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28 November 2026

Towards the Electrical Self-sufficiency of a University Campus: Techno-economic Case Studies

Alessandro Ciocia[1], Valeria Cocina[2], Giovanni Grosso[1], Gianfranco Chicco[1], Davide Astolfi[3], Filippo Spertino[1]

Abstract—A university Campus is a potentially optimal playground to approach the self-sufficiency of the electrical consumption by using photovoltaic (PV) generation and appropriate storage with a profitable economic investment. This work presents the case study of Politecnico di Torino, in which PV generation with nominal power of 1 MW is already operating with ≈100% self-consumption and ≈10% self-sufficiency. However, the simulation results demonstrate that the self-sufficiency can be significantly improved (up to 70%) by installing multi-megawatt PV generation and two tens of megawatt-hour of battery capacity. The techno-economic aspects considered are the cost effectiveness of the investment and the reduction of power injections into the grid.

Keywords—photovoltaic generation, self-consumption, self-sufficiency, battery storage, University campus.

I. Introduction

With increasingly rapid growth, renewable energy technologies are the backbone of the energy transition. Thanks to continuous innovation, renewable energy technologies are becoming increasingly efficient and competitive. They allow to generate electricity without emitting greenhouse gases and are practically inexhaustible. Solar energy is the great protagonist of the current energy transition. After having been a marginal energy source until a few decades ago, the exploitation of solar energy has grown dramatically in the last two decades. At the end of 2021, the global Photovoltaic (PV) installed capacity represented 945.4 GW of cumulative PV power [1]. The credit goes above all to technological innovation, particularly in the field of materials science, which has made PV plants also economically competitive with fossil fuels. In particular, the costs of producing electricity from PV systems have decreased by 82% in the last decade [2]. The prospects are even more encouraging, as with new generation technologies it will be possible to increase the solar panel efficiency by 30% and productivity by over 20% compared to today's solutions.

This paper proposes the sizing of PV generators and storage systems necessary in an Italian University, Politecnico di Torino, to maximize the self-sufficiency of the Campus, while respecting financial constraints.

For many years, Politecnico di Torino has been implementing a process of integrating the principles of sustainability with a shared and systemic strategy, in compliance with the Sustainable Development Goals adopted together with the 2030 Agenda by the United Nations (UN) in 2015. The principles of sustainability, the impact of the University on the environment and natural resources, and the actions to promote the sustainable development of the territory have been introduced in the statute of Politecnico di Torino since 2012. In 2018 a specific line of the "PoliTO4Impact" Strategic Plan [3] has been dedicated to the development of a sustainable Campus and the role of the University for the exchange of knowledge and technologies for sustainable development. The Strategic Plan recognizes the social role of the University and the need to:

- Orient every action towards the improvement of living conditions, the reduction of inequalities, the construction of social responsibility towards future generations with reference to sustainable development.
- Create and share polytechnic knowledge to support sustainable development at local, national, and international levels.
- Assess potential economic, social, political and environmental impacts.

The inclusion of sustainability principles in the University Strategic Plan helps to define some concrete sustainability objectives in the various areas of competence of the University, including interdisciplinary

research and improvement of the capacity to respond to the sustainable development goals of the UN Agenda 2030.

One of the most important goals of Politecnico di Torino is the achievement of carbon neutrality by 2040. To reach this ambitious goal of zero emissions, 10 years earlier with respect to the Net Zero commitments at international level (2050), a "Decarbonization Plan" has been launched for the reduction of CO_2 emissions. To reduce and rationalize energy consumption and the related impact on the environment, the following actions have been mentioned:

- Energy efficiency of existing buildings.
- Design of new buildings according to high quality standards, i.e., ITACA Protocol, and favoring the reuse of existing buildings.
- Use of efficient systems and the implementation of self-produced energy from Renewable Sources.
- Monitoring of electricity and heat consumption for more effective management.

The first actions of this Plan concern the upgrading of PV systems, the replacement of windows, the revamping with LED lighting, the environmental monitoring, through the implementation of new sensors installing in the buildings, and the optimization of thermal and electric systems.

