Design Considerations for Distributed Micro-Storage Systems in Residential Applications

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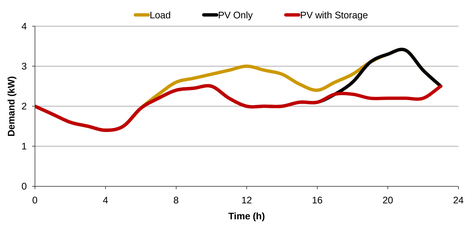
Abstract

- This paper presents some design considerations for distributed micro-storage systems (MSS) in residential applications.
- System Sizing as well as different system architectures are discussed.
- In addition, different energy storage technologies, communication, and inverter design considerations are also presented.

I. Introduction

- For more than one hundred years, utilities have supplied reliable power to the globe with relatively high quality of service.
- Today, as electricity demand and customers' expectations escalate, utilities are struggling to fulfill those needs.
- Energy storage can be used to mitigate the intermittency of supply and inject power to the grid to alleviate peak demands.

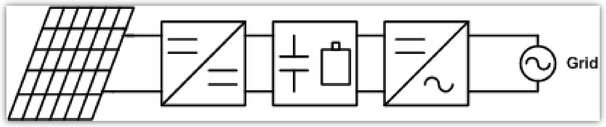


II. Energy Storage Technologies

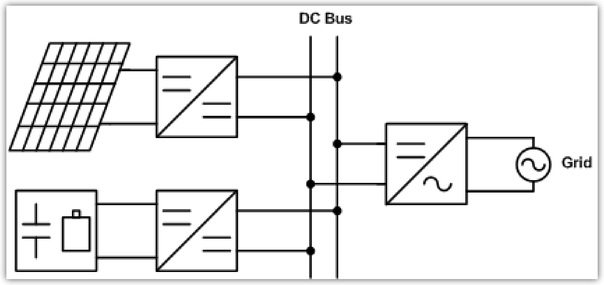
	Energy Density (Wh/kg)	Cost (kWh)	Cycle Life (Cycle)	Cost/Cycle Life
VRLA	30-50	$200	200-300	0.67-1
Li-Ion	90-190	$1,333	2000	0.67
NiMH	30-80	$800	1000	0.8
NaS	100	$450	2500	0.18
Zinc Bromine	70	$500	1000	0.5
EDLC SuperCap.	6-10	$44,070	1,000,000	0.044
LIC SuperCap.	15	$61,600	100,000	0.616

III. System Configuration

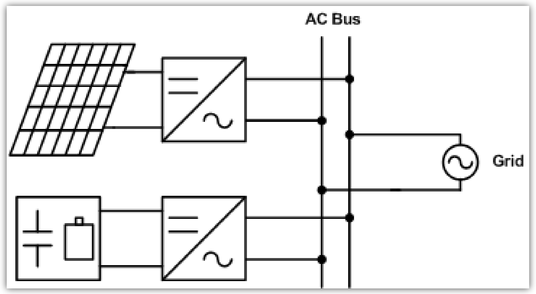
The power system architecture for the proposed MSS can be inline, dc coupled or ac coupled.



Inline Systems

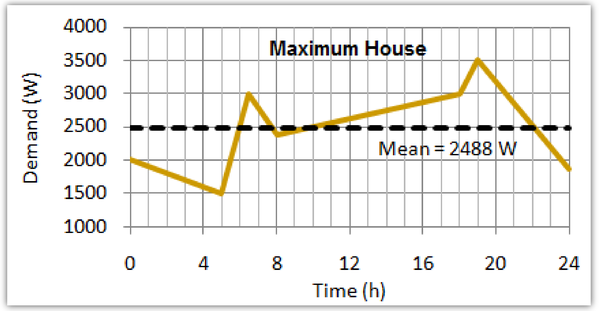


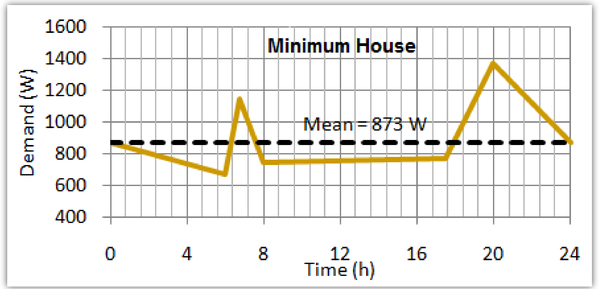
DC Coupled Systems



AC Coupled Systems

IV. System Sizing





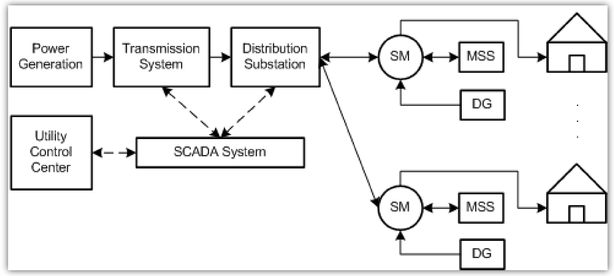
	1st Peak	2nd Peak	Total Energy
Max. House	105 min 512W	720 min 1012W	13,040Wh
Min. House	90 min 277W	360 min 502W	3,427.5Wh

	Typical Size	Nominal Size
Inverter	0.5 kW –1 kW	0.75 kW
Energy Storage	2 kWh – 3 kWh	2.5 kWh

V. Inverter Design Considerations

	Description
Grounding	• Important for high voltage systems for safety. • Required for systems above 50V in the U.S.
Isolation	• Can be achieved via line frequency (LF) and high frequency (HF) transformers. • Main purpose for isolation is to prevent dc current injection. • In the U.S., up to 0.5% dc current injection is allowed.
Architecture	• The power conversion stage can have a bidirectional single path inverter/charger, or two unidirectional separate paths for the inverter and the charger.
Number of Stages	• Can be single stage or multiple stages. • Trade off between simplicity and input voltage range.

VI. Communication and Smart Grid Integration



	Description
PLC	• Low cost. • Interference problems.
Ethernet	• Fast and reliable. • Requires access to the internet.
Wireless	• Highly accessible. • Example: Zigbee.
Optical Fiber	• Very high speed (light speed) and high data rates. • Initial cost is high.

VII. Conclusion

- Modularity, low cost and high quality power are key issues in the design of residential micro storage systems.
- AC coupled MSS is beneficial as it offers a robust design and allows for a modular and flexible storage system.
- The choice of the energy storage technology for the MSS is dependent on the budget and the operating conditions.
- Since the cost of energy storage devices are continuously decreasing, and due to the continuously increasing demand and prices of electric power, distributed residential micro storage is expected to gain more attention in the next few years.
- Communication between MSS and the utility must be very reliable since it is substantial for this application.