



Il ruolo degli utenti nella transizione energetica Comunità energetiche e gruppi di autoconsumo

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Responsabile del laboratorio di microreti elettriche intelligenti «Lambda»

Founder di



Startup di
SAPIENZA
UNIVERSITÀ DI ROMA

Il triangolo della transizione energetica



Decarbonization



Digitization

“To promote the sustainable supply and use of energy for the greatest benefit of all people”

Slogan del WEC



Decentralization

Elettrificazione degli usi finali

“**elettrificazione**”: uso e diffusione dell'**elettricità** come vettore energetico

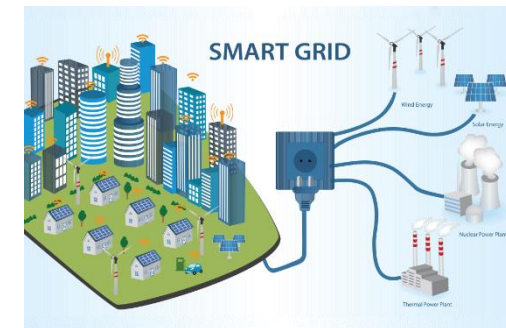
4 sub rivoluzioni (o transizioni ?) elettriche

1. la prima, finanziata da capitali privati, ha avuto il merito d'**introdurre** l'energia elettrica, anzitutto attraverso le centrali idroelettriche;
2. la seconda, portata avanti dall'Enel dal 1962 per conto dello Stato come politica energetica elettrica dell'epoca (nazionale e **monopolistica**), ha avuto il merito di renderla accessibile a tutti;
3. la terza è la “rivoluzione della **liberalizzazione**” iniziata nel 1999
4. la quarta è la “rivoluzione della **sostenibilità**” che stiamo vivendo

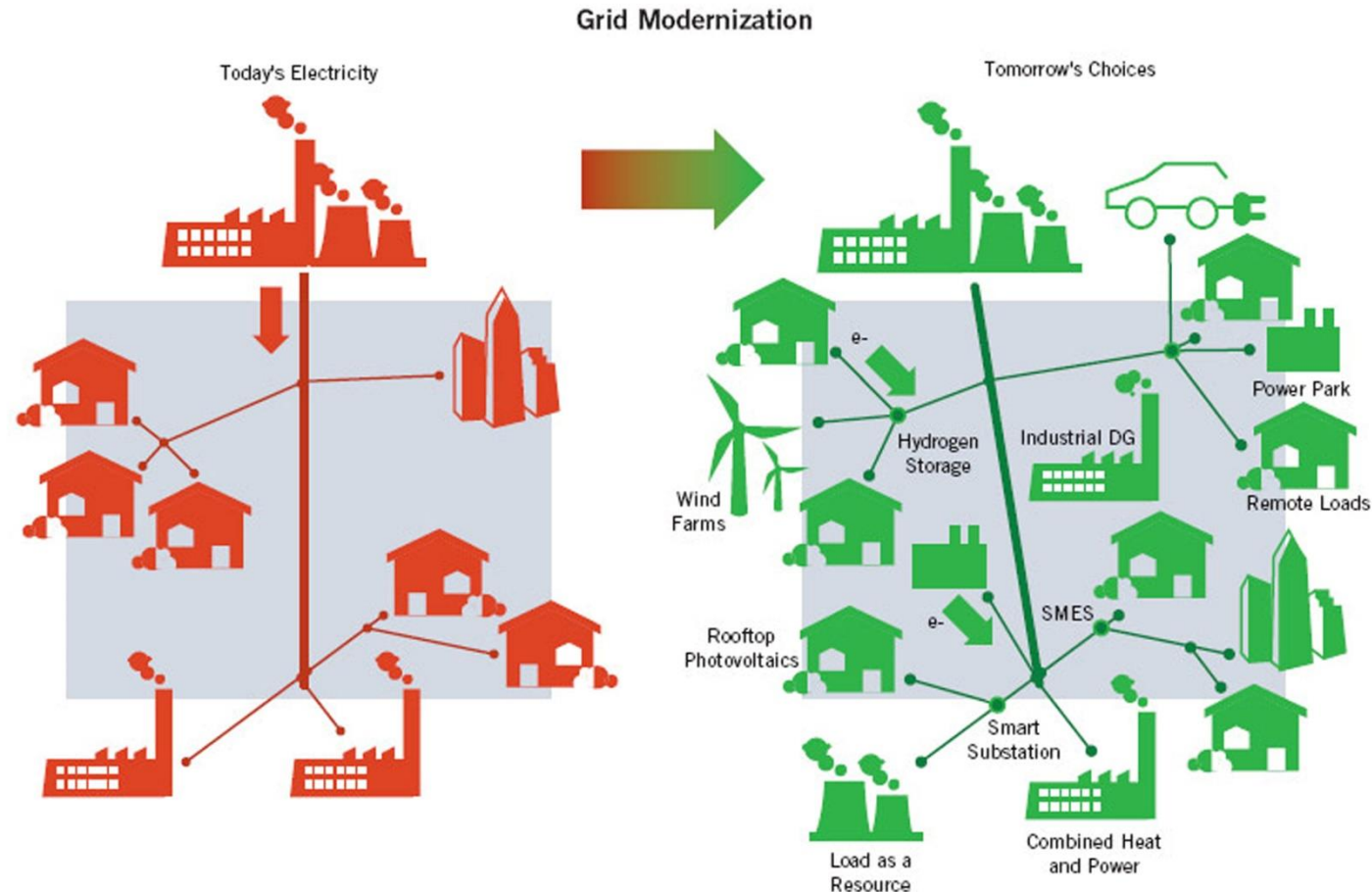
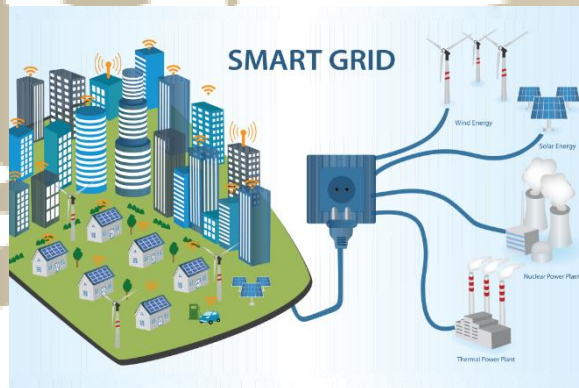
Sfide dell'elettrificazione

1. Elettrificazione massiva degli usi finali
2. Mobilità elettrica
3. Generazione da fonti rinnovabili
4. Mobilità elettrica
5. Digitalizzazione delle reti e dei processi
- 6. Ruolo attivo degli utenti**
- 7. Aggregazione delle utenze e comunità energetiche**
8. Microreti intelligenti e sostenibili

modello
sostenibile



Cosa è una “smart grid”



Grid = rete elettrica

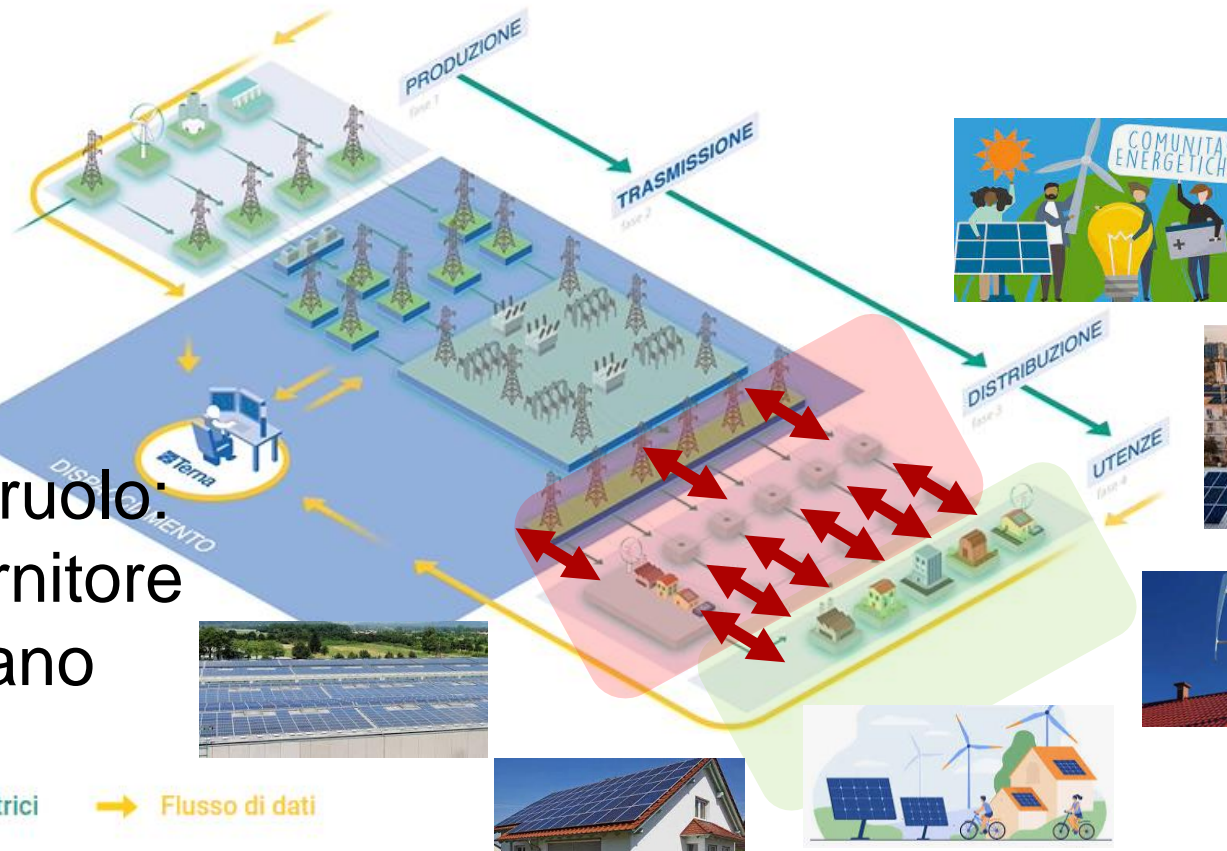
Smart = intelligente, brillante, sveglio, attivo, di moda, ...