On these bases, this paper addresses the path towards the self-sufficiency of the Campus, starting from an analysis of the electricity consumption. The PV generation and electronic conversion models are discussed, including the economic parameters to assess profitability of the investments. Finally, different sizes of PV generator and storage system are compared, in terms of achieved self-sufficiency and economic return.

II. Current Status of Generation and Consumption

The analyzed Campus is already equipped with several high-power PV systems, installed in recent years. Table I shows the power capacities of the existing plants, including the number of modules and the relative powers, where available (otherwise the entries are marked as N/D). The systems are quite different in terms of power, type, and orientation of the modules, due to the different dimensions, shapes and orientations of the pitches of the roofs of each building. In addition, the total installed capacity (just over 1 MW) is clearly insufficient to cover an appreciable share of the needs of the sites.

TABLE I. Power Capacities and Sun Exposure of PV Arrays.

PV plant name	Number of modules	Tilt	Azimuth	Module power [W]	Total power [kW]
("Central site")	400	26°	33°	360	144
	88			430	38
("Ex tornerie")	1849	26°	0°	327	605
("Rooms R")	117	0°	N/D	400	47
("Ex fucine")	140	26°	113°	280	39
	140			256	36
("Energy Center")	210	10°	28°	327	46
("Rooms P")	144	30°	28°	345	50
Total					**1004**

The "Central Site – Cittadella Politecnica" Campus of Politecnico di Torino can be seen as a high-power tertiary load. In fact, daily load profiles (Fig. 1) have a single peak of power during in the morning of working days and a non-negligible night load (more than 1 MW) on the different days. On holidays, the load profile is flat with values similar to those of the night load, since the university is closed; load profiles on Saturdays are an intermediate case, since the premises are partially open, with reduced opening hours and with reduced number of lectures and research activities.

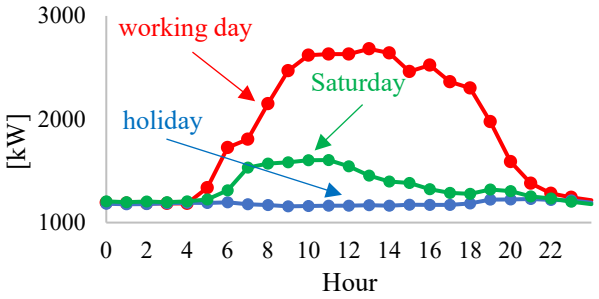

Fig. 1. Load profiles of Politecnico for different days.

Monthly electricity consumptions are shown in Fig. 2 for the period 2018-2022. The peak is typically in the summer months, mainly due to the high energy required by the cooling systems (except for August, when the electrical load is significantly reduced due to holidays). As for annual consumption, a slight increase in energy demand over the years can be observed (from 14.53 GWh in 2018 to 15.06 GWh in 2022), except for reduced consumption in 2020 (9.44 GWh) and 2021 (14.2 GWh) due to the closures imposed by the pandemic emergency.

III. Energy Exchange Model

In this section, the models for energy generation, conversion and exchange (considering the battery) are briefly outlined. Regarding the model of the PV production, it can be accurately calculated by using the equivalent electrical circuit with lumped parameters. In the literature, the most used is the Single -Diode Model (SDM), which is characterized by five parameters [4]. As written in [5], the use of an equivalent circuit well describes the operation of the photovoltaic generator; nevertheless, it implies a high and unnecessary computational burden in case of planning purposes. A simpler but sufficiently accurate model for planning purposes is the straightforward model described in the next subparagraph. With respect the use of the SDM, the straightforward model leads to annual energy deviations that are lower than 4% [4], i.e., within the uncertainty for irradiation measurements with commercial sensors based on reference solar cells [6].

