Asia Clean Energy Forum-2018

Manila, 4-8 June, 2018

"Quantifying demand side opportunities to improve integration of renewable energy in mini-grids in Nepal"

Bhupendra Shakya[1]

PhD candidate

Anna Bruce[1,3] , Iain MacGill[2,3]

[1] *School of Photovoltaics and Renewable Energy Engineering,*

[2]*School of Electrical Engineering and Telecommunications*

[3]*Centre for Energy and Environmental Markets*

University of New South Wales (UNSW),

Sydney, NSW 2052, Australia

Summary

- Integrating variable renewable energy into mini-grids increases the challenge of matching demand and supply.
- Current design practices for Renewable Energy Mini-Grid (REMG) systems are supply oriented and can miss some key opportunities on the demand-side to deliver low cost and reliable energy services.
- Users place different relative value on energy services, while some energy services have considerable flexibility due to inherent energy storage in the end-use equipment used, or user willingness to shift their usage, depending on affordability and reliability preferences.
- Present results of surveys of energy service characteristics across 154 households in five mini grids in Nepal in order to better understand and quantify these opportunities.
- Data presented includes energy consumption patterns, appliance ownership, energy service preferences and priorities and potential flexibility to move some loads across the day.
- Quantification of these characteristics can be used to design REMGs that are low cost and reliable.

Key Barriers

- 'UN SE4All', REMG -High Impact Opportunity (HIO) to provide electricity access and 40% electricity from MG by 2030

Key barriers in REMG deployment are

1. System design complexities (sizing): matching between variable supply and demand[1]

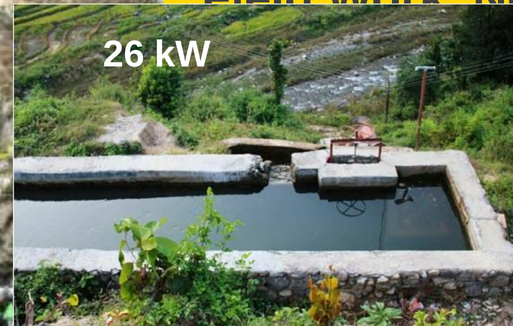
- High capital cost and uncertainties [2]

Energy Service Approach and opportunities:

- Key value of energy supply is in service provision (lighting, cooking, refrigeration) - not kWh delivered[3]
- Users assign relative value to energy services - preferences, capabilities
- Possible flexibility of energy services (inherent storage in appliances and services)
- Opportunity to better utilise RE at lower cost to meet most important energy service needs
  - Solar Home System (SHS) users very engaged to prioritise the Energy services
  - Grid users not very engaged
  - REMG users have opportunity to engage

(1 Gupta, 2013/Hazelton,2014/ Bhattacharya,2014 / 2 Gupta, 2013/Hazelton,2014/ Mohammad/ 2014, **Hurley-Dépret, 2017 / IRENA, 2015** 3 Sovacool, 2011)

Field Work Nepal (Feb-May, 2017)



Source of electrification	House holds
Solar-Wind MG, Makawanpur	20
Solar-Battery MG, Tanahun	16
Solar-Diesel Hybrid MG, Okhaldhunga	17
Micro Hydro MG, Dhading	8
Mini Hydro, Ramechhap	93
Total	154

“Collaboration with Alternative Energy Promotion Centre/ Renewable Energy for Rural Livelihoods programme”

- ***Detailed Consumer Survey for access to electricity, demand assessment , consumer preference***
- ***Key informant Interview (Plant operator, manager)***