Generazione diffusa e ruolo attivo degli utenti (aggregati)

Produzione Trasmissione Distribuzione Utilizzazione

La rete elettrica cambia ruolo:

- da fornitore
- a volano



- Rinnovabili
- Prosumer
- Comunità



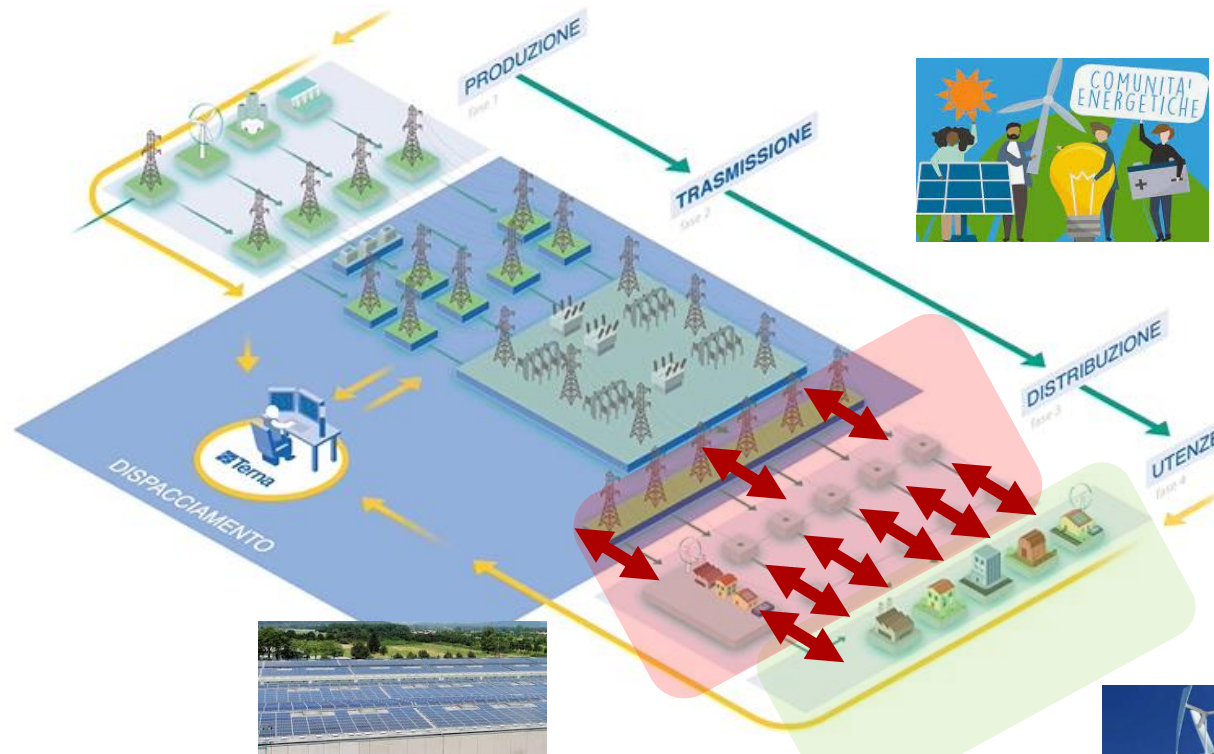
→ Flussi elettrici → Flusso di dati

Produzione

Trasmissione

Distribuzione

Utilizzazione



→ Flussi elettrici

→ Flusso di dati



Comunità Energetiche



Gruppi di autoconsumatori di energia rinnovabile che agiscono collettivamente.

Comunità Energetiche



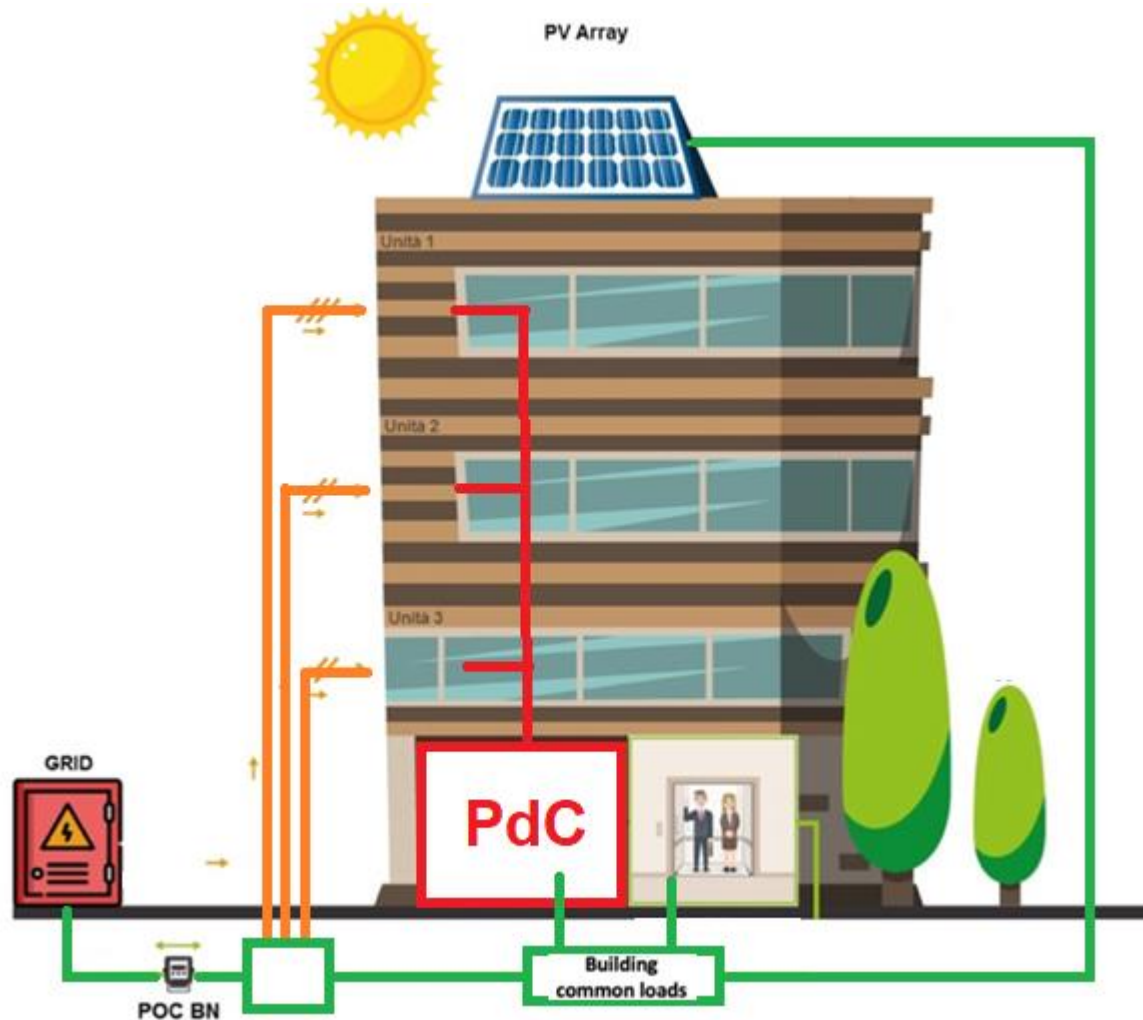
Comunità di energia rinnovabile.



