research issue, we highlight the reference literature.

2. Conceptual background

The current pandemic has dramatically highlighted the central role of the hospital structure in terms of the organization and delivery of health for our well-being, as well as that of the multiplicity of different energy services essential to deliver health (Yaps et al., 2021; Santiago et al., 2021; Liang et al., 2019; Castán Broto & Kirshner, 2020). Unfortunately, in Italy, investments in energy efficiency have fallen due to the economic crisis, as underlined by the International Energy Agency in its recent report (IEA 2022). Moreover, in this context the response of the European Union (2022) is not yet clear, unlike other crises, see the pandemic from SARS Covid 19. The role played by the European Government in the implementation of measures to support the energy crisis. Avoiding generating a new economic crisis is fragmented and does not show strong elements of union between the 27 Member States. In this context, the hospital principals (Liang et al., 2019; Weyman-Jones, 2019; Fawcett & Killip, 2019) are involved in a dual strategic path: they deliver health but, to deliver it consumes energy, are energy-intensive structures, therefore, for the hospital principals have set out a challenging process: The European Parliament is calling on the Council and the Commission to ensure that the European Parliament is fully involved in the implementation of the Kyoto Protocol. The hospitals in Europe (Mossialos et al., 2019; Johnson et al., 2019) have evidenced that to withstand this challenge it is necessary to combine adequate normative support (Prada et al., 2020) the collaboration of various subjects, identifying the best projects and the sharing of ideas and

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

cutting-edge technologies (Grillone et al., 2020). National experiences, in particular Italian ones, confirm the presence of several barriers to the full implementation of energy efficiency potential and, in particular: a market where consumers and businesses still experience long return times, difficult access to investment capital and dispersion of measures, resulting in high transaction costs (Saint Akadiri et al., 2019; Pichler et al., 2019). The role of the individual member countries of the European Union is strategic to build virtuous processes of implementation of operational projects that combine care and energy consumption. Improving the energy performance of Italian hospitals is one of the main objectives to accompany the energy transition of this country and the energy efficiency of the National Health System (Alola et al., 2919; Economidou et al., 2920). It should not be forgotten that energy efficiency is a lever that starts from the bottom up and is transversal to several economic sectors. The energy upgrading of hospitals Fox et al., 2019; Li, et al., 2019) would see its indirect benefits greatly reduced if not supported by the efficiency of the industrial sector associated with it. The health sector, with the peculiarities of the sectors included in it, is affected by redevelopment interventions as well as by interventions to improve the efficiency of its service processes. Efficiency must be supported by emerging technologies (Bygstad et al., 2020; Moro Visconti et al., 2020), such as the predisposition to the intelligence of buildings, technologies for the built environment, heat recovery and solutions for energy communities. Particulalrly, the moment of great changes that we are going through has shown with great evidence the importance of the scientific committee to seek solutions, for our social and economic well-being. Smart Readiness Technologies (Ronaghi, 2022; Sebastian, 2019) is seen by the European Commission as an important tool that can, on the one hand, encourage investment in Smart Ready Technologies (SRT) and, on the other hand, help SRT producers to improve their supply and organize it according to the types of demand (Santiago et al, 2021; Li & Zhang, 2022). Hence the importance of defining the Smart Readiness Indicator to promote the spread of smart building technologies, (Awada et al., 2021; EN ISA, 2022) quantify the level of "smartness" of buildings and certify the benefits that result in terms of energy efficiency and performance Woll et al., 2023; Kumar et al., 2020; Fisher et al., 2020). The role of information and training is strategic, in particular for the type of these structures, hospital facilities, which is very complex because it often combines the typical energy characteristics of a multiplicity of other types of "energy consumers": from the real estate/hotel sector (hospitals) (Ismail et al., 2020; Paparizos et al., 2020; Tavakoli et al., 2020) to the energy generation and transformation sector (large cogeneration/trigeneration plants), to research and sports (rehabilitation). This energy complexity can be broken down into prime factors by using the energy diagnosis (Alzubaidi & Soori, 2012; MacNaughton, 2018) report in the health field, providing an industry-specific data collection methodology, standardizing the technical glossary and defining minimum levels for energy monitoring, which can be an important tool for the definition of energy efficiency actions useful to define reliable reference parameters. Accurately estimating the real energy and economic savings of a building (Pallis et al., 2021; Yun et al., 2020; Giraudet, 2020; Dominguez-Delgado et al., 2020) requires an adequate knowledge of the building-plant system, or the characteristics of the building envelope, but also of the plant components present and how these two systems interact with each other. Enhancing the energy supply chain of Italian hospitals (Moro Visconti et al., 2020; Klemeš et al 2020; Sarkis, 2020; Martiniello et al., 2020) is a strategic priority that requires investment, simplification of authorization procedures and a push to the conversion of traditional buildings in the key of circular economy (Khadim et al., 2022, Marino & Pariso, 2022). In this context, energy efficiency can make an essential contribution to the transition to stimulating economic growth (Khan et al., 2021; Kahouli, 2018; Zhou et al., 2021). The knowledge gaps that the work intends to fill is to evaluate the improvement of the energy efficiency of the 1,062 principals. Bridging this knowledge gap is useful both for operators in the sector and for the theory related to energy management and the adoption of new technologies in public organizations. In the following paragraph, we present the methodology used to improve the energy efficiency of Italian hospitals.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

