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# "Characterisation of Energy Services for Maximising Energy Access Outcomes with Renewable Energy Mini Grid"

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# 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 Energy Service Characterisation (ESC) framework, strategies for potential flexibility of services across the day, and results : possibilities of low cost and reliable REMG using ESC framework then HOMER Pro modelling software

# 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]

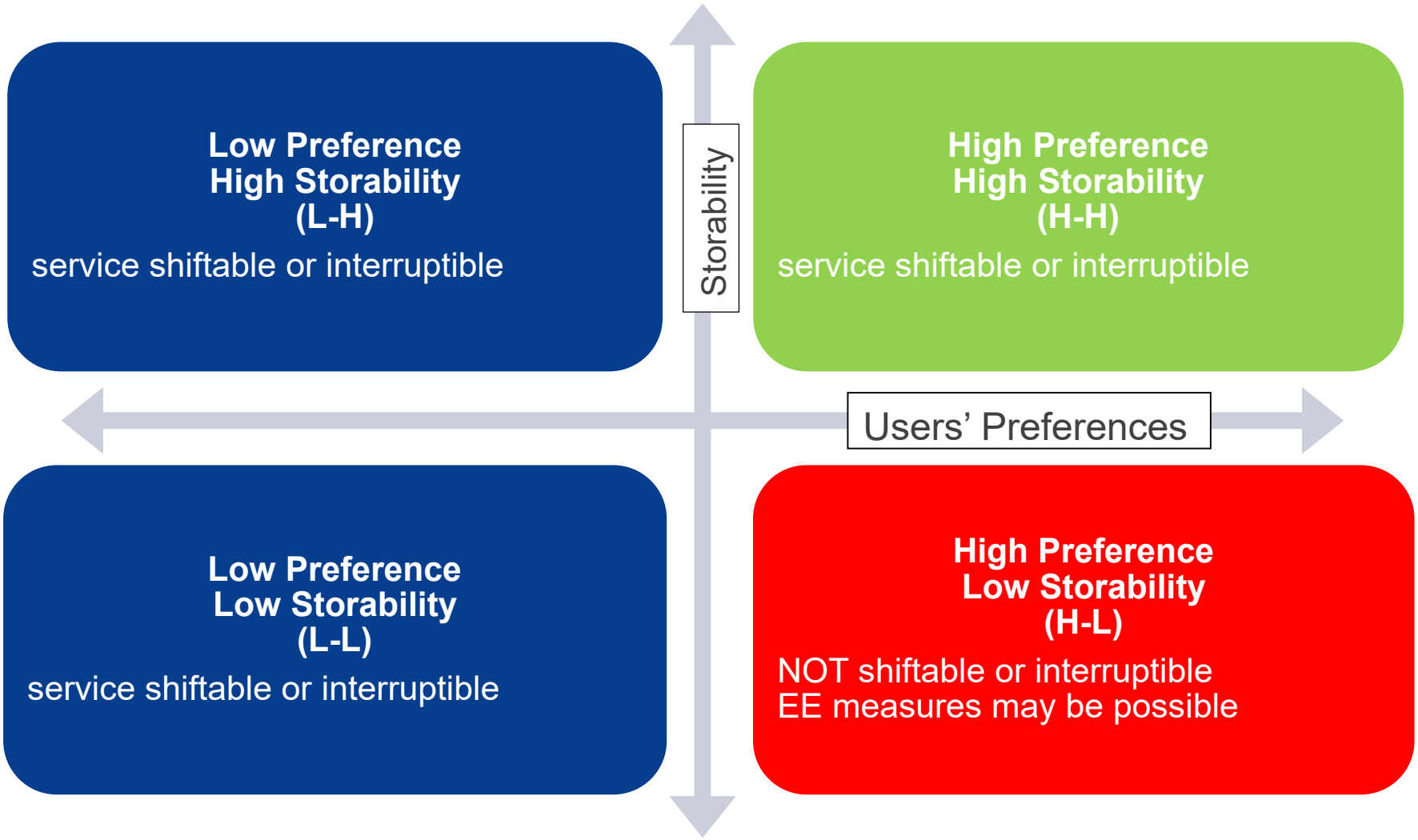
- High capital cost and uncertainties [2]