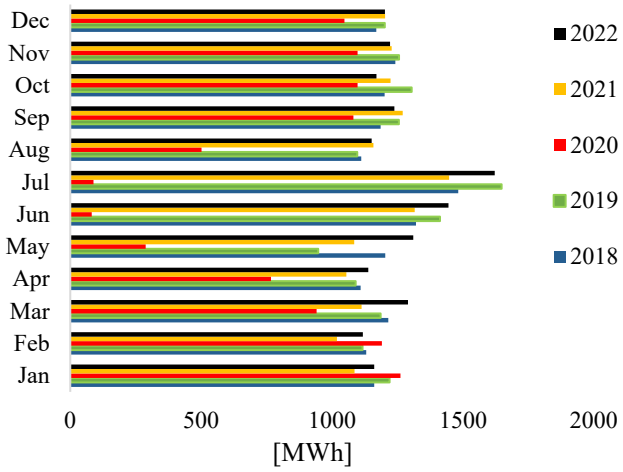

Fig. 2. Monthly electricity consumption of the Campus (2018 – 2022).

A. Model of the PV power generation

The electrical power $P_{PV,DC}$ generated by the modules on the DC side is given in Equation (1) [7], as a function of the irradiance G and of the cell temperature T_c (computed from the ambient temperature T_a with the NOCT method [8]). In order to make the model more realistic, an irradiance threshold G_0 and efficiency coefficients are introduced, namely, η_{dr} for losses due to PV module dirt, η_{refl} for glass reflection losses, η_{mis} for current-voltage (*I-V*) mismatch losses, and η_{wir} for wire losses.

The estimated power is therefore given by:

$$P_{PV,DC}(t) = \eta \cdot P_n \frac{G(t)-G_0}{1000}\left\{1 + \frac{\gamma_{P\%}}{100}[T_c(t) - 25]\right\} \quad (1)$$

with $\eta = \eta_{dr}\,\eta_{refl}\,\eta_{mis}\,\eta_{wir}$, where $G(t)$ and G_0 are expressed in W/m² and $T_c(t)$ in °C. P_n is the nominal power of the PV system, which must be determined for balancing the load. A typical parameter selection is given in Table II, referring to modules in c-Si [9].

TABLE II. SELECTED PARAMETERS FOR THE PV SYSTEM

Modules dirt coefficient η_{dr}	0.976
Reflection losses coefficient η_{refl}	0.973
Mismatch losses coefficient η_{mis}	0.97
Wire losses coefficient η_{wir}	0.99
Thermal coefficient of the power $\gamma_{P\%}$ [%/°C]	-0.5
Minimum irradiance G_0 [W/m²]	17.7
NOCT [°C]	47

B. Model of the Inverter

The overall efficiency of the inverter depends on the losses in the energy conversion and transformation phases and on the consumption of the auxiliary systems (control, measurement and cooling) [10]. Such efficiency depends as well on the incoming power and therefore a characteristic efficiency curve should be constructed. Furthermore, through a statistical analysis of the solar irradiance, it is possible to estimate the frequency at which the inverter operates for a given load and to compute an average efficiency, which summarizes the inverter performance on the grounds of the operating cycle of the PV system. The efficiency η_C is the ratio between the AC output P_{AC} and the DC input. The variation of η_C as a function of the incoming power P_{DC} can be approximated by assuming three components, which are a constant contribution P_0, a linear one $k_{lin}P_{AC}$ and a quadratic one $k_q P_{AC}^2$. The balance is imposed in Equation (3):

$$P_{DC} = P_{AC} + P_{loss} = P_{AC} + P_0 + k_{lin} \cdot P_{AC} + k_q \cdot P_{AC}^2. \qquad (2)$$

A quadratic equation for P_{AC} is obtained; selecting the physically acceptable solution (positive) and dividing by P_{DC}, the DC/AC conversion efficiency is obtained. Fig. 3 shows the efficiency as a function of the input power, with typical values of P_0 and k_{lin}, and k_q; each of these three contributions leads to a 0.7% of losses at full load. Thus, the maximum efficiency is 97.9%.

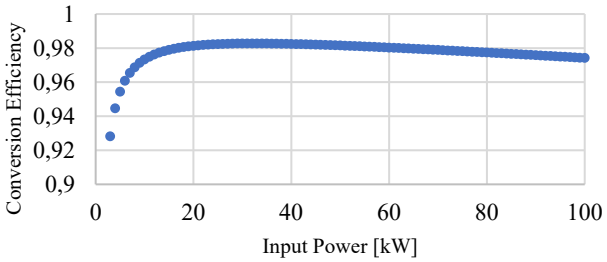

Fig. 3. Example of the approximate characteristic curve of a 100 kW inverter efficiency, with P_0 = 0.2 kW, k_{lin}= 0.005, and k_q = 0.0002 kW^{-1}.