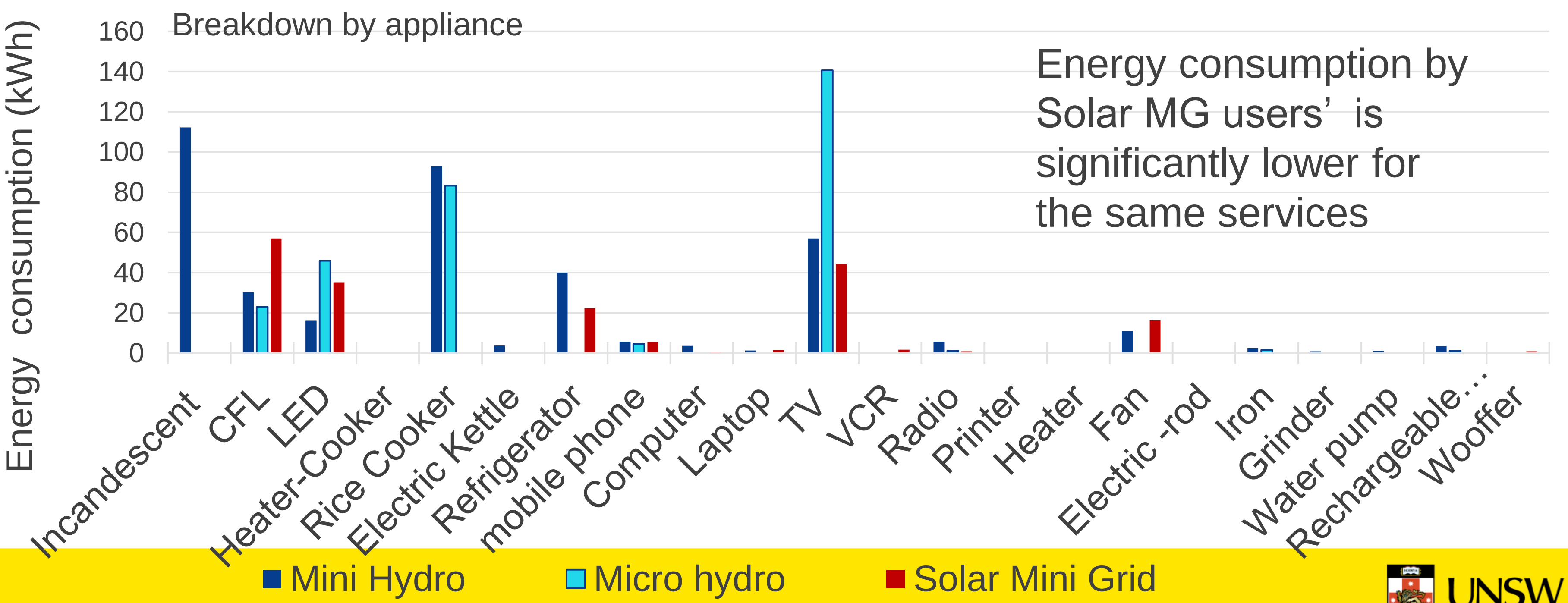
UNSW SYDNEY

Techno-economic and Social Characteristics

	Solar-Wind-MG	Solar-Battery	Solar-diesel MG,	Micro-hydro MG,	Mini hydro MG
Generating Capacity (kW)	25 (15 PV+10 Wind)	18 PV	63 (31 PV + 40 DG)	26	1030
Settlement	**Rural Market centre**	**Rural Market centre**	**“Commercial” centre**	**Rural Market centre**	**Rural / “Commercial centre”**
Ownership structure	Community	Private/ community	Private / community	Community / Cooperative	Cooperative
Adequacy of supply	**Access Deficit**	**Spare power**	**Access Deficit**	**Access Deficit**	**Adequate**
Metering	No meter, power limiter (MCB)	Smart meter	Smart meter	Traditional meter	Traditional meter
Tariff (US c/kWh)	**4 - 13**	**16 - 75**	**31 - 98**	**4 - 7**	**4 - 5**
Productive end-uses	Poultry, Eatery	Poultry, Eatery	Telcom tower, Petrol pump, Health Centre	Agro-processing Mill, Furniture, Metal workshop	Agro-processing Mill, Furniture, Bakery, Metal workshop