3. Methodology

The methodological approach has been that of a joint evaluation both of organizational type that is energetic. The energy analysis concerned: the breakdown of electricity consumption, analysis of the consumption of the last six years derived from the monthly bills of hospitals, the consumption now, distribution of electricity consumption, and air conditioning needs. In the period between the years 2016 and 2022 using the data source of the Ministry of Health calculated for 1009 of the hospital principals estimated the total of 1062 annual average energy consumption, Using the same source, the average annual energy supply costs of Italian hospitals were calculated. The critical parameters for the Italian hospital principals were compared with those of the hospital principals of the 27 European Member States. The analysis of the energy bills of the 1062 hospitals, in particular, the absorption and equivalent hours show divergent results. The hourly consumption curves provide data that have been ordered and analyzed with MATLAB software to represent significant carpet plots for an energy balance. This analysis was carried out over six years, but the three graphs for the year 2022 are shown. The bottom-up and mouse-down approach to changing energy consumption to climate change has used data from the 20 Regional Environmental Protection Agencies (ARPA) as a source. The organizational analysis concerned: the plant characteristics of the structure, the age of the building and building maintenance over the last 6 years. The 1,062 hospital garrisons (Istat, 2022) are divided into the national territory as follows: 216 in the northwest, 170 northeast, 231 centers, 280 South, and 165 Islands. Of the total of the principals who were contacted, only 5% were not available at the meeting for the proposed organizational and energy analysis. Therefore, 1,009 hospital principals and their documentation were evaluated for the years considered: 2016 - 2022 both in terms of organizational and energy analysis. The 53 missings are divided among the 5 macro areas as follows, northwest 12, northeast 8, center 10, south 13 and islands 10. The Principals' Organisational and Energy Managers met the working group between February and December 2022. The collected data were processed for organizational analysis with the Enterprise Resource Planning method (ERP - Infor visual - Dynamic enterprise performance management/2022). Process mapping is a valuable tool for organizational analysis and the process of reviewing the organizational system. The mapped processes were not only physical but also informative. This analysis tool allows the identification of the activities of each person and - possibly also through a timely survey for a significant period - the relative time load to translate it into the saturation of the resource. The investigation makes to emerge anomalies and criticalities in the allocation of the activities between functions and it is precisely on this that often is based a review of internal procedures to arrive at a king - design of portions of the organization: such as merging into a single dedicated person, a series of activities previously distributed over multiple uncoordinated resources (Marino & Pariso, 2021). The energy analysis and data processing were carried out with the Energy Software for Simplified Audits (SEAS) of National agency, new technologies, energy and sustainable development, (ENEA). The joint analysis, organizational and energy, represent one of the crucial moments in the implementation of a sustainable management system, both because it requires the hospital management an effort of analysis and overall evaluation of the site, both because its results depend on a large part of the choices regarding the organizational structure and characteristics of the energy management system within the hospital. The relationship between the two analyses, organizational and energy, allows us to better evaluate the results presented in the next paragraph.

ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

4. Results

In the period between 2016 and 2022, the average total primary energy consumption for Italian health facilities is 129.5 ktep divided into 62.7 ktep of electricity and 66.8 ktep of thermal energy, as highlighted in Table 1.

Table 1. Average annual consumption of Italian hospital principals

Year	Electricity [Tep]	Thermal Energy [Tep]	TOT	% E.E.	% T.E.
2016	49.650	56.339	105.989	47%	53%
2017	54.019	54.295	108.314	50%	50%
2018	58.032	57.939	115.971	50%	50%
2019	55.126	56.606	111.732	49%	51%
2020	54.045	50.676	104.721	52%	48%
2021	57.536	55.120	112.656	51%	49%
2022	56.802	57.154	113.956	50%	50%
Average	**55.030**	**55.447**	**110.477**	**50%**	**50%**

Source: Ministero della Salute – our elaboration

Table 2 shows the increasing costs of energy supply - average values - of Italian hospitals.

Table 2. Annual average costs energetic supply of the Italian hospitals

Year	Electricity [€]	Thermal Energy [€]	TOT [€]
2016	€ 30.617.263,00	€ 38.863.569,00	€ 69.480.832,00
2017	€ 34.110.712,00	€ 40.525.319,00	€ 74.636.031,00
2018	€ 47.327.137,00	€ 50.402.969,00	€ 97.730.106,00
2019	€ 48.044.675,00	€ 49.420.011,00	€ 97.464.686,00
2020	€ 46.786.558,00	€ 39.684.148,00	€ 86.470.706,00
2021	€ 45.489.397,00	€ 35.121.162,00	€ 80.610.559,00
2022	€ 42.297.572,00	€ 33.676.449,00	€ 75.974.021,00
Average	**€ 42.096.187,71**	**€ 41.099.089,57**	**€ 83.195.277,29**

Source: Ministero della Salute - our elaboration

A comparison between energy consumption and associated costs shows a more marked gap in recent years; this trend is also justified by the recent pandemic and war events involving sources of energy supply. By evaluating the parameters among the various hospitals in the territory, it is possible to verify the widespread difficulty of the Italian Health System in the management of energy supply and distribution sources within the hospital facilities. Specifically, the following parameters are compared and then summarized in Table 3:

- Energy consumption in gross surface area [Tep/m2]
- Thermal energy compared to square meters and Degrees Day [kWh/m2 DD]
- Electricity per square meter [kWh/m2]
- Unit expenditure on electricity supply [€/kWh]
- Unit expenditure on methane supply [€/Sm3]
- Unit expenditure on the supply of heat from district heating [€/MWh]

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

Table 3. Comparative Analysis

Italian Hospital Principals comparison with the 27 European Countries			
Energy consumption in gross surface area	0,035	Tep/m^2	low energy class
Thermal energy compared to square meters and Degrees Day	0,06	kWh/m^2 DD	low energy class
Electricity per square meter	125	kWh/m^2 DD	Average energy class
Unit expenditure on electricity supply	0,39	€/kWh	Above average Europe (0.16)
Unit expenditure on methane supply	0,44	€/ Sm^3	Under average Europe (0,43)
Unit expenditure on the supply of heat from district heating	92	€/MWh	Above average Europe (70)

Source: Ministero della Salute - Eurostat, ns elaboration (2016 - 2022)

The elaboration of the results of the organizational analysis shows that the 1009 hospital principals had a structure in 1962 and the original body was built between 1959 and 1961. The extensions relate to:

- the building surface to be used for the shelter;
- the surface of the laboratory activities and
- the management of the facilities.

In the '70s 65% of the buildings were enlarged with other pavilions and in the early 90s, other pavilions were built in 70% of the buildings studied. In the case of 320 garrisons, there are enlargement interventions that belong to both the 1970s and 1990s. The management of the plants to the location, expansion and installation of new plants, the various thermal plants, refrigeration units and substations of district heating, is varied within the structure, depending also on the different use of the departments over the years.