C. Model of the Battery

The role of the storage appears in the balance between load and generation, minimizing the interaction of the PV system with the grid. According to that, the constraints are [11]:

- The absorption from the grid takes place only when the PV generation and the storage do not balance the load.
- The battery is charged only if the PV power generation exceeds the load, and only if the battery is fully charged the excess power is sent to the grid.

The inputs of the model are the PV power $P_{PV,AC}(t)$, the load power $P_{load}(t)$, the power managed by the battery at the DC side $P_{batt,DC}(t)$ with time step duration Δt = 1 h, and the State Of Charge (SOC) of the battery $SOC(t-1)$ in the previous time step. The flowchart of the battery model is shown in Fig. 4. The steps are:

- *Step α: computation of the SOC.* The battery SOC is:

$$SOC(t) = SOC(t-1) - \frac{P_{batt,DC}(t) \cdot \Delta t}{C_{batt}} \qquad (3)$$

where $P_{batt,DC}(t)$ is the average power (kW) delivered or absorbed by the battery in the time step Δt that ends at time t, and C_{batt} is the total battery energy capacity determined in the design phase (kWh). At the initial time, the *SOC* is set to 100%.

- *Step β: comparison between the PV system power and the load.* The power P_{net} demanded or given to the battery (and, possibly, to the grid) is the difference between the PV power generation and the load power:

$$P_{net}(t) = P_{PV,AC}(t) - P_{load}(t) \qquad (4)$$

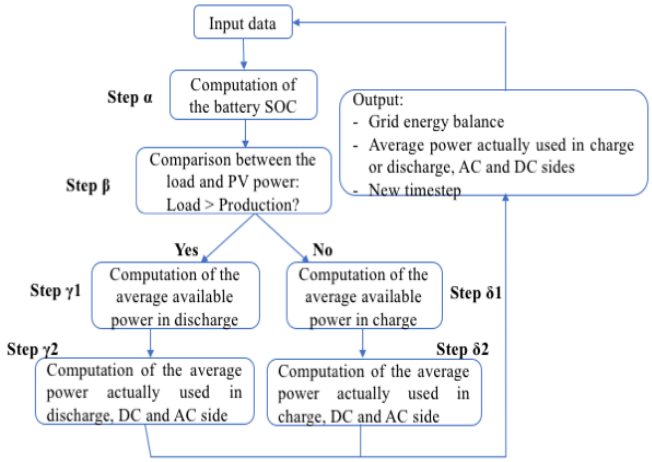

Fig. 4. Flowchart of the model for the battery.

- *Step β: comparison between the PV system power and the load.* The power P_{net} demanded or given to the battery (and, possibly, to the grid) is the difference between the PV power generation and the load power:

$$P_{net}(t) = P_{PV,AC}(t) - P_{load}(t) \qquad (4)$$

If P_{net} is negative, the power has to be absorbed from the battery or the grid and the discharge power requested to the battery is $P_{net,disc}(t) = P_{net}(t)/\eta_{disc}$, where η_{disc} is a discharge efficiency coefficient, which takes into account the conversion losses in the discharge phase. If P_{net} is positive, the charge power that can be fed into the battery is $P_{net,char}(t) = P_{net}(t) \cdot \eta_{char}$, where η_{char} takes into account the losses in the battery charge phase. As indicated in Fig. 4, the calculated charge or discharge powers are used to compute the actual exchanged values, which are influenced by the SOC.

- *Step γ1: computation of the average available power in discharge.* $P_{av,disc}$ is computed before the DC/AC conversion, which means neglecting η_{disc}:

$$P_{av,disc}(t) = [SOC(t) - SOC_{min}] \cdot C_{batt}/\Delta t \qquad (5)$$

where SOC_{min} is the minimum SOC, below which the health state of the battery is affected.