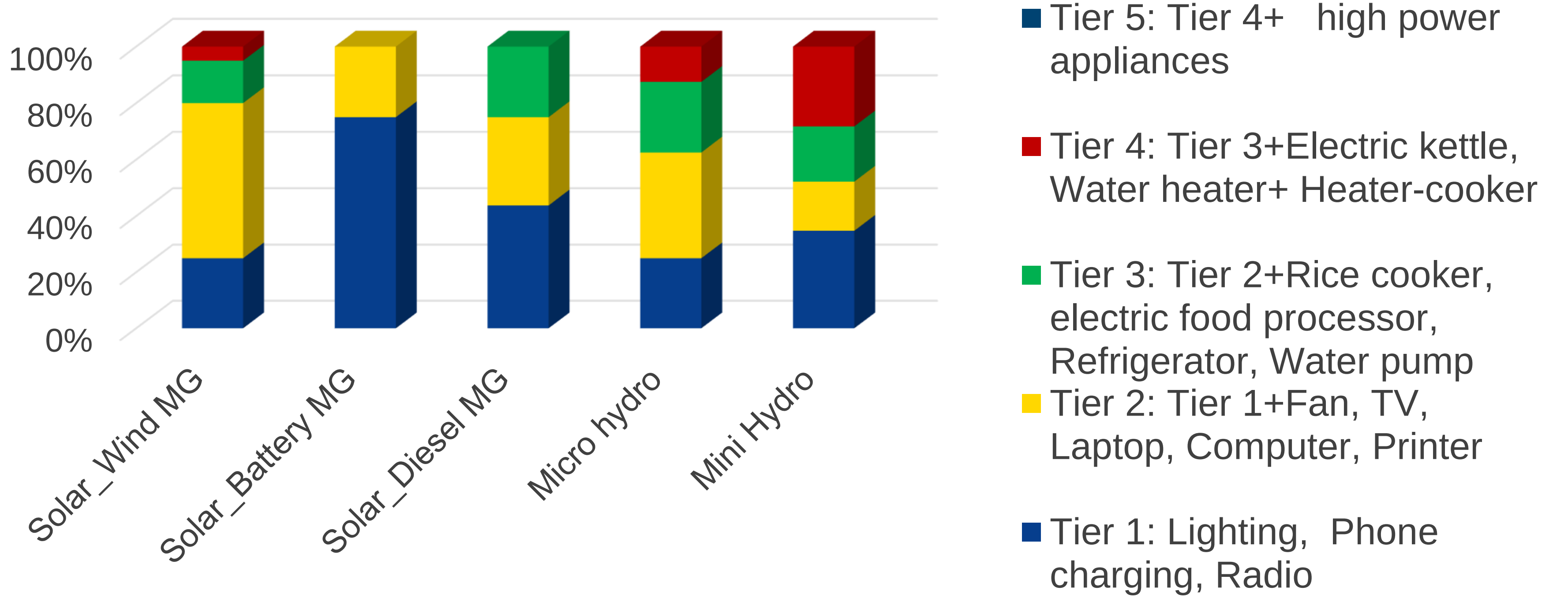
Annual household energy consumption

Consumption depends on: types of supply sources, settlement, tariff structure