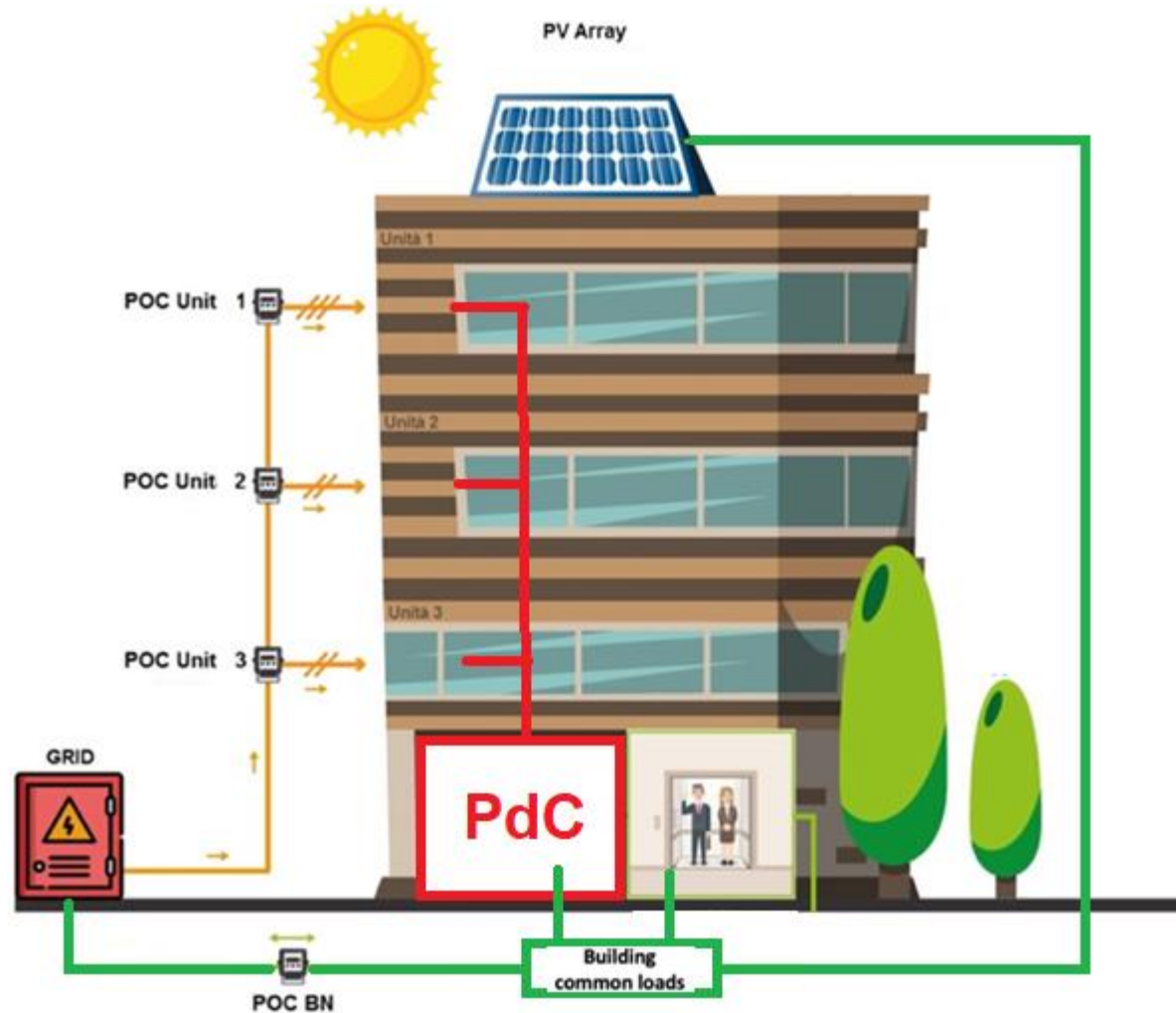
Autoconsumo collettivo “fisico” o “virtuale”?

- **Aggregazione con autoconsumo “totalmente fisico”**
- **Aggregazione con autoconsumo “parziale”**
- **Aggregazione con autoconsumo “virtuale” (scelto da ARERA)**
- **Aggregazione con autoconsumo “ibrido”**