In this field, plant engineering, it emerges from the ERP analysis that in the decision-making process there is an overlap of functions for the same decision of 7.5%, other data, in 65% of cases, the absence of structure dedicated to energy management, even if the figure of the energy manager is present in all the hospital principals. The age of buildings, in 87% of cases exceeds 60 years and maintenance over the last 6 years is around 16%.

The energy analysis concerned: the characteristics of the electrical system, in particular, defined the distribution of electricity consumption within the buildings, dividing the energy absorbed by the various types of users. With this method, it will be easy to compare with other average values available in the literature, with the possibility of finding criticalities in the system. In table 4 we report the comparison between consumption and expenditure in the six years considered by the 1009 hospitals analyzed.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

Table 4. Comparison of consumption of E.E. in Euro during the analyzed time.

Comparison of consumption and expenditure electricity MT from 2016 to 2022			
	Average 2016 - 2022		
Time	**Avg Temperature °C**	**TOT kWh**	**Cost [€] (no VAT)**
2016	4,5	343903,3	46.161,18 €
2017	6,3	312920	42.333,92 €
2018	11,0	343927	46.349,20 €
2019	14,6	349818,7	47.196,57 €
2020	18,1	401758	54.546,98 €
2021	22,8	482275	63.960,49 €
2022	26,3	567570,5	76.385,41 €
Total Cost			**376.933.75 €**

Source: our elaboration

Starting from Table 1 it can be seen that consumption remains similar, even if compared with expenditure in the six reference years, there is a significant additional cost, as show in Table 4, therefore it is possible to suppose a monthly consumption calculated as average in this period but, considering in particular, the analysis of bills, Through the analysis of the distributor measurements and then concludes with the analysis of absorption and equivalent hours shows that energy expenditure in hospitals has increased significantly. After examining the bills of the last six years, to improve the comparison and analysis, electricity suppliers were asked for the hourly curves of consumption. The obtained data were ordered and analyzed with MATLAB software to represent significant carpet plots for an energy balance. This analysis was carried out over six years, but only three graphs are reported for the year 2022. It was done by varying the color bar of the graphs obtained, respectively on full-scale, minimum values (between 0 kWh and 650 kWh) and maximum values (between 650kWh and the maximum value found, 1165.5 kWh). From the tables you can make some considerations: a) the maximum value of energy measured is 1165.5 kWh measured at 15:00 on August 4, while lowering the scale to a minimum, the energy value never falls below 360 kWh; b) the highest consumptions are measured in conjunction with the periods when there is air conditioning, in the hottest hours of the day; c) in the night range between 23:00 and 6:00 consumption is much lower, and during the day you can see how, from 16:00 / 17:00 onwards consumption tends to decrease; d) the difference between public and working days is clear, almost halving. This shows that electricity consumption is particularly dependent on work activities such as offices and clinics; e) almost abnormal behavior is evident in the first half of January. The cooling requirement has been calculated in two different ways: Top-down and bottom-up. Top-down, we studied the trend of electricity consumption compared to the average external temperature; as can be seen from Figure 1, the consumption remains almost constant for temperatures below 14-15, while, for higher temperatures, the trend is increasing. This increase is certainly attributable to the conditioning load, which increases with the increase in the external temperature.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

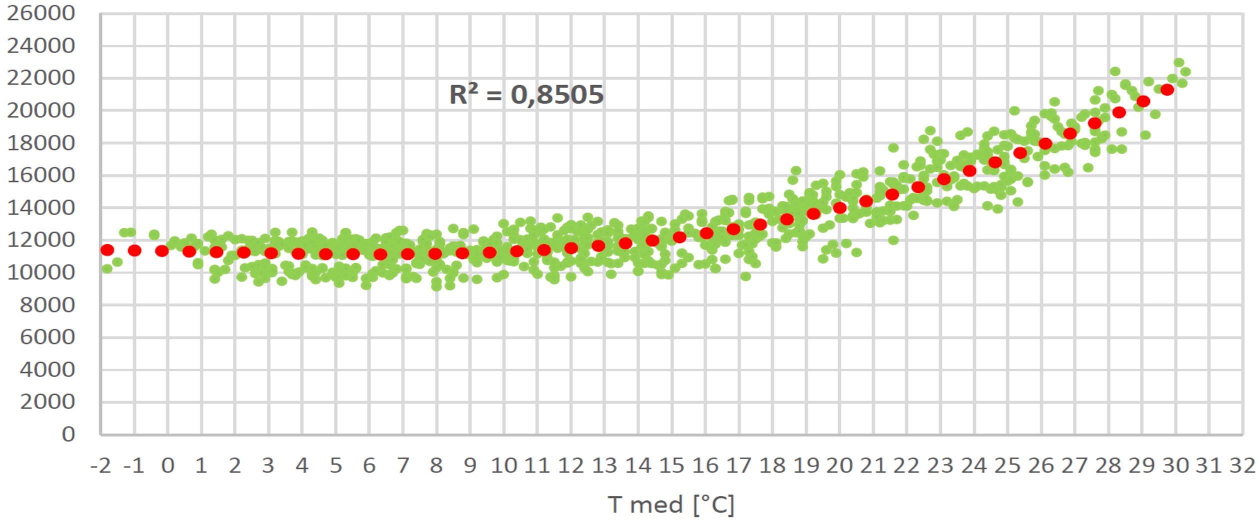

Figure 1. Average temperature vs the Electric daily consumption
Source: our elaboration

It therefore also calculated the standard electricity requirement as the average value of consumption recorded for temperatures less than 15 μc and subtracted this proportion to days when the temperature is higher as in Figure 2.