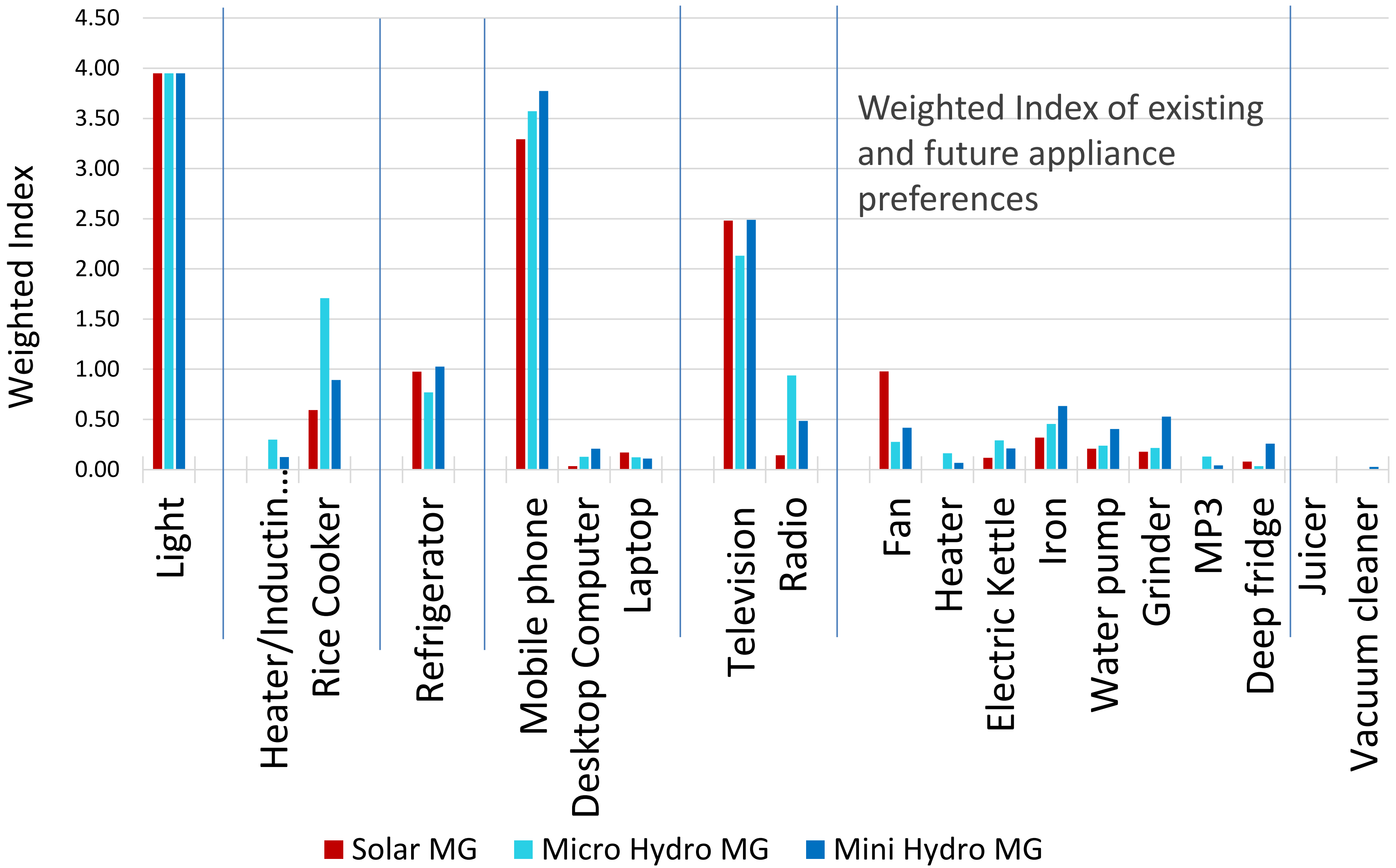
Energy consumption by Solar MG users' is significantly lower for the same services