Modello Fisico



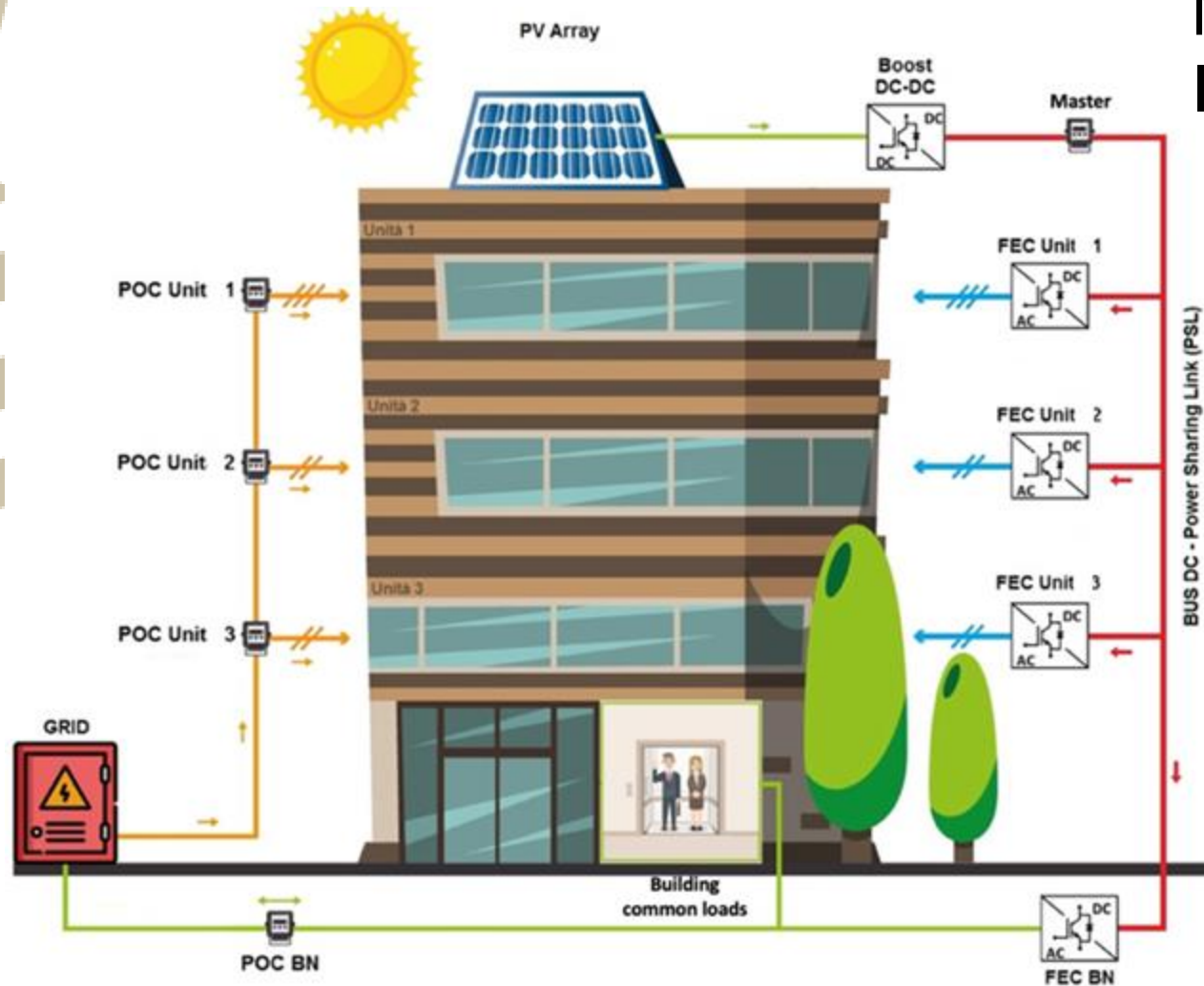
Modello Parziale



Modello Virtuale

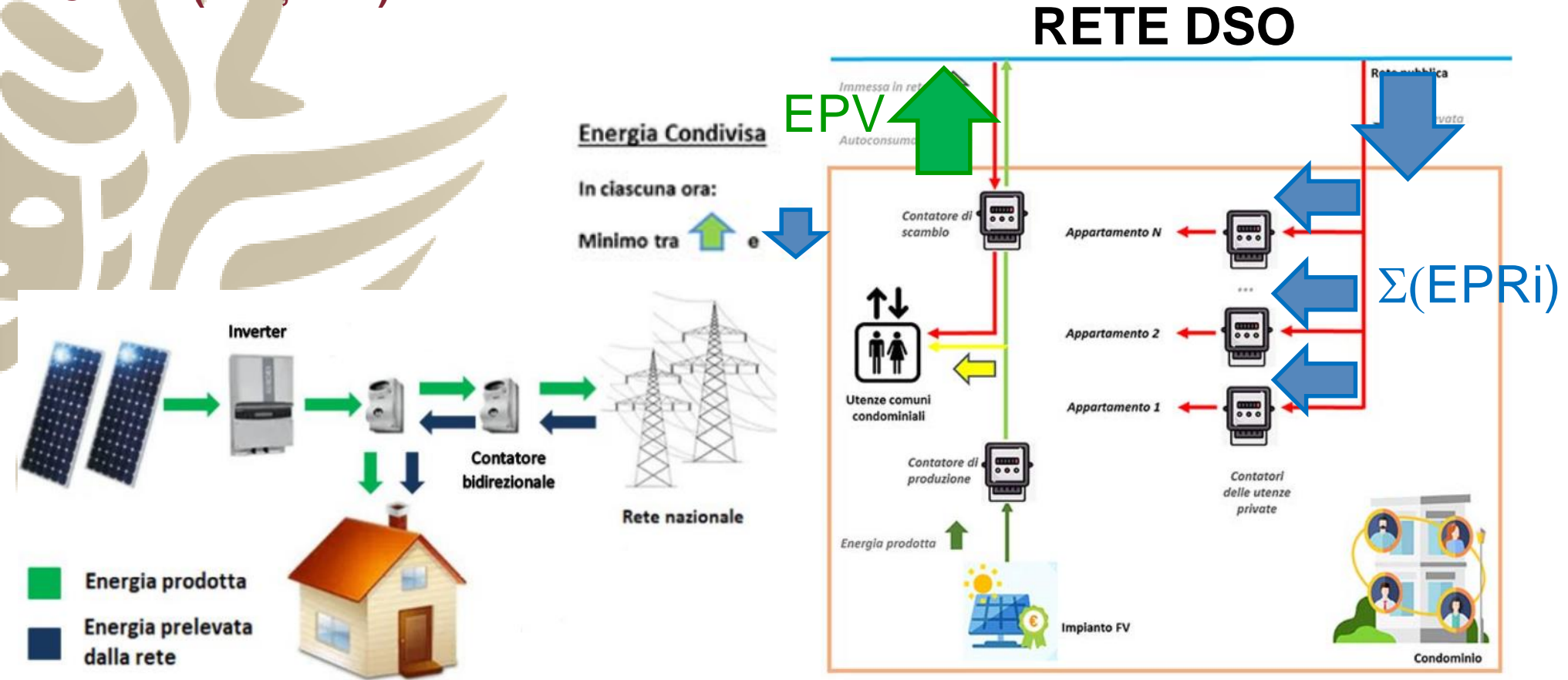


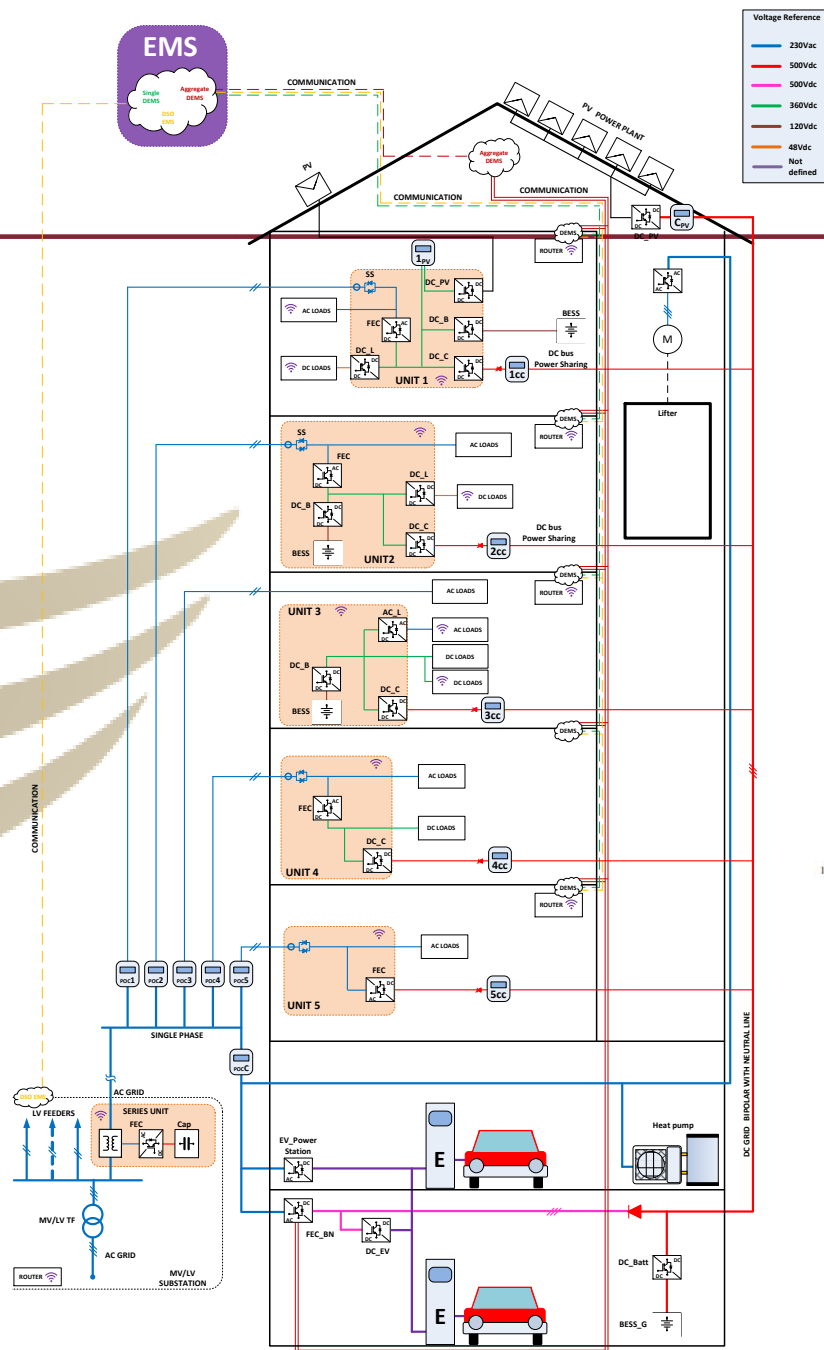
Modello Ibrido



«Energia elettrica condivisa» EEC (**Delibera ARERA 318/2020/R/eel**)

$$EEC = \min (EPV; EPR)$$



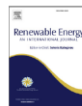


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Innovative power-sharing model for buildings and energy communities

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ABSTRACT

The paper proposes an innovative power-sharing model, i.e., a power-system architecture for aggregation of users able to share the power produced by common generators and energy services. The model is suitable for both multi-tenant buildings and groups of multiple buildings and it is applicable for both existing and new buildings. It is scalable for larger systems and suitable for an easier integration with smart meters. The novel principle of this model is that the power produced by common generators can

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Power Sharing Model for Energy Communities of Buildings

Luigi Martirano^a, Senior Member, IEEE, Sara Rotondo, Student Member, IEEE, Mostafa Kermani^b, Member, IEEE, Ferdinando Massarella, and Roberto Gravina

Modeling and Design of a Residential Energy Community with PV Sharing

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Napoli	PART		PART	PART			SPOKE	PART		SPOKE				
Bari							PART	SPOKE			PAR			
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Milano	PART			SPOKE	PART	PART			PART	PART				
Roma	PART			PART			PART		SPOKE		PAR			
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Firenze				PART (2°)	PART (1°)				PART (3°)					
Cagliari								PART	PART	PART				
Brescia					PART		PART				PAR			
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Palermo		PART	PART						PART					
Pisa							PART (3°)			PART (2°)	PART			
Cassino		PART (2°)							PART (3°)					
Parthenope			PART				PART			PART				
Salerno		PART (2°)				PART (3°)	PART (1°)							
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NEST
NETWORK FOR ENERGY SUSTAINABLE TRANSITION

