Gender sensitive climate change adaptation enabled through prosumer power sharing in off-grid scenarios

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How Climate Change Affects Women

- 80% of people displaced by climate change are women.
- Women are not equipped to deal with these impacts due to a lack of assets, financial resources and limited access to information.
- Improved electricity access can enhance climate change adaptation for remote communities.
- Interconnected Solar Home Systems (SHSs) with power sharing can improve access to energy services.
- This can lead to better adaptation opportunities for women.

The Solar Home System (SHS)

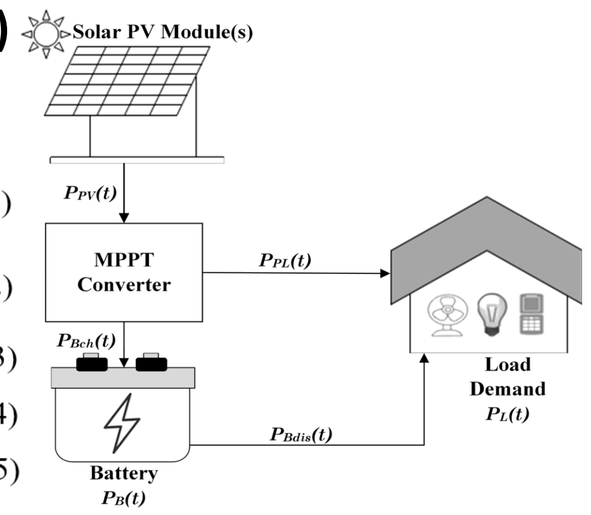
$$\min C_{PV}.S_{PV} + C_B.P_{BMAX} + \sum_{j=1}^{J}(1+r)^{j-1}\{(\gamma_{PVj}.C_{PVj} + \mu_{PV}).S_{PV} + (\gamma_{Bj}.C_{Bj} + \mu_B).P_{BMAX}\} \quad (1)$$

$$LPSP = \frac{\sum_{t=1}^{T}[P_L(t) - (P_{PL}(t) + P_{BDIS}(t))]}{\sum_{t=1}^{T} P_L(t)} \quad (2)$$

$$P_{PL}(t) + P_{BDIS}(t) \le P_L(t) \qquad \forall t \in [1,T] \quad (3)$$

$$P_{PL}(t) + \frac{P_{BCH}(t)}{\eta_{BCH}} \le \eta_{MPPT}.P_{PV}(t) \qquad \forall t \in [1,T] \quad (4)$$

$$LPSP < 0.1 \quad (5)$$



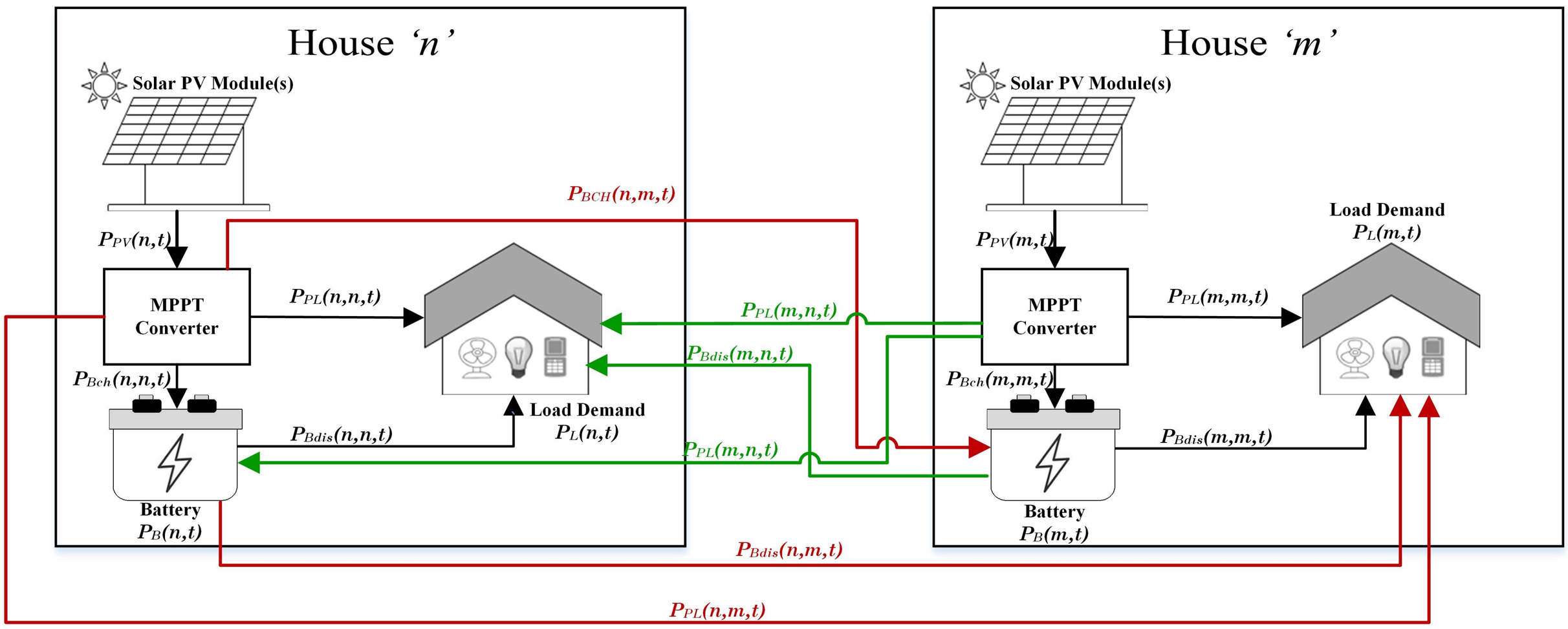
The Proposed Solution: Decentralized Prosumer Microgrids