Access Status: Multi-tier framework-service



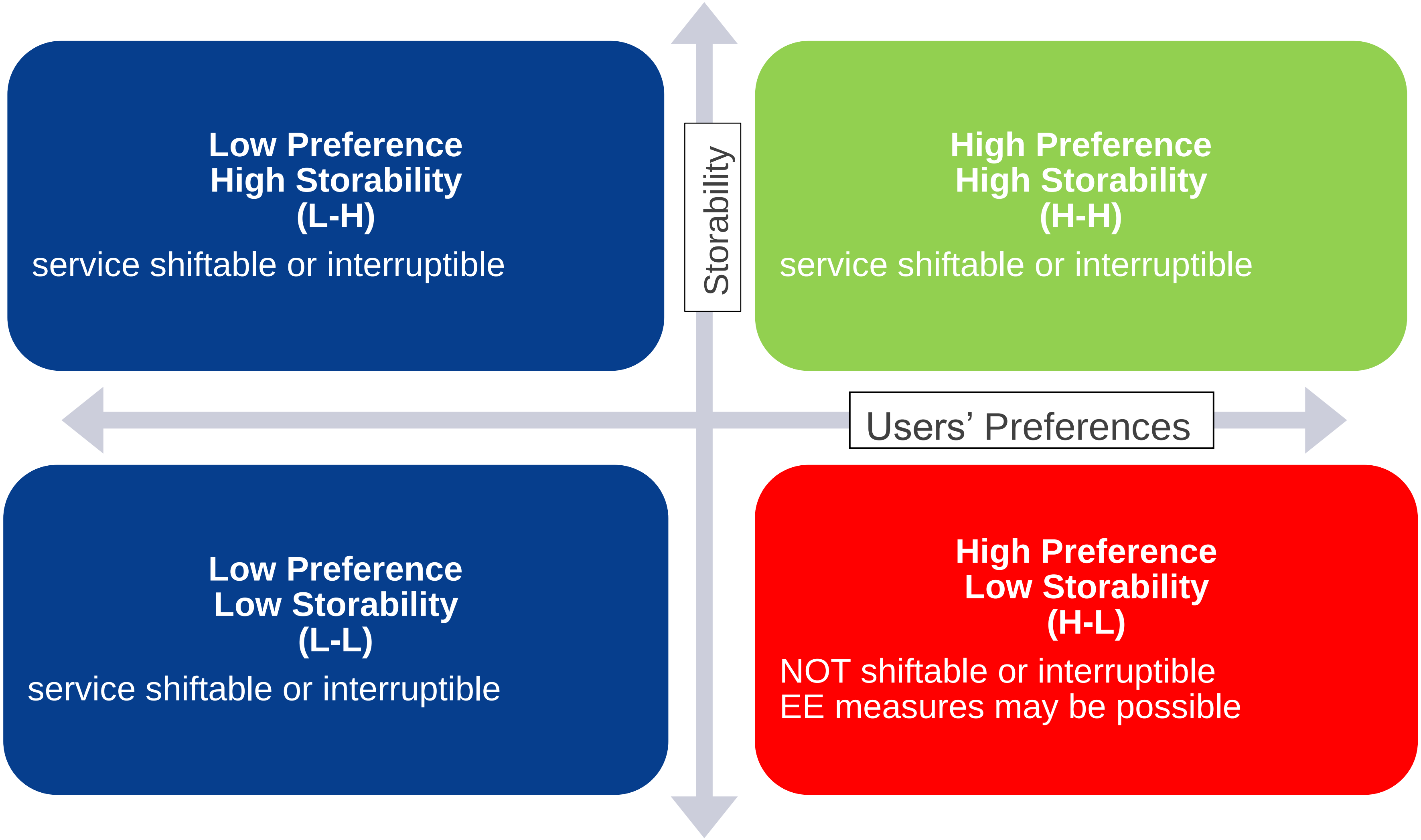
	Solar Wind MG	Solar Battery MG	Solar Diesel MG	Micro Hydro	Mini Hydro
Reliability, interruption/ week (index)	<14 (**4**)	<3 (**5**)	<14 (**4**)	<3 (**5**)	<3 (**5**)
Duration, hours/ day (index)	<8 (**2**)	23 (**5**)	<16 (**3**)	<22 (**4**)	23 (**5**)
Quality, appliance under perform due to over/ under voltage)	14% (**4**)	0% (**5**)	29% (**4**)	60% (**3**)	26% (**4**)
Access Index	**1.75**	**1.25**	**1.81**	**2.13**	**2.41**