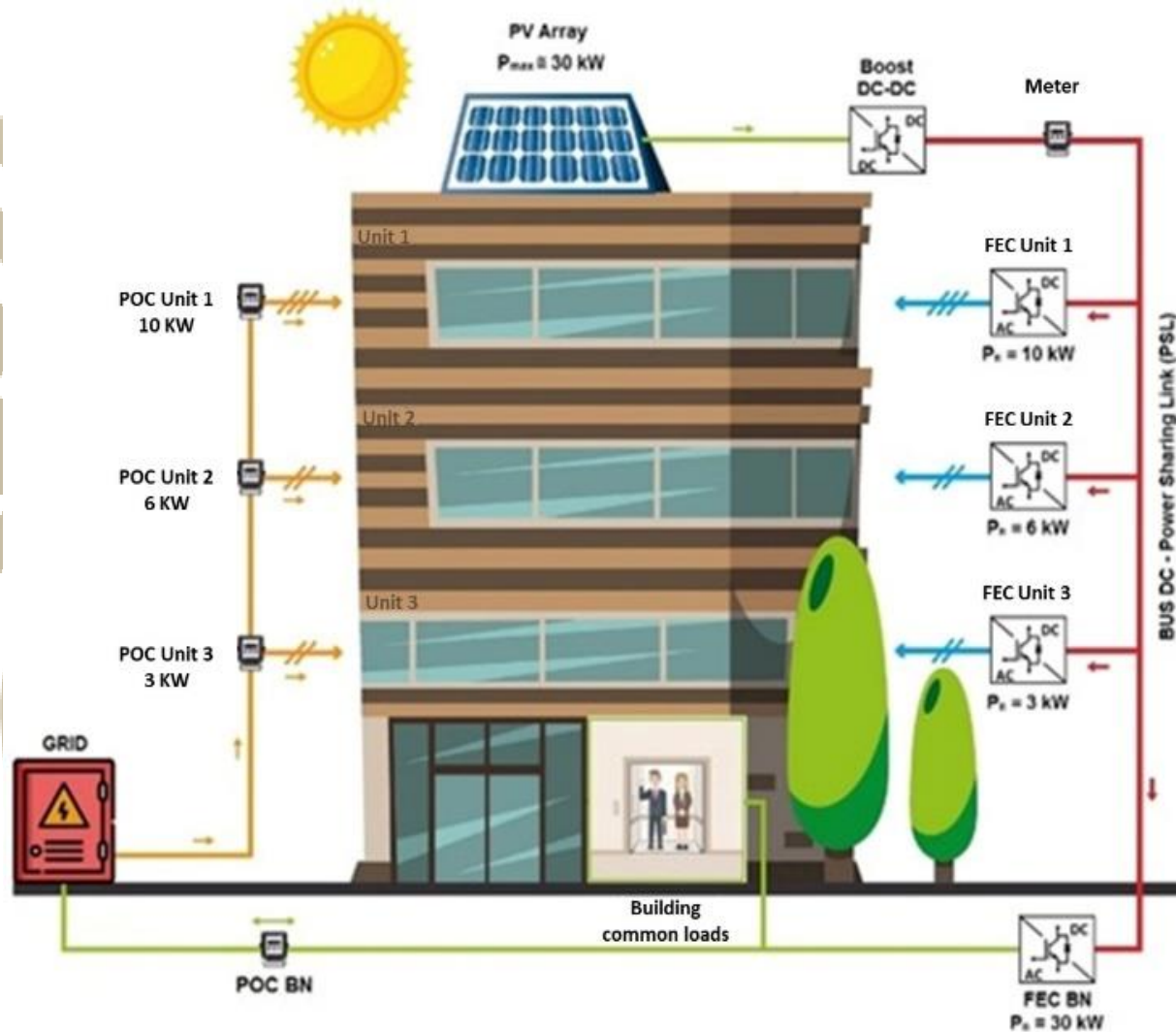
NEST

Network for Energy
Sustainable Transition

Spoke 8. Usi Finali dell'Energia

WP4. Comunità energetiche

160Meuro

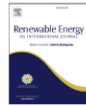


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Innovative power-sharing model for buildings and energy communities

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Smart microgrids for energy communities: power sharing model

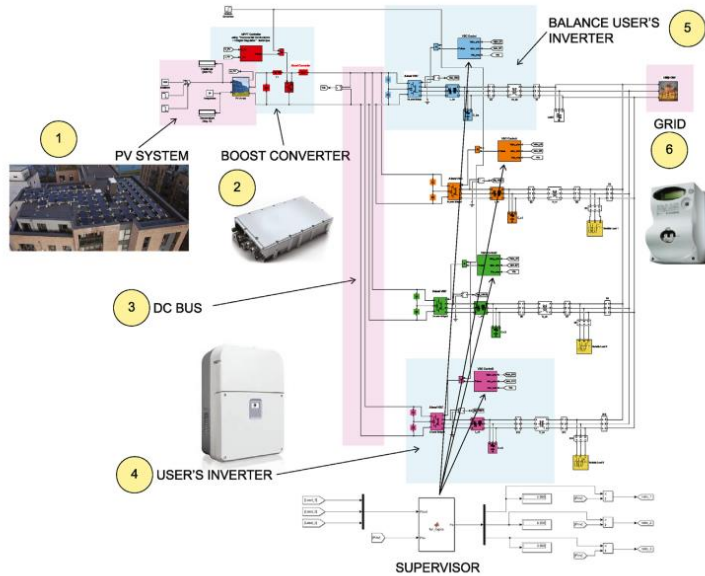


Fig. 5. Matlab/Simulink model.



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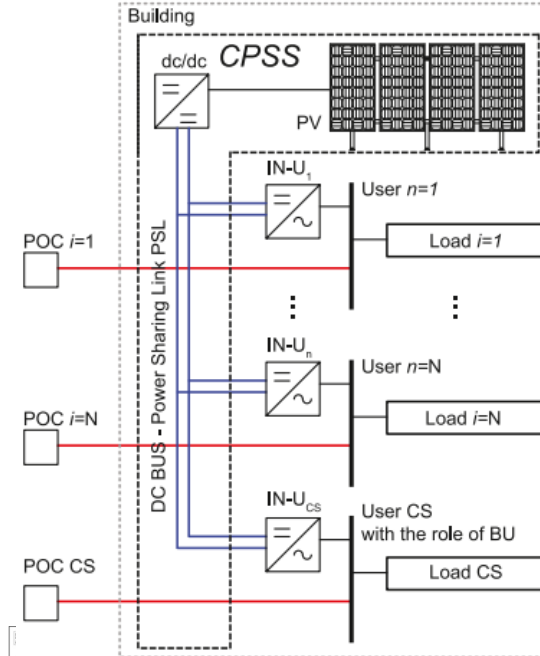


Fig. 1. Scheme of power-sharing model (PSM).

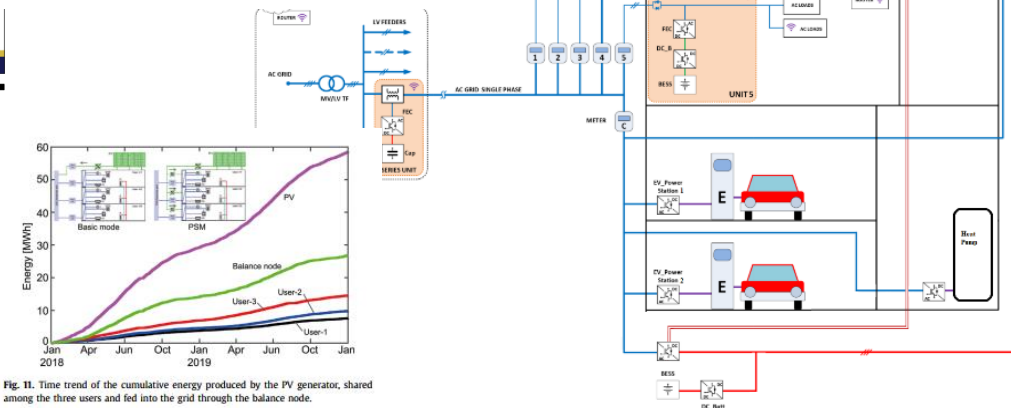
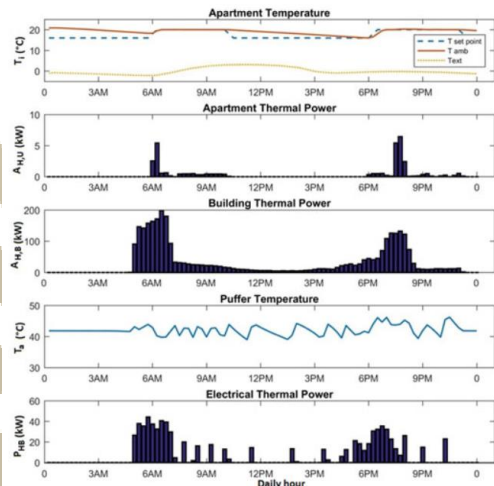


Fig. 11. Time trend of the cumulative energy produced by the PV generator, shared among the three users and fed into the grid through the balance node.

Smart microgrids for buildings



Control T1 - Boiler Control

It is possible to reduce the electric peak load in case of high global load or to store energy in case of low (or negative) global load by forcing the set points T_s of the central boilers.

if $p(t) > P_{M1} \rightarrow$ BEMS forces T_B from T_{BN} to T_{BL}
if $p(t) < P_{m1} \rightarrow$ BEMS forces T_B from T_{BN} to T_{BH}

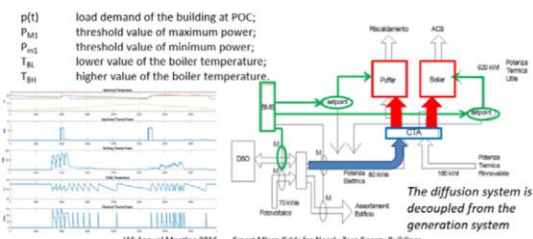


Fig. 8. Simulated building load, control mode N.