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)

# Energy service characterisation framework




Source: Shakya B., Bruce A., Macgill I., *Survey Based Characterisation of Energy Services for Improved Design and Operation of Standalone Microgrids,* Renewable and Sustainable Energy Reviews, 2018

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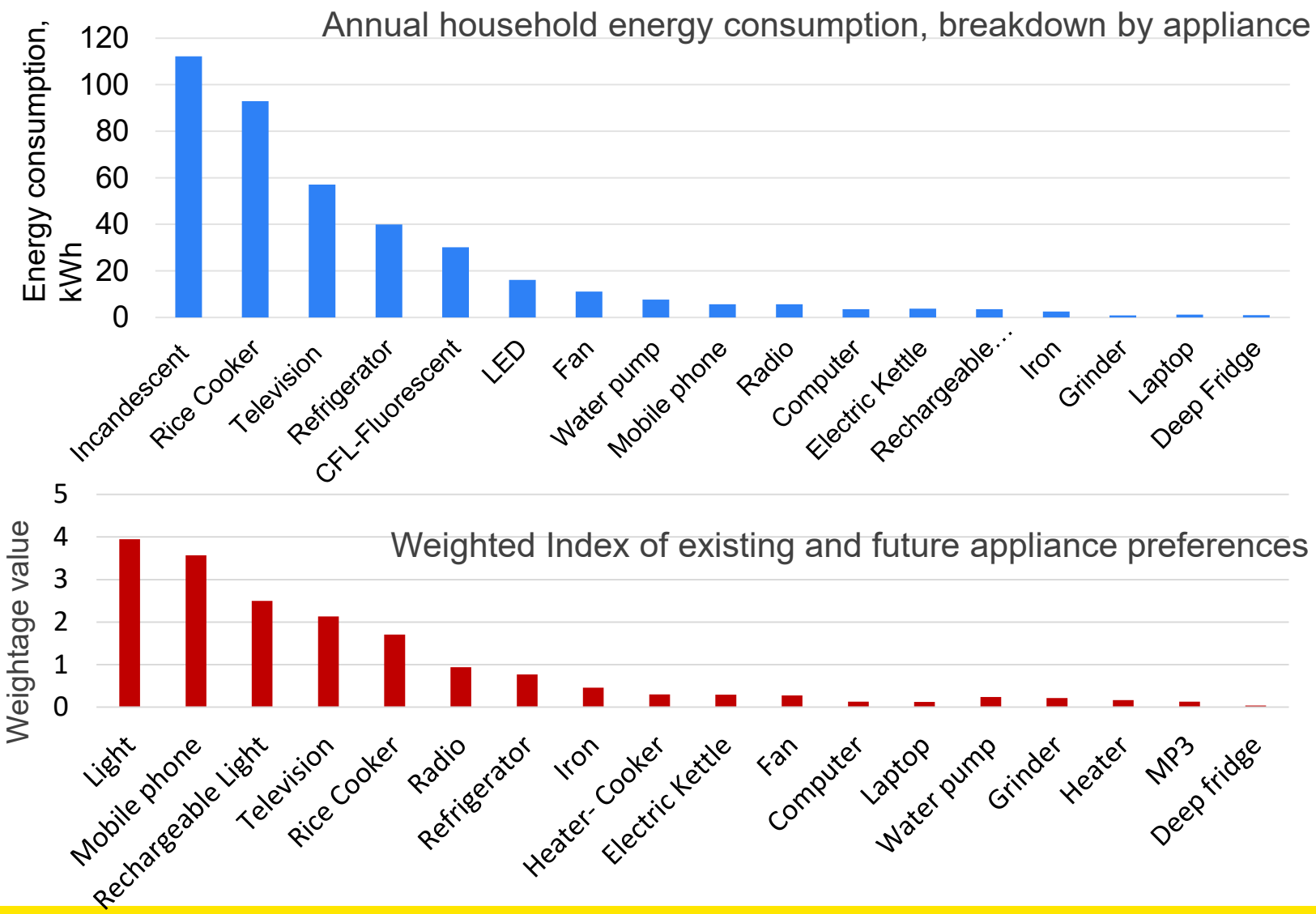
# Survey results:




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

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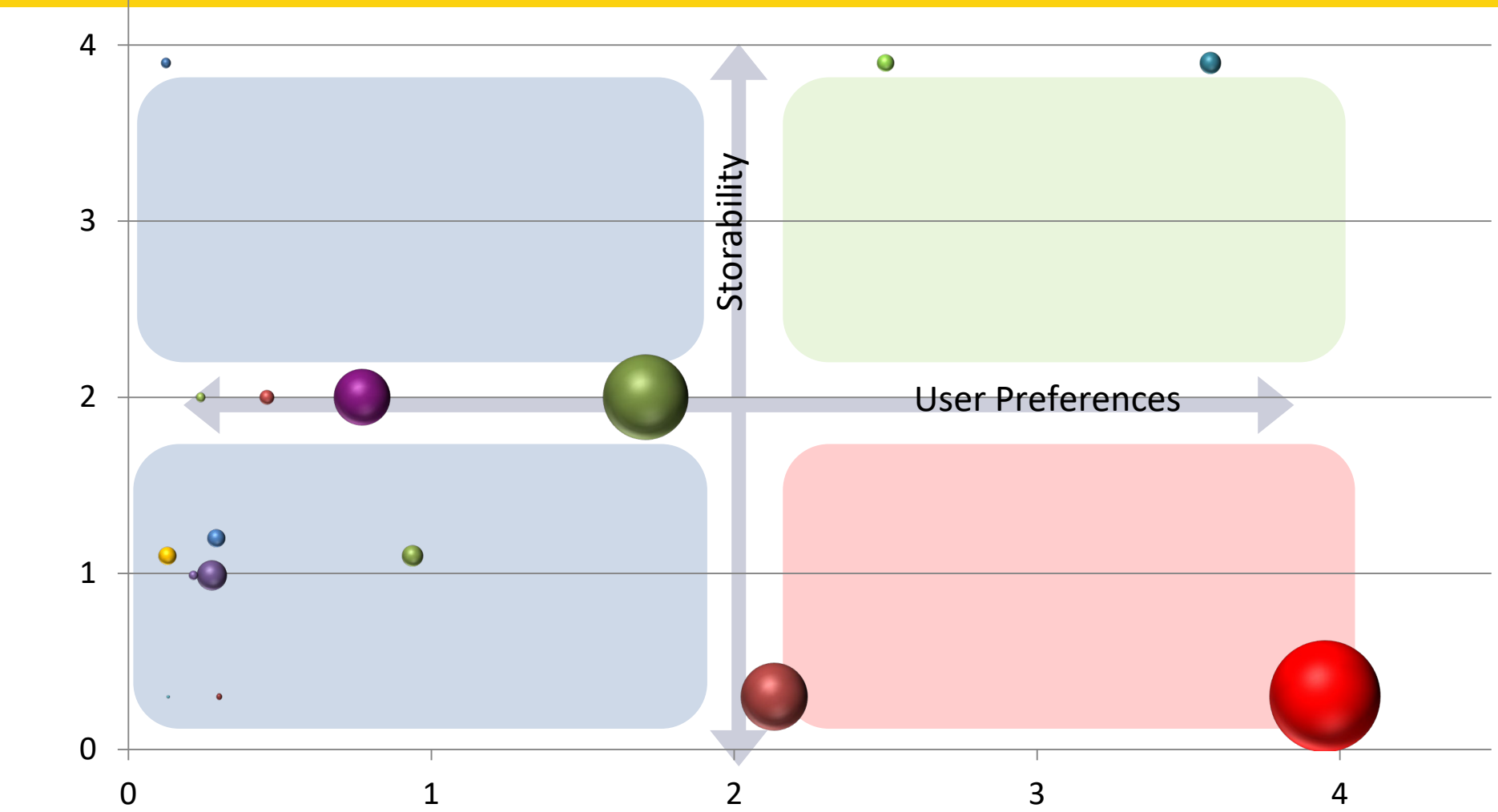
# Service Characterisation of Mini Hydro MG