Appliance Preferences

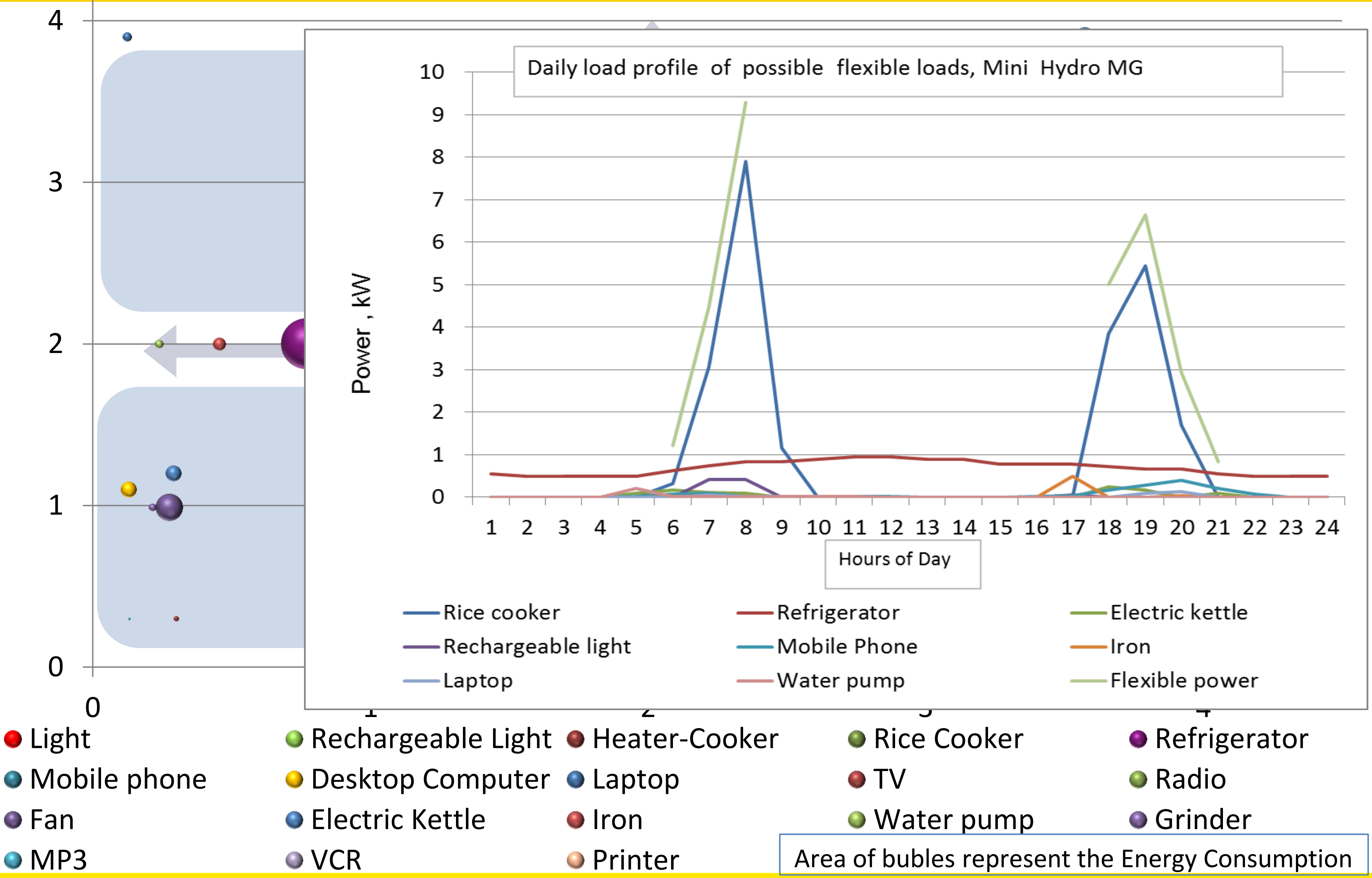


Order of preferences- Light, Mobile phone, Television, Rice cooker , Refrigerator

Energy service characterisation framework



Service Characterisation of Mini Hydro MG



Conclusion

Supply	Energy efficiency	Demand Management Possibilities
Mini Hydro MG	Light, TV, Refrigerator	**Rice cooker, refrigerator**, (mobile phone, iron, rechargeable light, water pump, laptop)
Micro Hydro MG	TV	**Rice cooker,** (mobile phone and rechargeable light)
Solar MG	Refrigerator	**Refrigerator,** (mobile phone, laptop and rechargeable light)

- Proposed energy service characterisation framework and load profile can be used to develop an effective load shifting strategy
- Provides a basis for designing REMGs to provide important services at reduced cost
- Users are generally aware of or positive towards energy efficiency measures and load shifting
- Financial incentives, awareness, metering and load control mechanisms are possible options for implementation of demand side management

Thank you!

(ADB, supervisors)

(Questions Please ?)