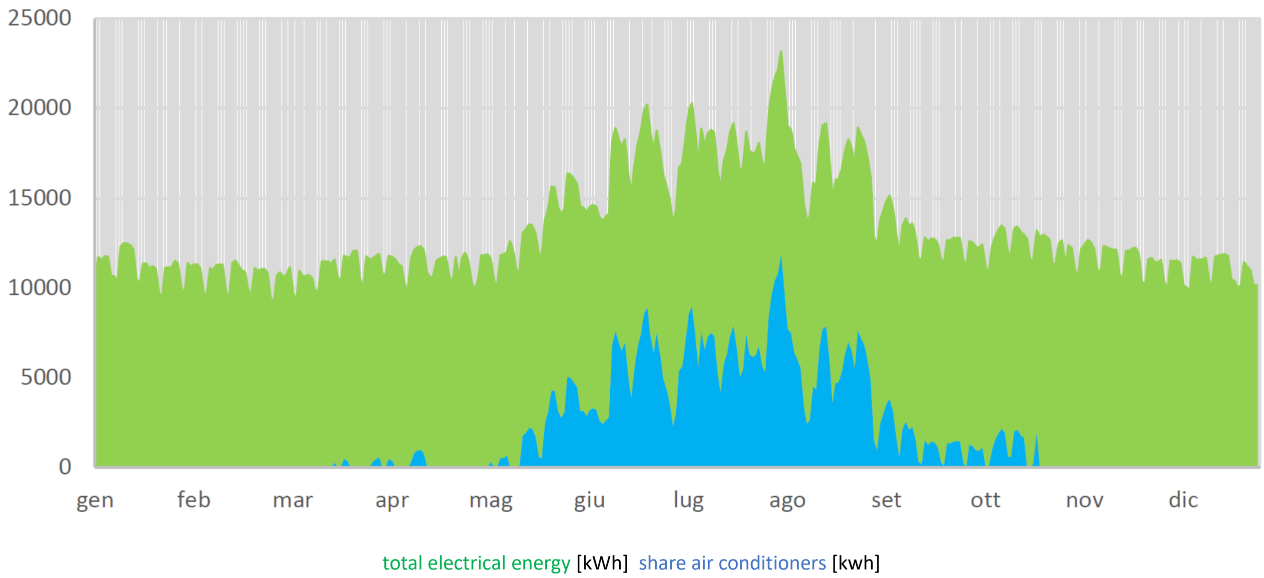

Figure 2. Consumption subdivision with conditioning quota - Electricity consumption 2022
Source: our elaboration

By carrying out this operation for six years the average need for conditioning was obtained at 14.1%.
Bottom-up. From the data of the refrigeration units and of the facilities' split systems, consumption was calculated on an annual basis assuming methods and hours of operation. As in talks with the hospital's technical staff, it was found that the refrigeration units were on average from mid-April to mid-October, in conjunction with the shutdown of the heating systems (except for particular climatic conditions). The assumption used for the

ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

calculation is an average of 12 per day of operation for all days of the period (180 days), except for groups currently undergoing restructuring, not yet operational. The power absorbed is assumed to be 30%, estimated from the characteristic absorption curve of the groups, initial absorption, followed by an exponential decrease. The annual consumption is calculated as:

$$\sum_{n=1}^{GF} Pot_{el,n} * 30\% * h_{funz} \left[\frac{kWh}{year}\right]$$

The results are shown in Table 5.

Table 5. Annual consumption calculated for the refrigeration units of hospitals

Installed Electrical Power [kW]	Electrical Power absorbed [kW]	h equivalent	Consumption [kWh/Year]
66,18	19,85	2160	42882,4
66,18	19,85	2160	42882,4
66,18	19,85	2160	42882,4
62,70	18,81	2160	40629,6
112,50	33,75	2160	72900
86,51	25,95	2160	56058,48
86,51	25,95	2160	56058,48
88,10	26,43	2160	57088,8
19,70	5,91	2160	12765,6
62,70	18,81	2160	40629,6
62,70	18,81	2160	40629,6
62,70	18,81	2160	40629,6
19,70	5,91	2160	12765,6
18,10	5,43	2160	11728,8
270,00	81,00	0	0
270,00	81,00	0	0
		Annual total	**570531,2**

In the same way, obtained the calculation of the split systems present in hospital facilities, the average electricity consumption was calculated, assuming 8 hours of operation for portable systems and 6 hours per day of operation for all the others, for only 122 days of the summer period; the power absorbed was calculated by multiplying by the electrical absorption efficiency $\eta = 97\%$ the electrical power shown on the data sheets of the different models. Annual consumption is shown in Table 6.

ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2023 Volume 10 Number 3 (March)
http://doi.org/10.9770/jesi.2023.10.3(15)

Table 6. Annual consumption calculated for split plants

Numbers of Installation Split	Tot. Installed Power [kW]	Power Adsorbed [kW]	h equivalent	Consumption [kWh/Year]
4	3,5	3,395	732	2485,1
1	2	1,94	732	1420,1
11	12	11,64	732	8520,5
10	12,1	11,737	732	8591,5
10	12	11,64	732	8520,5
7	7,1	6,887	732	5041,3
1	1,5	1,455	732	1065,1
1	0,9	0,873	732	639
5	4	3,88	732	2840,2
4	4,15	4,0255	732	2946,7
1	0,9	0,873	732	639
20	18	17,46	732	12780,7
3	2,9	2,813	732	2059,1
1	0,75	0,7275	732	532,5
1	0,9	0,873	732	639
5	5	4,85	732	3550,2
2	1,8	1,746	732	1278,1
8	7,8	7,566	732	5538,3
5	5,7	5,529	732	4047,2
1	0,75	0,7275	732	532,5
3	3,8	3,686	732	2698,2
1	1,3	1,261	732	923,1
1	1,5	1,455	732	1065,1
1	0,9	0,873	732	639
2	1,8	1,746	732	1278,1
1	0,9	0,873	732	639
30	30	29,1	976	28401,6
			Total for the Year	**109310,7**

The joint analysis of the 1009 Italian hospitals, highlights, the criticality and potential that are reported in the following paragraph.

5. Discussion

The processes of organizational and energy management such as health, increasingly have to deal with the stringent requirements of sustainability dictated by the recent economic crisis and subsequent European directives. These require energy redevelopment by combining the high-quality parameters required by citizens and the need for the National Health System to comply with budgetary constraints. The results show that the energy efficiency of Italian hospitals the European average, has structural weaknesses, but energy efficiency for Italian hospitals is also a strategic lever to restart. Healthcare construction is extremely involved in these objectives since it is one of the most energy-intensive sectors because of the many functions it incorporates and the need to operate the services provided, which must be guaranteed, at least for hospital facilities, 24 hours a day 365 days a year, ensuring:

a) continuity in medical services
b) high thermal comfort (in winter and summer) for patients and staff
c) healthy working and hospitalization environments.