- *Step γ2: computation of the actual average power in discharge.* $P_{batt,DC}$ is calculated considering the limit P_{lim} as the maximum battery power:

$$P_{batt,DC}(t) = \min\{-P_{net,disc}(t);\ P_{av,disc}(t);\ P_{lim}\} \qquad (6)$$

The negative sign for $P_{net,disc}(t)$ is due to a different definition with respect to $P_{batt,DC}$. $P_{batt,DC}$ is positive because it is a power delivered by the battery, while $P_{net,disc}(t)$ is negative because it is a requested power. The power delivered on the AC side $P_{batt,AC}$ is calculated multiplying $P_{batt,DC}$ by the efficiency η_{disc}. This quantity is the power actually provided by the battery. If it is lower than the demanded power $P_{net}(t)$, the residual will be absorbed from the grid, as indicated in Eq. (7):

$$P_{grid,abs}(t) = \left[-P_{net}(t) - P_{batt,AC}(t)\right]$$
$$= \eta_{disc}\left[-P_{net,disc}(t) - P_{batt,DC}(t)\right] \qquad (7)$$

- *Step δ_1: computation of average power available in charge.* The average power available for the charge phase is proportional to the difference between the SOC and the maximum SOC:

$$P_{av,char}(t) = [SOC_{max} - SOC(t)] \cdot C_{batt}/\Delta t \quad (8)$$

where SOC_{max} is the maximum possible charge of the battery, which is equal to unity or 100%.

- *Step δ_2: computation of the average actual charge power.* $P_{batt,DC}(t)$ is constrained by the available power and by the maximum admissible power:

$$P_{batt,DC}(t) = -\min\{P_{net,char}(t); P_{av,char}(t); P_{lim}\} \quad (9)$$

The minus sign indicates that$P_{batt,DC}(t)$is a power absorbed by the battery. The average absorbed power on the AC side is given calculated taking into account the conversion efficiency $P_{\text{batt,AC}}$ is calculated dividing $P_{\text{batt,DC}}$ by the efficiency η_{char}. If the absolute value of the above is lower than $P_{net}(t)$, there is an excess power which is fed into the grid.

Finally, the output of the procedure is calculated: the energy balance including PV, load, battery, and the grid:

$$P_{grid}(t) = P_{FV,AC}(t) + P_{batt,AC}(t) - P_{load}(t) \quad (10)$$

It can be verified that $P_{grid}(t)$ corresponds to $P_{grid,del}(t)$ when it is positive and to $-P_{grid,abs}(t)$ when it is negative.

D. Self-sufficiency and self-consumption

Self-Sufficiency (*SS*) expresses the share or percentage of the energy supplied to the load without the aid of the grid [12]:

$$Self\text{-}sufficiency = \frac{E_{load} - E_{grid,abs}}{E_{load}} \quad (11)$$

This parameter increases as the installed power and storage capacity increase, since the load requires less energy from the grid [13]. However, by choosing high values of power and energy capacity, self-sufficiency tends to be established on a limit value, since:

- For the same energy storage capacity and increasing power, the excess power with respect to the load increases, but the excess energy that can be stored is limited, prevents grid absorption from being reduced below a certain value, and also increases energy injections into the grid.
- For the same power and increasing energy storage capacity, the energy stored during the day and supplied to the load at night increases. However, it is limited by the difference between production and load, also resulting in a minimum amount of energy that is always taken from the grid. Moreover, a storage system that is oversized compared to the energy with which it can be charged is economically disadvantageous, because it is not exploited at full capacity.

A similar index expresses the ratio between the load fed without grid support and the energy produced:

$$Self\text{-}consumption = \frac{E_{load} - E_{grid,abs}}{E_{PV}} \quad (12)$$

Self-consumption decreases as the power of the plant increases, because the energy taken from the grid is reduced until it reaches a limit value while the denominator continues to increase, and increases as capacity increases, as the interaction with the grid is reduced.

IV. Economic Model

The economic analysis of the system aims at estimating the required investment capital and the return time, considering the produced energy and of the capital flux along the whole useful lifetime (25 years).