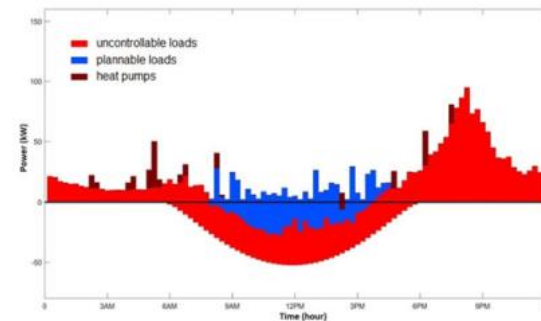
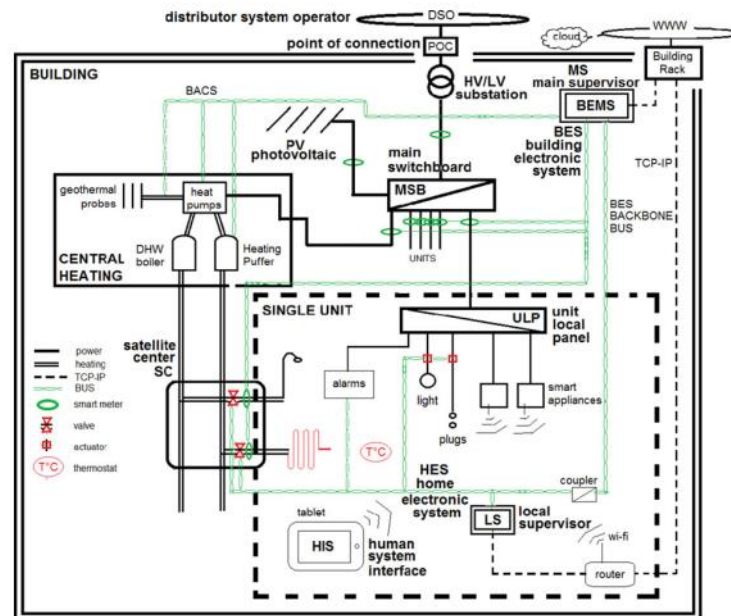


Fig. 11. Simulated building load, control mode Ad3.

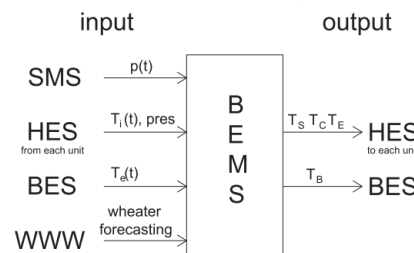
TABLE VI
RESULTS FOR A SAMPLE DAY IN MARCH

BEMS		N	Ad1	Ad2	Ad3
Peak power P_p	kW	120	105	95	93
ΔP_p	p.u.	-	0.87	0.79	0.78
Daily energy spent	kWh	998	980	980	980
GSHP energy	kWh	66	49	49	49
Daily energy from the grid E_d	kWh	641	623	583	577
ΔE_g	p.u.	-	0.97	0.90	0.90
E_H	h	8.27	9.3	10.2	10
Self consumption	kWh	357	356	390	392
Grid feeding	kWh	35	36	1	0
SCR	p.u.	0.90	0.91	0.99	1.00



$$A_{H,U}(t) = K_p * (T_p(t) - T_i(t)) + K_i * \int_0^t (T_p(t) - T_i(t)) dt \quad (3)$$

$$T_a(t + \Delta\tau) = \frac{C_a * T_a(t) + (A_{P,B}(t) - A_{H,B}(t)) \Delta\tau + H_a * \Delta\tau * T_{ac}}{C_a + H_a * \Delta\tau} \quad (4)$$



Demand Side Management in Microgrids for Load Control in Nearly Zero Energy Buildings

Luigi Martirano, *Student Member, IEEE*, Emanuele Habib, *Giuseppe Parise, Life Fellow, IEEE*, Giacomo Greco, *Student Member, IEEE*, Matteo Manganelli, *Student Member*

Smart microgrids for buildings

MARTIRANO *et al.*: AGGREGATION OF USERS IN A RESIDENTIAL/COMMERCIAL BUILDING MANAGED BY A BEMS

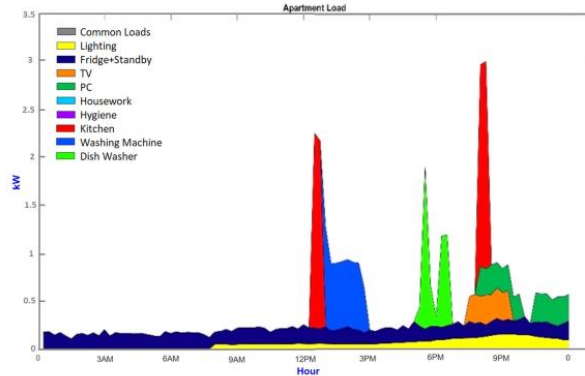


Fig. 4. Single apartment load profile.

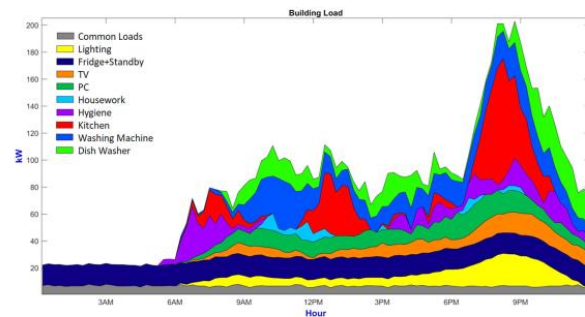


Fig. 5. Load demand example of residential units as a whole.

Under floor heating system
from a satellite center

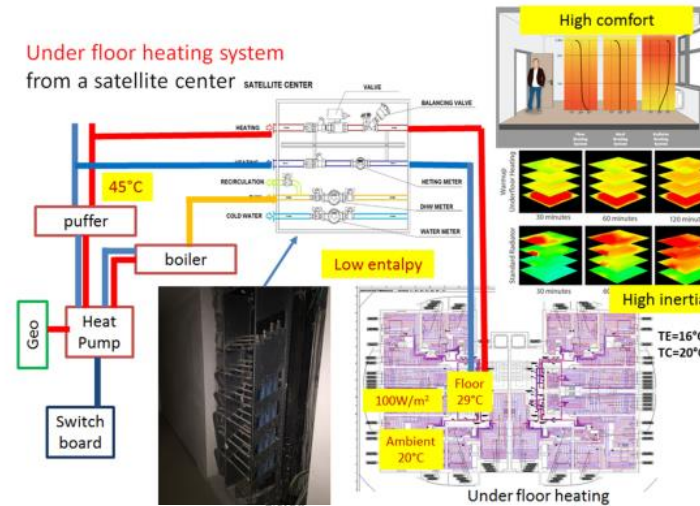


TABLE II
IMPACT OF THE CONTROLS ON THE ENERGY BEHAVIOR

		November		December		January		February		March	
		N	C	N	C	N	C	N	C	N	C
Peak Power Pp	kW	285	215	277	208	302	246	282	205	291	206
Peak Reduction ratio	p.u.	-	0.76	-	0.75	-	0.81	-	0.72	-	0.71
Daily energy consumption	kWh	2260	2148	2548	2316	2927	2737	2530	2298	2512	2467
Daily Energy Reduction ratio	p.u.	-	0.95	-	0.91	-	0.94	-	0.91	-	0.98
Residential GSHP Energy	kWh	221	127	421	303	661	547	414	298	371	270
Commercial GSHP Energy	kWh	199	198	312	314	458	458	307	307	305	305
Daily Energy from grid	kWh	1509	1358	1980	1744	2245	2051	1724	1458	15175	1448
Grid Energy Reduction ratio	p.u.	-	0.9	-	0.88	-	0.91	-	0.85	-	0.95
Equivalent hours	h	7.9	10	9.18	11.12	9.69	11.11	8.9	11.2	8.61	11.95
Self-Consumption	kWh	752	791	568	571	682	685	806	840	994	1019
Grid Energy	kWh	39	0	3	0	3	0	3	0	3	0
SCR	p.u.	0.95	1.00	0.99	1.00	0.99	1.00	0.96	1.00	0.97	1.00

SCR=0.95-0.99

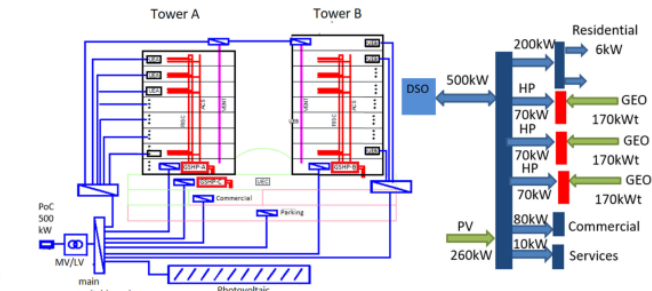
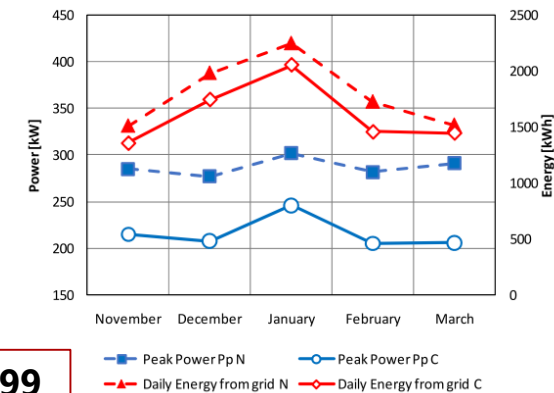


Fig. 9. Proposed smart microgrid.