In Italy, from the research carried out, it emerges that the patrimony of hospital principals, in most cases, is no longer suitable for current uses, The buildings were built in times when regulatory constraints were not stringent and there was no attention to the issues of efficiency and energy saving. The hospital structures should be adaptable to the continuous evolution of the technologies and the organization of the Services and instead are structures that over the years fall into obsolescence. Over the years there have been no technological innovations to cope with the continuous and increasing use of facilities and adaptation to new regulations (Marino & Pariso, 2021a). This absence is evident in all its difficulties of implementation when, and this is the Italian case, the incidence of costs for energy consumption is predominant in an economic situation dictated by the crisis of supply of energy sources (Vaziri et al., 2020) and relative increase in costs. In addition, no work has been undertaken over time to modernize the old hospital complexes, it is unlikely that these changes will lead to an optimization of energy consumption, but they may lead to partial improvements that do not significantly affect overall consumption. About a third of the energy consumed in Italy is related to the health sector. In this sector, hospital principals have average consumption three times higher than in the residential civil sector in similar climatic conditions (ENEA 2022). These buildings, therefore, have ample energy and economic savings that can be achieved both through more prudent management of energy flows and through energy efficiency interventions of the building-plant systems. In the total budget of the National Health System, the energy, thermal and electricity supply correspond respectively to 5% and 2.2% of the budget share, equal to 27% of total expenditure (ENEA 2022), a significant figure for our country. Attacking this figure, saving a share with the rationalization of consumption has the consequence of freeing economic resources for the entire public sector. Net of a new building for hospital principals, some actions are possible in the short term. It is interesting to note that both at theoretical and practical level, a first action for the reduction of the expense regards the reorganization of the relative management to the energetic efficiency, eliminating the decisional and operating duplication present in the management process is the possible saving of 7%. A second action is to structure energy efficiency units and establish the role of the energy manager. The high potential for energy saving and therefore economics that can be achieved in the field of Health, cannot ignore a key figure, the energy manager (Aoudia et al., 2018) as head of the structure dedicated to energy management. Structure and professional figures can represent in hospital facilities an opportunity for rational use of energy resources of a certain structure, based on data collected by monitoring systems, on the empirical observation of installations and the continuous analysis of energy performance indicators. This figure and structure are necessary to determine the energy performance of each hospital with skills related to the identification and characterization of cost centers and the correct definition of energy efficiency interventions. Third short-term action, the mandate of this structure must make priority technological investments both to implement the reduction of energy consumption of hospital facilities and for interventions aimed at reducing dispersion and implementation of technologies for the exploitation of renewable energy sources. These three actions can improve the energy efficiency of Italian hospitals. The current energy and economic crisis, requires hospitals the need to support the priority of the health service, therefore clinical - diagnostic, and energy. It's a necessary cultural and organizational change to be achieved quickly. The European Directives from 2012/27/U3, concerning the energy efficiency of energy end-uses and energy services, to reduce emissions and respect the European targets set, has given a strong impetus to the energy upgrading of buildings to achieve minimum energy efficiency standards, Encouraging Member States to support the public sector in the examination of energy service offers by using and managing particular Service Contracts. Italy as emerges from the research presents a strong weakness concerning the energy efficiency of hospital facilities used to provide health services.

Conclusions

The energy management of hospital facilities is complex due to the large amounts of energy used and transformed the performance of all health and non-health activities that take place daily in the 1062 hospitals analyzed. The hospital is the only public building that does not know breaks in its daily activities throughout the year. It is a structure in operation 24 hours and 365 days a year. The different services provided have a multiplicity of energy consumption profiles and can be essentially divided into two main categories: hotel-type consumption for the well-being of patients and staff and consumption more closely related to health functions supported by treatment and diagnosis equipment. In recent years, numerous opportunities for energy upgrading of buildings have not been implemented by creating energy profiles of obsolete and inefficient hospital facilities. Moreover, the obtained financings have regarded interventions centered on the core business of the hospital garrisons, therefore, investments in medical technologies for the diagnosis and the treatment of the pathologies, or more urgent building interventions such as regulatory adaptation in terms of safety of structures. A possible way to obtain financial resources that allow important interventions of requalification and energy efficiency of health facilities, requires a management change, both energy and organizational.

References

Ai, H., Zhong, T., & Zhou, Z. (2022). The real economic costs of COVID-19: Insights from electricity consumption data in Hunan Province, China. *Energy Economics*, 105. https://doi.org/10.1016/j.eneco.2021.105747

Aoudia, F. A., Gautier, M., & Berder, O. (2018). RLMan: An energy manager based on reinforcement learning for energy harvesting wireless sensor networks. *IEEE Transactions on Green Communications and Networking*, 2(2), 408-417. DOI**:** 10.1109/TGCN.2018.2801725

Alola, A. A., Bekun, F. V., & Sarkodie, S. A. (2019). Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. *Science of the Total Environment,* 685, 702-709. https://doi.org/10.1016/j.scitotenv.2019.05.139

Alola, A. A., Ozturk, I., & Bekun, F. V. (2021). Is clean energy prosperity and technological innovation rapidly mitigating sustainable energy-development deficit in selected sub-Saharan Africa? A myth or reality. *Energy Policy*, *158*. https://doi.org/10.1016/j.enpol.2021.112520

Alzubaidi, S., & Soori, P. K. (2012). Energy efficient lighting system design for hospitals diagnostic and treatment room—a case study. *Journal of light & visual environment,* 36(1), 23-31. https://doi.org/10.2150/jlve.36.23

Awada, M., Becerik-Gerber, B., Hoque, S., O'Neill, Z., Pedrielli, G., Wen, J., & Wu, T. (2021). Ten questions concerning occupant health in buildings during normal operations and extreme events including the COVID-19 pandemic. *Building and Environment,* 188. https://doi.org/10.1016/j.buildenv.2020.107480