The cash flow in the year y is defined as:

$$CF_y = \left(c_A E_{aut,y} + c_V E_{grid,del,y} - c_{O\&M} P_n - I_y\right) [€] \quad (13)$$

where:

- c_A is the rate for energy purchase from the grid [€/kWh];

- $E_{aut,y}$ is the self-consumed energy in the y-th year [kWh];
- c_V is the rate for selling energy to the grid [€/kWh];
- $E_{grid,del,y}$ is the energy delivered in the grid in the y-th year [kWh];
- $c_{O\&M}$ is the annual Operation & Maintenance cost [€/kW];
- I_y is the investment at the y-th year [€].

The formula is generalized to include in the cash flow the investment for each year. In the first year, there are the installation costs for PV and storage systems. In the next years, the negative cash flows are due to maintenance and the replacement of the batteries every 10 years. The Net Present Value (NPV) is the sum of the cash flows over N years:

$$NPV = CF_0 + \sum_{y=1}^{N} \frac{CF_y}{(1+i)^y} \qquad (14)$$

being CF_y the discounted cash flow of the y-th year, referred to the equivalent value it would have at the time of the initial investment ($y = 0$), while i is the discount rate.

To compare different investments, the internal rate of return (*IRR*) is used. The *IRR* is the value of the discount rate for which the *NPV* of all the cash flows is equal to zero. The best investment is that one with the highest *IRR*.

The financial parameters considered in the present work are shown in Table III [14][15].

TABLE III. PARAMETERS OF THE ECONOMIC MODEL.

Installation cost of the PV system $c_{I,PV}$ [€/kW]	800
Installation cost of the battery $c_{I,batt}$ [€/kWh]	300
Operation & maintenance (O&M) costs $c_{O\&M}$[€/kW]	10
Energy purchase rate c_A [€/kWh]	0.16
Energy selling rate c_V [€/kWh]	0.04
Discount rate i	3%

V. OPTIMIZING THE SELF-SUFFICIENCY OF THE CAMPUS

This section presents three case studies related to the sizing of PV and storage systems for the University Campus; in every case, the calculations are performed for an entire year with hourly time step. In the reference case (#1) there is the analysis of power profiles and the self-sufficiency calculation with the actual installed PV system. Case study #2 simulates a higher PV power, sized to yearly match the consumption of the Campus. Finally, the last case study (#3) simulates the highest PV power coupled with an adequate storage system to increase self-sufficiency and limit the injections into the grid.

Regarding the inputs of the PV model, irradiance and temperature profiles are obtained with a calibrated meteorological station installed on the rooftop of the Campus. Irradiance is measured by a pyranometer with uncertainty <5%, and the accuracy of the air temperature thermometer is ±0.1 °C.

A. Indicative sizing of the PV and storage system

A first estimation for determining the appropriate power rating of the PV system can be achieved as follows, considering the available surface on the roofs of the Campus (for a total of over 17,000 m^2). An arbitrary nominal power $P_n^{'}$ is assumed and, using the meteorological data, the annual energy E_{PV} produced by the PV system can be estimated, from which the annual productivity per kilowatt of installed power is computed as:

$$e_{FV} = \frac{E_{FV}}{P_n'} \text{ [kWh/kW/year]} \qquad (15)$$

Knowing the annual energy consumption E_{load}, a preliminary size of the minimum power to be installed is:

$$P_n^* = \frac{E_{load}}{e_{FV}} \quad (16)$$

and a first guess for the battery size is:

$$C_{batt}^* = \frac{E_{load}}{365} \quad (17)$$

In Table IV, the preliminary estimates are reported, based on the energy consumption of the year 2022.

TABLE IV. INITIAL PV POWER AND BATTERY STORAGE SIZES.

Annual energy consumption E_{load} [MWh/year]	15065
Annual PV capacity e_{FV} [kWh/kW/year]	1340
Reference PV power P_n^* [MW]	11.25
Reference battery size C_{batt}^* [MWh]	41.27

B. Profiles in a typical sunny day

An example of load, PV production and battery cycles is reported in Figures 6 and 7, based on the meteorological data from a typical sunny day. The values 9 MW of PV power and 23 MWh of battery are assumed. The PV production has the typical profile of a sunny day (from hour 5 to hour 21, with a peak at hour 13). The load is less than 1.5 MW at nighttime and around 3 MW in the daytime. From 1 am to 8 am, power is absorbed from the grid (Fig. 5), which is since the battery has insufficient charge from the day before (Fig. 6).