Aggregation of Users in a Residential/Commercial Building Managed by a Building Energy Management System (BEMS)

Luigi Martirano, Giuseppe Parise, Giacomo Greco, Matteo Manganelli, Emanuele Habib

Smart microgrids for buildings

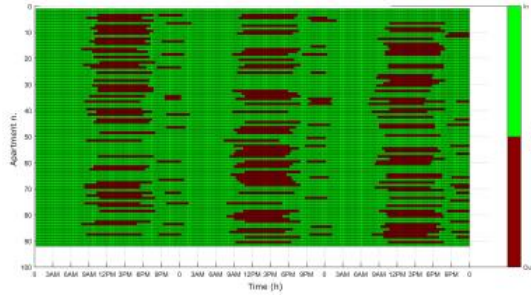


Fig. 3. Simulation of presence.

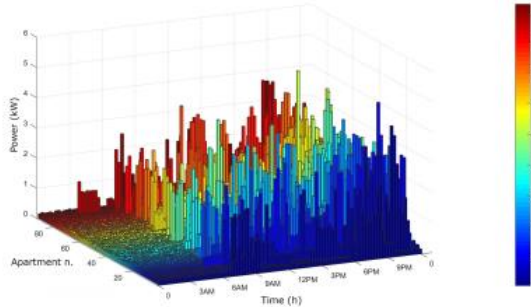
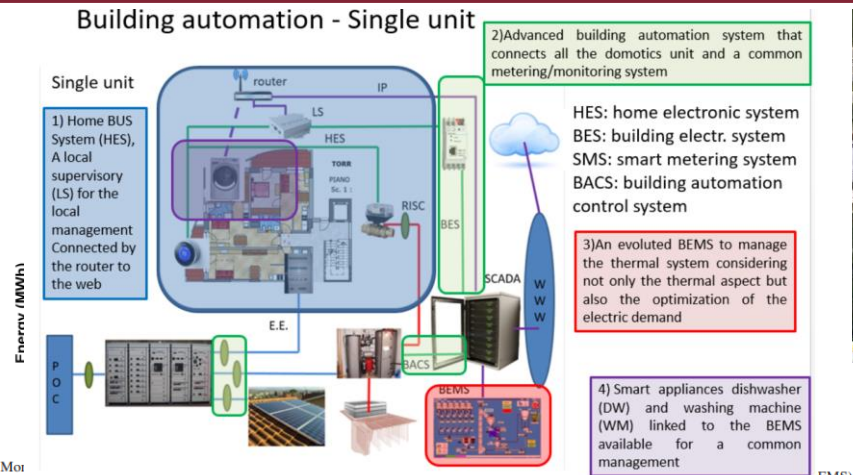


Fig. 4. Simulation of load profiles of apartments.



EMS).

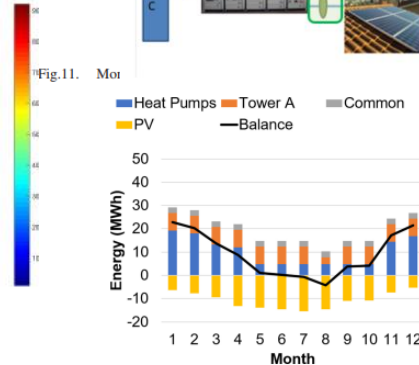
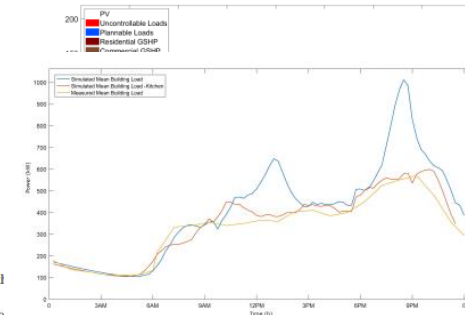


Fig. 12. Monthly energy balance in scenarios 2 and 3 (private microgrid with EMS).

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Design of a New Architecture and Simulation Model for Building Automation Toward Nearly Zero Energy Buildings

Matteo Manganelli ¹, Member, IEEE, Giacomo Greco, Student Member, IEEE, and Luigi Martirano ², Senior Member, IEEE



Modelli di aggregazione di utenze in edifici di tipo residenziale con gestione energetica ottimizzata mediante sistemi di controllo avanzati e sistemi di building automation

L. Martirano, E. Habib, M. Manganelli

Report Rd/PAR2015/130

P_i^{ess}	Power injected or absorbed by the ESS at time i .	[kW]
P_i^{ev}	Aggregated power injected/absorbed by EVs at i .	[kW]
P_i^{poc}	Power flow at the grid point of connection at i .	[kW]
SOC_i^{ess}	State of charge of the ESS at time i .	[%]
$T_{u,i}^{air}$	Air temperature in unit u at time i .	[°C]
T_i^{boiler}	Boiler water temperature at time i .	[°C]
$T_{u,i}^{pipes}, T_{u,i}^{floor}$	Pipes, floor and walls temperature in unit u at time i .	[°C]
$T_{u,i}^{walls}$		[°C]
T_i^{ext}	External air temperature at time i .	[°C]

Control Variables

c_i^{ess}	$c_i^{ess} \in \{0, 1\}$, $c_i^{ess} = 1$ if the ESS recharges at i .
$c_{e,i}^{ev}$	$c_{e,i}^{ev} \in \{0, 1\}$, $c_{e,i}^{ev} = 1$ if EV e recharges at i .
d_i^{ess}	$d_i^{ess} \in \{0, 1\}$, $d_i^{ess} = 1$ if the ESS discharges at i .
$d_{i,e}^{ev}$	$d_{i,e}^{ev} \in \{0, 1\}$, $d_{i,e}^{ev} = 1$ if EV e discharges at i .
$G_{u,i}$	Water mass flow intake of housing unit u

$$V = \sum_{i=k}^{k+N-1} \left\{ a_1 c_i + a_2 \sum_{u \in U} (T_{u,i}^{air} - \tilde{T}_{u,i}^{air})^2 + a_3 (T_i^{boiler} - \tilde{T}_i^{boiler})^2 + a_4 (SOC_i^{ess} - \tilde{SOC}_i^{ess})^2 + a_5 (P_i^{poc})^2 \right\} \quad (1)$$

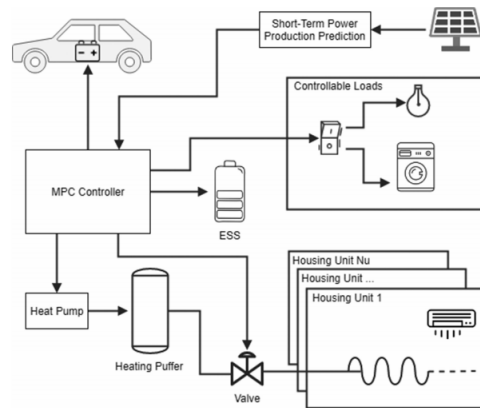


Fig. 1. Reference architecture of a smart building, consisting of several units heated by a centralized controlled system.

V. CONCLUSION

This article has presented a MPC-based energy management algorithm for managing heating and electricity loads in a smart building. The managed loads include a heat pump, an electricity storage, electric vehicles and flexible loads. The control objective has been to minimize costs of energy consumption while ensuring that the technical constraints of the system are

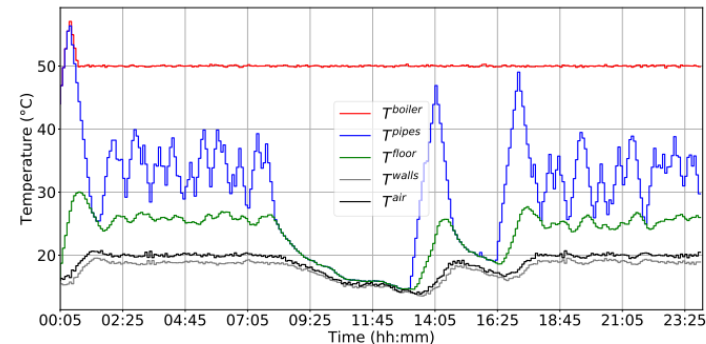
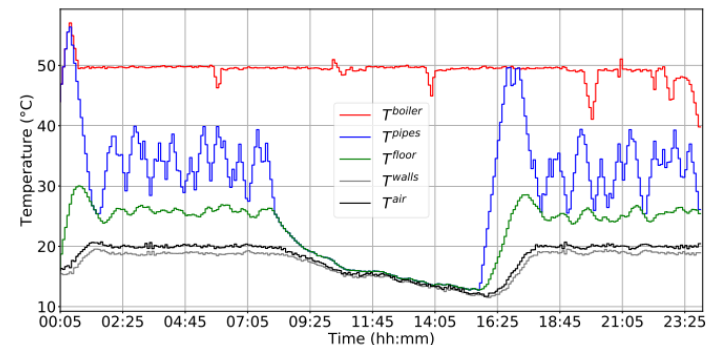


Fig. 5. Simulation 2: Temperatures in building unit 1.