Baltussen, R., Marsh, K., Thokala, P., Diaby, V., Castro, H., Cleemput, I., & Broekhuizen, H. (2019). Multicriteria decision analysis to support health technology assessment agencies: benefits, limitations, and the way forward. *Value in Health*, 22(11), 1283-1288. https://doi.org/10.1016/j.jval.2019.06.014

Bellini, V., Guzzon, M., Bigliardi, B. et al. (2020). Artificial Intelligence: A New Tool in Operating Room Management**.** Role of Machine Learning Models in Operating Room Optimization. *J Med Syst* 44**,** 20 (2020). https://doi.org/10.1007/s10916-019-1512-1

Bygstad, B., & Øvrelid, E. (2020). Architectural alignment of process innovation and digital infrastructure in a high-tech hospital. *European Journal of Information Systems*, 29(3), 220-237. https://doi.org/10.1080/0960085X.2020.1728201

Castán Broto, V., & Kirshner, J. (2020). Energy access is needed to maintain health during pandemics. *Nature Energy*, 5(6), 419-421. DOI:10.1038/s41560-020-0625-6

Clarke, C. E., Hart, P. S., Schuldt, J. P., Evensen, D. T., Boudet, H. S., Jacquet, J. B., & Stedman, R. C. (2015). Public opinion on energy development: the interplay of issue framing, top-of-mind associations, and political ideology. *Energy Policy*, 81, 131-140. https://doi.org/10.1016/j.enpol.2015.02.019

Martino, B. D., Marino, A., Rak, M., & Pariso, P. (2019, July). Optimization and validation of eGovernment business processes with support of semantic techniques. In *Conference on Complex, Intelligent, and Software Intensive Systems* (pp. 827-836). Springer, Cham. DO**I:**10.1007/978-3-030-22354-0_76

Dominguez-Delgado, A., Domínguez-Torres, H., & Domínguez-Torres, C. A. (2020). Energy and economic life cycle assessment of cool roofs applied to the refurbishment of social housing in southern Spain. *Sustainability*, 12(14). https://doi.org/10.3390/su12145602

Economidou, M., Ringel, M., Valentova, M., Castellazzi, L., Zancanella, P., Zangheri, P., Bertoldi, P. (2022). Strategic energy and climate policy planning: Lessons learned from European energy efficiency policies. *Energy Policy*, *171*. https://doi.org/10.1016/j.enpol.2022.113225

Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. Energy and Buildings, 225. https://doi.org/10.1016/j.enbuild.2020.110322

ENEA (2022) https://www.espa.enea.it/prodotti-e-servizi/software-per-l-autovalutazione-del-grado-di-efficienza-energetica-della-pmi.html
Enea (2022) Rapporto Annuale sull'EFFICIENZA ENERGETICA 2021 https://www.efficienzaenergetica.enea.it/pubblicazioni/raee-rapporto-annuale-sull-efficienza-energetica/rapporto-annuale-sull-efficienza-energetica-2022.html (last download December 2022)

European Union (2022) https://energy.ec.europa.eu/index_en (last access Nov. 2022)

European Union Agency for Network and Information Security "ENISA". Smart hospitals. Security and resilience for smart health service and infrastructures. www.enisa.europa.eu. Last Accessed Nov. 2022

Eurostat (2022) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview&action=statexp-seat&lang=it

Eurostat (2022) https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview&action=statexp-seat&lang=it

Fawcett, T., & Killip, G. (2019). Re-thinking energy efficiency in European policy: Practitioners' use of 'multiple benefits' arguments. *Journal of Cleaner Production*, 210, 1171-1179. https://doi.org/10.1016/j.jclepro.2018.11.026

Fischer, G. S., da Rosa Righi, R., de Oliveira Ramos, G., da Costa, C. A., & Rodrigues, J. J. (2020). ElHealth: Using Internet of Things and data prediction for elastic management of human resources in smart hospitals. *Engineering Applications of Artificial Intelligence*, 87. https://doi.org/10.1016/j.engappai.2019.103285

Fox, M., Zuidema, C., Bauman, B., Burke, T., & Sheehan, M. (2019). Integrating public health into climate change policy and planning: state of practice update. *International Journal of Environmental Research and Public Health*, 16(18). https://doi.org/10.3390/ijerph16183232

Giraudet, L. G. (2020). Energy efficiency as a credence good: A review of informational barriers to energy savings in the building sector. *Energy Economics*, 87. https://doi.org/10.1016/j.eneco.2020.104698

Grillone, B., Danov, S., Sumper, A., Cipriano, J., & Mor, G. (2020). A review of deterministic and data-driven methods to quantify energy efficiency savings and to predict retrofitting scenarios in buildings. *Renewable and Sustainable Energy Reviews*, 131. https://doi.org/10.1016/j.rser.2020.110027

International Energy Agency (2022) https://www.iea.org/reports/world-energy-outlook-2022 (last access Nov. 2022)

Ismail, A., Abdlerazek, S., & El-Henawy, I. M. (2020). Development of smart healthcare system based on speech recognition using support vector machine and dynamic time warping. *Sustainability*, 12(6). https://doi.org/10.3390/su12062403

Istat (2022) http://dati.istat.it/Index.aspx?DataSetCode=DCIS_OSPEDSSN#

Johnson, H. C., Gossner, C. M., Colzani, E., Kinsman, J., Alexakis, L., Beauté, J., ... & Ekdahl, K. (2020). Potential scenarios for the progression of a COVID-19 epidemic in the European Union and the European Economic Area, March 2020. *Eurosurveillance*, 25(9). https://doi.org/10.2807/1560-7917

Kahouli, B. (2018). The causality link between energy electricity consumption, CO2 emissions, R&D stocks and economic growth in Mediterranean countries (MCs). *Energy*, 145, 388-399. https://doi.org/10.1016/j.energy.2017.12.136

Khadim, N., Agliata, R., Marino, A., Thaheem, M. J., & Mollo, L. (2022). Critical review of nano and micro-level building circularity indicators and frameworks. *Journal of Cleaner Production*. 357, https://doi.org/10.1016/j.jclepro.2022.131859