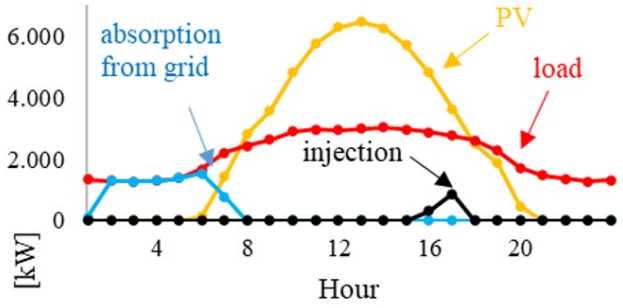

Fig. 5. Profiles of PV power, load and exchange with the grid in the day 10/06/2022.

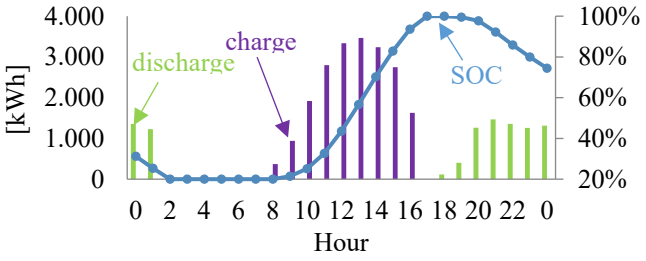

Fig. 6. Battery charge, discharge and SOC in the day 10/06/2022.

C. Profiles in a typical cloudy day

The behavior shown in Fig. 7 and Fig. 8 represents a typical cloudy day. The PV power is around 1 MW above the load only for 3-4 hours. Massive absorption from the grid is requested in the morning, when the storage gets exhausted, and at night. The battery is discharged during the night and, due to the insufficient difference between the PV power and the load, the charge during the daylight period is very limited.

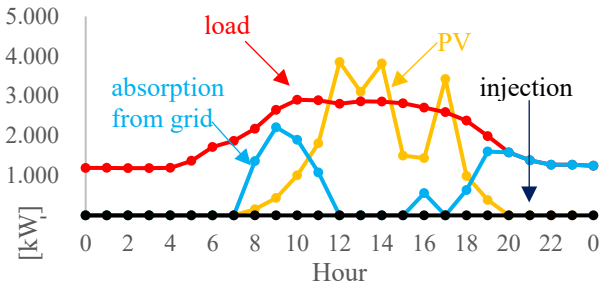

Fig. 7. Profiles of PV power, load and exchange with the grid in the day 04/04/2022.

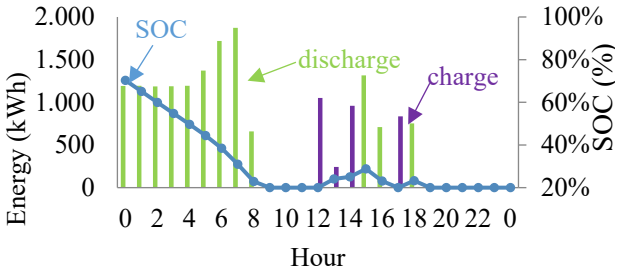

Fig. 8. Battery charge, discharge and SOC in the day 04/04/2022.

D. Case #1: Existing PV system and no battery

In the case corresponding to the present installations at the Campus (1 MW PV power, no battery), the monthly production is in average one order of magnitude lower than the load. There is no energy fed into the grid, which means that the PV power is totally self-consumed. From an economic point of view, the return of investment time is in the order of 4 years. This is due to the low installation cost and to the high savings, in the case of self-consumption, with respect to the 2022 energy tariffs. The NPV at 25 years is 2.5 M€ against an initial investment of 800 k€.