1) Objective function:

$$\min \sum_{n=1}^{N}\sum_{t=1}^{T}\{\eta_{MPPT}P_{PV}(n,t) - \sum_{m=1}^{N}\frac{P_{BDIS}(n,m,t)}{\eta_{BDIS}(n)\eta_{dist}(n,m)} + \frac{P_{PL}(n,m,t)}{\eta_{dist}(n,m)}\} \quad (6)$$

$$\sum_{m=1}^{N}(P_{PL}(m,n,t) + P_{BDIS}(m,n,t)) \le P_L(n,t) \quad (7)$$

$$\sum_{m=1}^{N}(P_{PL}(m,n,t) + \frac{P_{BCH}(n,m,t)}{\eta_{BCH}(n)}) \le \eta_{MPPT}(n,t).P_{PV}(n,t) \quad (8)$$



Services Enabled through Improved *Energy Access*

Energy Access for households is defined according to ESMAP's Multi-tier Framework (MTF 2015) [2].

INDICATIVE CALCULATION OF CONSUMPTION FOR MTF TIERS 1-5

Appliance/ Service	Power (W)	Hours/day	Baseline Annual Usage (kWh)				
			Tier 1	*Tier 2*	*Tier 3*	*Tier 4*	*Tier 5*
Task lighting	½	4-8	1.5	2.9	2.9	5.8	5.8
Mobile Phone charger	2	2-4	1.5	2.9	2.9	2.9	2.9
Radio device	2 or 4	2-4	1.5	5.8	5.8	5.8	5.8
General lighting	12	4-12		17.5	17.5	35.0	52.5
Fan	20 or 40	4,6,12,18		29.2	87.6	175.2	262.8
TV	20 or 40	2		14.6	29.2	29.2	29.2
Food processor	200	½			36.5	36.5	36.5
Washing machine	500	1			182.5	182.5	182.5
Refrigerator	300	6				657.0	657.0
Iron	1,100	1/3				120.5	120.5
Air conditioner	1,500	3					1,642.5
Total (kWh)			4.5	73	365	1,250	3,000

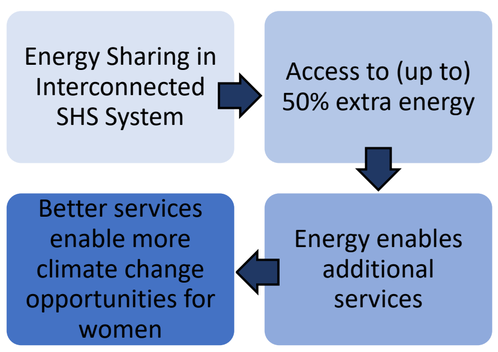
Results: The Benefits of Power Sharing

- Excess power sharing potential of a four-house interconnected SHS system is studied.
- Stochastic load profiles [1] are used for each tier.

Tier	*Before Power Sharing*	*After Power Sharing*	*Increase (%)*
	Energy used per household (Wh/day)		
1	45	67.5	50.0
2	196.2	295.2	50.5
3	882.9	1197.9	35.7
	LCOE (cents/ kWh)		
1	32.75	21.11	-35.5
2	23.17	17.35	-25.1
3	26.96	16.57	-38.5

In Summary: What access to extra energy means to women?

- SHSs are widespread but waste more than 50% of the generated energy.
- Interconnected SHS with four houses enables up to 50% more energy utilization, at up to 38.5% lower energy costs.
- Households can use this additional energy for appliances, not previously accessible to SHS owners.
- This provides climate resilience and adaptation opportunities for women [3].



References

[1] Narayan, Nishant (2018): Electrical power consumption load profiles for households with DC appliances related to Multi-tier framework for household electricity access. Version 1. 4TU.ResearchData. dataset.
[2] M. Bhatia and N. Angelou, "Beyond Connections: Energy Access Redefined ESMAP Technical Report; 008/15," WORLD BANK, Washington DC 2015.
[3] R. Arshad, H.A. Khan and R. Khalid, "Prosumer Power Sharing and Climate Change Adaptation in a Gendered Context" Presented at IEEE GreenTech, Sustainability, and Net Zero Policies & Practices Symposium (GTSNZ) 2023, Dubai, UAE.

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