Khan, I., Hou, F., Zakari, A., & Tawiah, V. K. (2021). The dynamic links among energy transitions, energy consumption, and sustainable economic growth: A novel framework for IEA countries. *Energy*, 222. https://doi.org/10.1016/j.energy.2021.119935

Klemeš, J. J., Van Fan, Y., & Jiang, P. (2020). The energy and environmental footprints of COVID-19 fighting measures–PPE, disinfection, supply chains. *Energy*, 211. https://doi.org/10.1016/j.energy.2020.118701

Kumar, S., Raut, R. D., & Narkhede, B. E. (2020). A proposed collaborative framework by using artificial intelligence-internet of things (AI-IoT) in COVID-19 pandemic situation for healthcare workers. *International Journal of Healthcare Management*, 13(4), 337-345. https://doi.org/10.1080/20479700.2020.1810453

Lal, A., Erondu, N. A., Heymann, D. L., Gitahi, G., & Yates, R. (2021). Fragmented health systems in COVID-19: rectifying the misalignment between global health security and universal health coverage. *The Lancet*, 397, 61-67. https://doi.org/10.1016/S0140-6736(20)32228-5

Li, Y., Kubicki, S., Guerriero, A., & Rezgui, Y. (2019). Review of building energy performance certification schemes towards future improvement. *Renewable and Sustainable Energy Reviews*, 113. https://doi.org/10.1016/j.rser.2019.109244

Li, Y.H., & Zhang, B.S. (2022). Relational governance and performances of supplier alliance: mediating effect of knowledge transfer. *Transformations in Business & Economics*, Vol. 21, No 2A (56A), pp.549-566.

Liang, X., Shen, G. Q., & Guo, L. (2019). Optimizing incentive policy of energy-efficiency retrofit in public buildings: a principal-agent model. *Sustainability*, 11(12). https://doi.org/10.3390/su11123442

Liang, X., Yu, T., Hong, J., & Shen, G. Q. (2019). Making incentive policies more effective: An agent-based model for energy-efficiency retrofit in China. *Energy Policy*, 126, 177-189. https://doi.org/10.1016/j.enpol.2018.11.029

Liu, H., Khan, I., Zakari, A., & Alharthi, M. (2022). Roles of trilemma in the world energy sector and transition towards sustainable energy: A study of economic growth and the environment. *Energy Policy*, 170. https://doi.org/10.1016/j.enpol.2022.113238

MacNaughton, P., Cao, X., Buonocore, J., Cedeno-Laurent, J., Spengler, J., Bernstein, A., & Allen, J. (2018). Energy savings, emission reductions, and health co-benefits of the green building movement. *J. Expo. Sci. Environ. Epidemiol*, 28(4), 307-318. https://doi.org/10.1038/s41370-017-0014-9

Marino, A., & Pariso, P. (2022). Africa's View of the Circular Economy: Bottlenecks and Opportunities. *The International Journal of Environmental Sustainability*, 19(2), 1-16. doi:10.18848/2325-1077/CGP/v19i02/1-16.

Marino, A. (2001). The tourist sector: public versus private—the Italian and Spanish experience. *Tourism Management*, *22*(1), 43-48. DOI10.1016/S0261-5177(00)00023-6

Marino, A., & Pariso, P. (2021). Human resource management in public transports: organizational typologies and research actions. *VINE Journal of Information and Knowledge Management Systems*, 51(03). https://doi.org/10.1108/VJIKMS-01-2021-0006

Marino, A. & Pariso, P. (2021a). E-tourism: How ICTs Help the Local Tourist District Drive Economic Vitality. The Case of Campania, Italy. *International Journal of Innovation and Technology Management* (IJITM), 18(03), 1-25. https://doi.org/10.1142/S0219877021500097

Martínez, S. H., Harmsen, R., Menkveld, M., Faaij, A., & Kramer, G. J. (2022). Municipalities as key actors in the heat transition to decarbonise buildings: Experiences from local planning and implementation in a learning context. *Energy Policy*, *169*. https://doi.org/10.1016/j.enpol.2022.113169

Martiniello, L., Morea, D., Paolone, F., & Tiscini, R. (2020). Energy performance contracting and public-private partnership: How to share risks and balance benefits. *Energies*, 13(14). https://doi.org/10.3390/en13143625

Mavrotas, G., Diakoulaki, D., Florios, K., & Georgiou, P. (2008). A mathematical programming framework for energy planning in services' sector buildings under uncertainty in load demand: The case of a hospital in Athens. *Energy policy*, *36*(7), 2415-2429. https://doi.org/10.1016/j.enpol.2008.01.011

Moro Visconti, R., & Morea, D. (2020). Healthcare digitalization and pay-for-performance incentives in smart hospital project financing. *International Journal of Environmental Research And Public Health*, 17(7). https://doi.org/10.3390/ijerph17072318

Mossialos, E., & Le Grand, J. (2019). Cost containment in the EU: an overview. Health care and cost containment in the European Union, 1-154. Routledge

OECD (2021) https://data.oecd.org/energy.htm (last accessed, 2022)

Pallis, P., Braimakis, K., Roumpedakis, T. C., Varvagiannis, E., Karellas, S., Doulos, L., ... & Vourliotis, P. (2021). Energy and economic performance assessment of efficiency measures in zero-energy office buildings in Greece. *Building and Environment*, 206. https://doi.org/10.1016/j.buildenv.2021.108378

Paparizos, C., Tsafas, N., & Birbas, M. (2020). A Zynq-based robotic system for treatment of contagious diseases in hospital isolated environment. *Technologies*, 8(2), 28. https://doi.org/10.3390/technologies8020028

Patil, S., Kenia, N., & Gunatilake, H. (2021). Divide and Prosper? Impacts of power-distribution feeder separation on household energy-use, irrigation, and crop production. *Energy Policy*, *156*. https://doi.org/10.1016/j.enpol.2021.112427

Pichler, P. P., Jaccard, I. S., Weisz, U., & Weisz, H. (2019). International comparison of health care carbon footprints. *Environmental Research Letters*, 14(6), https://doi.org/10.1088/1748-9326/ab19e1