E. Case #2: Reference PV power, no battery

In the case of PV size indicated in Table IV, without battery, the difference between annual PV production and load is negligible (15.07 GWh produced against 15.06 GWh consumed). The production remarkably exceeds the load from April to September (up to 400 MWh) and slightly in January and February. Nevertheless, the intermittency of the diurnal PV power profile largely limits the self-consumption. Much energy is fed into the grid in the daytime and is absorbed at night. The return of investment is 8 years and the NPV at the 25-th year is 12 M€ against an initial investment of 9 M€. Fig.9 shows the monthly values for grid injections, absorption and sufficiency, where sufficiency is the monthly product of *SS* by the load. This chart demonstrate that SS is high, but the absence of storage leads to high exchanges with the grid.

F. Case #3: Reference PV power, with battery

The optimization of the model, which has taken into account the constraints on the energy injection less than 10% of the load and IRR > 6%, has led to the sizing of 9 MW of PV power and 23 MWh of battery. The generation is slightly undersized with respect to the load, except for the month of August. In this case, the monthly absorption from the grid does not exceed 100-200 MWh and the injection does not exceed 200 MWh.

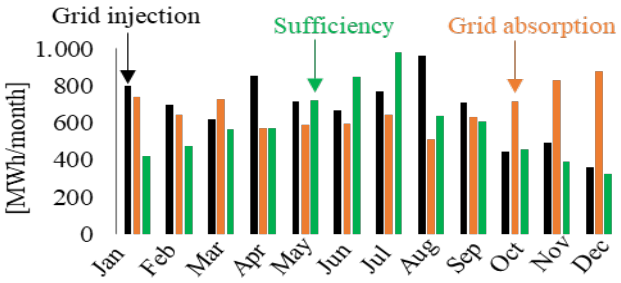

Fig. 9. Case #2: monthly values for grid injection, absorption, and sufficiency.

G. Comparison of the test cases

Case #1, despite the high economic profitability, is not interesting by an energy point of view, since the PV system accounts for only 9% of the average load. In Case #2, the exploitation of the PV power is higher, but there is still less than 50% of self-consumption and self-sufficiency. In Case #3, the self-consumption and self-sufficiency increase up to 89% and 71%, respectively, and the energy injection into the grid is limited to 6%. All the energy exchange and economic details of the three cases are reported in Table V.

TABLE V. COMPARISON OF THE TEST CASES

	Case #1	**Case #2**	**Case #3**
Size			
PV Power [MW]	1.0	11.3	9.0
Battery capacity [MWh]	-	-	23.0
Average daily load [MWh]		41.27	
Energy exchanges AC side (first year)			
PV Production [GWh]	1.3	15.1	12.1
Annual load [GWh]		15.1	
Annual grid injection [GWh]	0.0	8.1	0.9
Annual grid absorption [GWh]	13.7	8.1	4.4
Battery (first year)			
Charged energy [GWh]	-	-	4.5
Discharged energy [GWh]	-	-	4.1
Energy balance (first year)			
Self-consumption	100%	46%	89%
Self-sufficiency	9%	46%	71%
Absorption	91%	54%	29%
Injection	0%	54%	6%
PV production / load ratio	9%	100%	80%
Economic parameters			
Initial investment [M€]	0.8	9.0	14.1
25th year NPV [M€]	2.6	12.9	4.3
IRR	25%	14%	6%

VI. CONCLUSIONS

This work has dealt with the techno-economic modelling of a PV and storage system for the University Campus, with constraints on maximum grid injection (10%) and minimum rate of return. The system has been optimized based on the real consumption profiles of the Campus and on the meteorological data gathered on-site. A reliable model, accounting for the most important losses in the energy conversion and for realistic O&M costs and energy market tariffs, has been set up. Various scenarios have been explored and compared to the existing PV system of Politecnico di Torino (1 MW without storage), which accounts for only 9% of the average load. The main result of the study is that an adequate storage is fundamental for largely improving the self-consumption and the self-sufficiency. By appropriately adjusting the size of the system (9 times the already existing PV power), it is possible to reach self-consumption ≈90% and self-sufficiency ≈70%. This solution is particularly interesting by an energy point of view, but it is economically more demanding as regards the investment capital and return time. It is noticeable that the optimized solution for the PV system is slightly undersized with respect to the average load. This is due to the constraint on the maximum energy injection into the grid. Actually, for a PV system designed with a larger size, the seasonal variations in the available PV power would lead to large power injections into the grid in the late spring and summer.

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