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Joint Model Predictive Control of Electric and Heating Resources in a Smart Building

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Smart microgrids for energy communities



Figure 2. Administration district (yellow); buildings included in the future microgrid (red); buildings object of this work (blue)

A smart microgrid for buildings of the public administration

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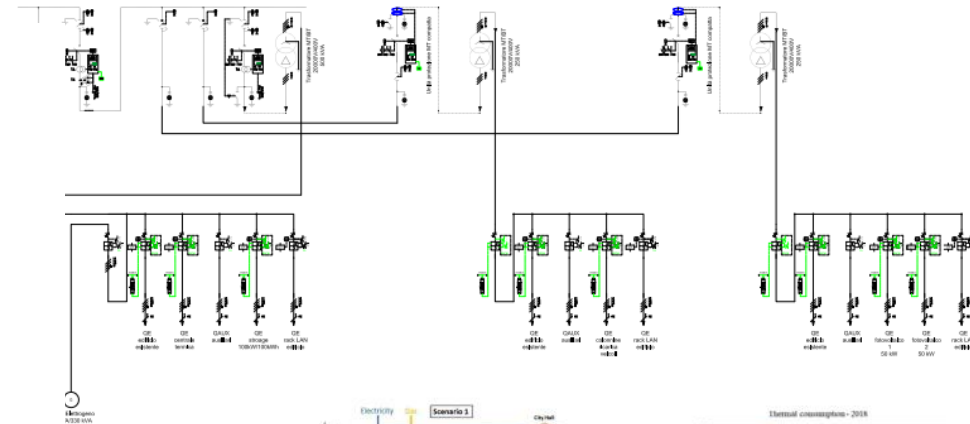


Figure 3. Energy vectors Scenario 1

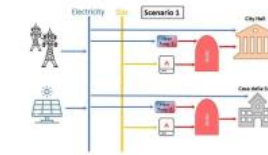


Figure 4. Energy vectors Scenario 2

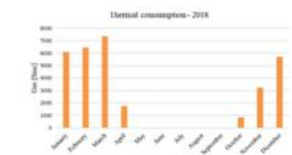
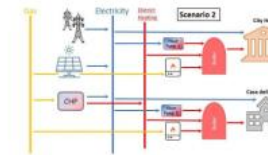


Figure 7. Building 1 thermal consumption

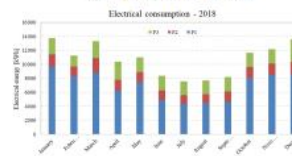


Figure 8. Building 1 electrical consumption

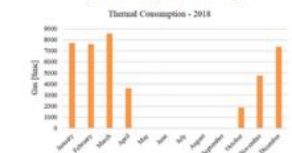


Figure 9. Building 2 thermal consumption

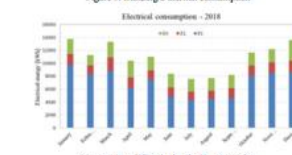
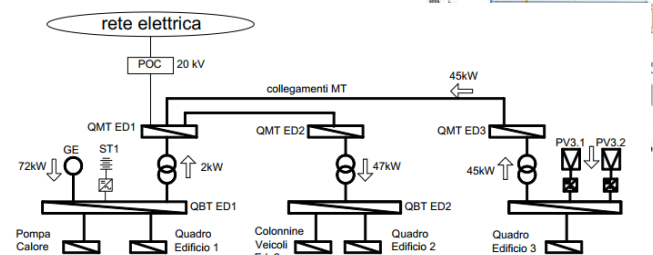


Figure 10. Building 2 electrical consumption



Smart microgrids for energy communities

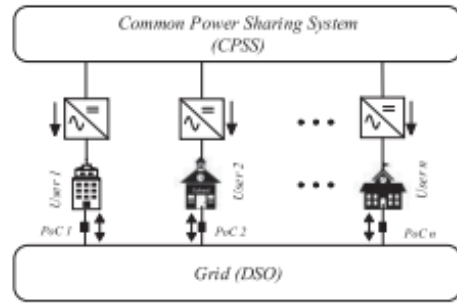


Fig. 2. Suggested PSM scheme.

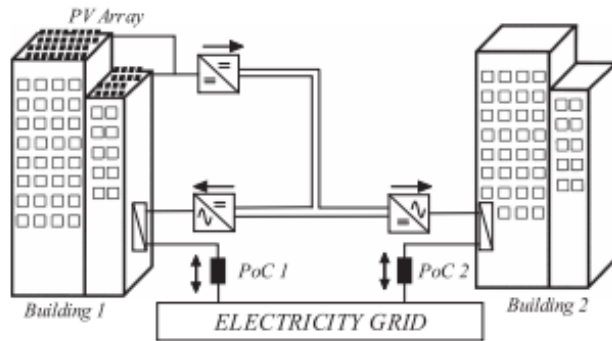
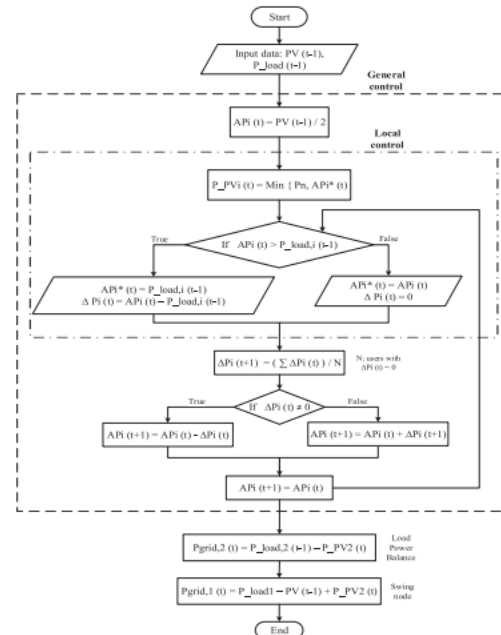


Fig. 3. Case study: Power sharing between two buildings.



INPUT DATA											
Building 1 Demand								82 MWh/y			
Building 2 Demand								141 MWh/y			
PV production								122 MWh/y			
cost of electrical energy from national grid								0.2 €/kWh			
cost of electrical energy exported								0.05 €/kWh			
SCENARIO No-PV				SCENARIO BASIC				SCENARIO PSM			
Building 1		Building 2		Building 1		Building 2		Building 1		Building 2	
[MWh/y]	[€/y]	[MWh/y]	[€/y]	[MWh/y]	[€/y]	[MWh/y]	[€/y]	[MWh/y]	[€/y]	[MWh/y]	[€/y]
PV absorbed				39		0		32		48	
Electrical Energy from National Grid				82	16400	141	28200	43	8600	141	28200
								50	10000	93	18600
PV exported				[MWh/y]		[€/y]		[MWh/y]		[€/y]	
						83		4150		43	
Self Consumption (SC) coefficient						0.32				0.66	
ECONOMICAL ANALYSIS											
Electrical Energy Expenses for Scenario No-PV								44558 €			
Investment Cost PV System								130000 €			
Investment Cost Power Sharing								15000 €			
Investment Cost PV + Power Sharing								145000 €			
SCENARIO BASIC				SCENARIO PSM							
EE Expenses		[€/y]		[€/y]		[€/y]		[€/y]		[€/y]	
		32650		32650		26450		26450		26450	
Savings		11908		11908		18108		18108		18108	
Net Present Value (NPV)				44992 €				133007 €			
Internal Rate of Return (IRR)				6%				11%			
Payback Time (PBT)				10.9 Years				8.0 Years			

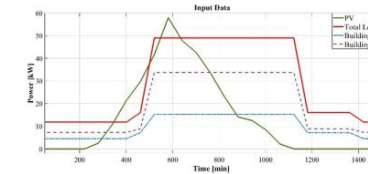


Fig. 11. Input data for scenario PSM.

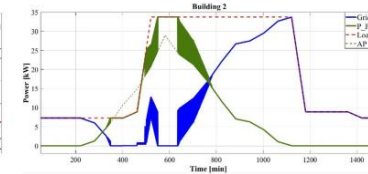


Fig. 13. Results of Scenario PSM: power profiles for Building 2.

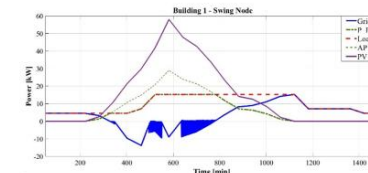


Fig. 12. Results of scenario PSM: power profiles for building 1 - Swing Node.

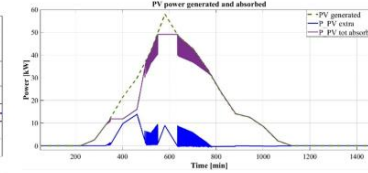
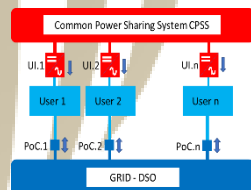


Fig. 14. Results of Scenario PSM: total power produced by the PV; total power absorbed from the PV; extra generated power.



Power Sharing Model for Energy Communities of Buildings

Luigi Martirano ^{ID}, Senior Member, IEEE, Sara Rotondo, Student Member, IEEE, Mostafa Kermani ^{ID}, Member, IEEE, Ferdinando Massarella, and Roberto Gravina



Modello di microgrid per "smart building" come energia community con gestione ottimizzata delle risorse energetiche. Parte 1: Analisi di modelli di reti energetiche per smart building e NER.



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Grazie per l'attenzione

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“Affrettati lentamente”