Prada, M., Prada, I. F., Cristea, M., Popescu, D. E., Bungău, C., Aleya, L., & Bungău, C. C. (2020). New solutions to reduce greenhouse gas emissions through energy efficiency of buildings of special importance–Hospitals. *Science of the Total Environment*, 718. https://doi.org/10.1016/j.scitotenv.2020.137446

Ronaghi, M. H. (2022). Toward a model for assessing smart hospital readiness within the Industry 4.0 paradigm. *Journal of Science and Technology Policy Management*, (ahead-of-print). https://doi.org/10.1108/JSTPM-09-2021-0130

Russo, M. A., Ruivo, L., Carvalho, D., Martins, N., & Monteiro, A. (2021). Decarbonizing the energy supply one pandemic at a time. *Energy Policy*, *159*. https://doi.org/10.1016/j.enpol.2021.112644

Saint Akadiri, S., Alola, A. A., Akadiri, A. C., & Alola, U. V. (2019). Renewable energy consumption in EU-28 countries: policy toward pollution mitigation and economic sustainability. *Energy Policy*, 132, 803-810. https://doi.org/10.1016/j.enpol.2019.06.040

Santiago, I., Moreno-Munoz, A., Quintero-Jiménez, P., Garcia-Torres, F., & Gonzalez-Redondo, M. J. (2021). Electricity demand during pandemic times: The case of the COVID-19 in Spain. *Energy policy*, *148*. https://doi.org/10.1016/j.enpol.2020.111964

Sarkis, J. (2020). Supply chain sustainability: learning from the COVID-19 pandemic. *International Journal of Operations & Production Management*, 41(1), 63-73. https://doi.org/10.1108/IJOPM-08-2020-0568

Sebastian, M. P. (2019). Smart hospitals: challenges and opportunities. Indian Institute of Management Kozhikode Working papers (315).https://iimk.ac.in/uploads/publications/3052smartHospitals_MPS2019.pdf

Smol, M. (2022). Is the green deal a global strategy? Revision of the green deal definitions, strategies and importance in post-COVID recovery plans in various regions of the world. *Energy Policy*, *169*. https://doi.org/10.1016/j.enpol.2022.113152

Su, B., Goh, T., Ang, B. W., & Ng, T. S. (2022). Energy consumption and energy efficiency trends in Singapore: The case of a meticulously planned city. *Energy Policy*, 161. https://doi.org/10.1016/j.enpol.2021.112732

Szczygielski, J. J., Brzeszczyński, J., Charteris, A. & Bwanya. P. R. (2021). The COVID-19 storm and the energy sector: The impact and role of uncertainty. *Energy Economics*, 109, 105258. https://doi.org/10.1016/j.eneco.2021.105258

Tavakoli, M., Carriere, J., & Torabi, A. (2020). Robotics, Smart Wearable Technologies, and Autonomous Intelligent Systems for Healthcare During the COVID-19 Pandemic: An Analysis of the State of the Art and Future Vision. *Advanced Intelligent Systems*, 2, 7. https://doi.org/10.1002/aisy.202000071

Zavadil, M., Rogalewicz, V., Vaclavikova, A., Gavurova, B., & Bilan, S. (2020). Application of HB-HTA Methods in an Economic Quantification of Processes Covering Laboratory Technology in Hospitals. *Transformations in Business & Economics*, Vol. 19, No 1 (49), pp.53-84.

Vaziri, S. M., Rezaee, B., & Monirian, M. A. (2020). Utilizing renewable energy sources efficiently in hospitals using demand dispatch. *Renewable Energy*, 151, 551-562. https://doi.org/10.1016/j.renene.2019.11.053

Wen, J., Okolo, C. V., Ugwuoke, I. C., & Kolani, K. (2022). Research on influencing factors of renewable energy, energy efficiency, on technological innovation. Does trade, investment and human capital development matter? *Energy Policy*, 160. https://doi.org/10.1016/j.enpol.2021.112718

Weyman-Jones, T. G. (2019). Energy in Europe: Issues and Policies. Routledge.

Woll, A., & Tørresen, J. (2023). What is a Smart Hospital? A Review of the Literature. Human-Automation Interaction, 145-165. Springer
Yang, Q., Zhang, L., Zou, S., & Zhang, J. (2020). Intertemporal optimization of the coal production capacity in China in terms of uncertain demand, economy, environment, and energy security. *Energy Policy*, *139*. https://doi.org/10.1016/j.enpol.2020.111360

Yap, S. F., Xu, Y., & Tan, L. (2021). Coping with crisis: The paradox of technology and consumer vulnerability. *International Journal of Consumer Studies*, 45(6), 1239-1257. https://doi.org/10.1111/ijcs.12724

Yu, L., Wu, S., Jiang, L., Ding, B., & Shi, X. (2022). Do more efficient buildings lead to lower household energy consumption for cooling? Evidence from Guangzhou, China. *Energy Policy*, 168, 13119 https://doi.org/10.1016/j.enpol.2022.113119

Yun, B. Y., Park, J. H., Yang, S., Wi, S., & Kim, S. (2020). Integrated analysis of the energy and economic efficiency of PCM as an indoor decoration element: Application to an apartment building. *Solar Energy*, 196, 437-447. https://doi.org/10.1016/j.solener.2019.12.006

Zhou, X., Cai, Z., Tan, K. H., Zhang, L., Du, J., & Song, M. (2021). Technological innovation and structural change for economic development in China as an emerging market. *Technological Forecasting and Social Change*, 167. https://doi.org/10.1016/j.techfore.2021.120671

Funding: As part of the Research Program V:ALERE – Università della Campania Luigi Vanvitelli, Italy We declare that, the work has not been published previously, that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. The authors contributed equally; all of them agreed on the final version of the manuscript.

Author Contributions: The authors contribute equaly; they have read and agreed to the published version of the manuscript.

Alfonso MARINO, professor circular economy, (Università della Campania – Luigi Vanvitelli, Italy) degree in business economics with specific competencies in sustainability and circular economy.
ORCID ID: https://orcid.org/0000-0003-1722-0539

Paolo PARISO, PhD in business economics, (Università della Campania – Luigi Vanvitelli, Italy) degree in business economics, with specific competences in SMEs.
ORCID ID: https://orcid.org/0000-0003-1066-4102