- Light
- Rechargeable Light
- Heater-Cooker
- Rice Cooker
- Refrigerator
- Mobile phone
- Desktop Computer
- Laptop
- TV
- Radio
- Fan
- Electric Kettle
- Iron
- Water pump
- Grinder
- MP3
- VCR
- Printer

Area of bubbles represent the Energy Consumption

Source: Shakya B., Bruce A., Macgill I., *Survey Based Characterisation of Energy Services for Improved Design and Operation of Standalone Microgrids,* Renewable and Sustainable Energy Reviews, 2018

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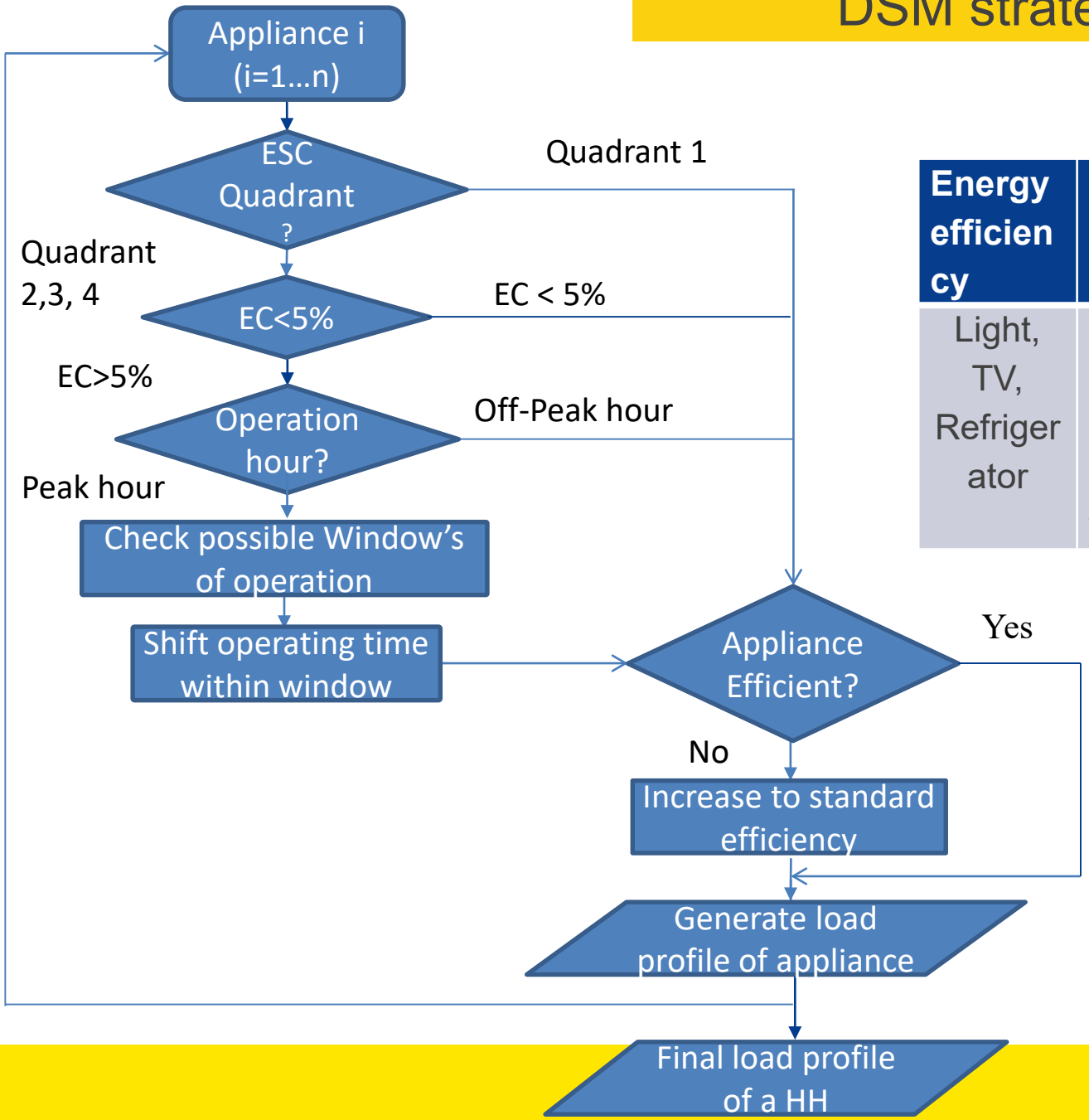
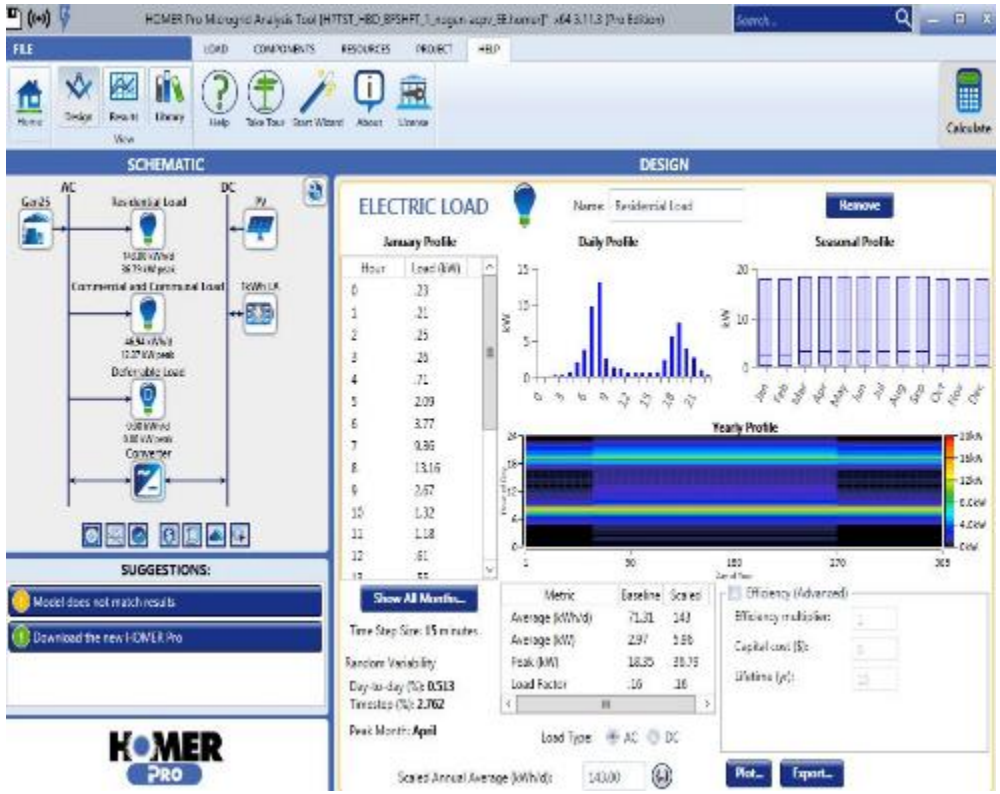
# DSM strategies




| Energy efficiency | Demand Management Possibilities |
|---|---|
| Light, TV, Refrigerator | **Rice cooker, refrigerator**, (mobile phone, iron, rechargeable light, water pump, laptop) |

Use "LoadProGen" and Manual calculation for infrequent load

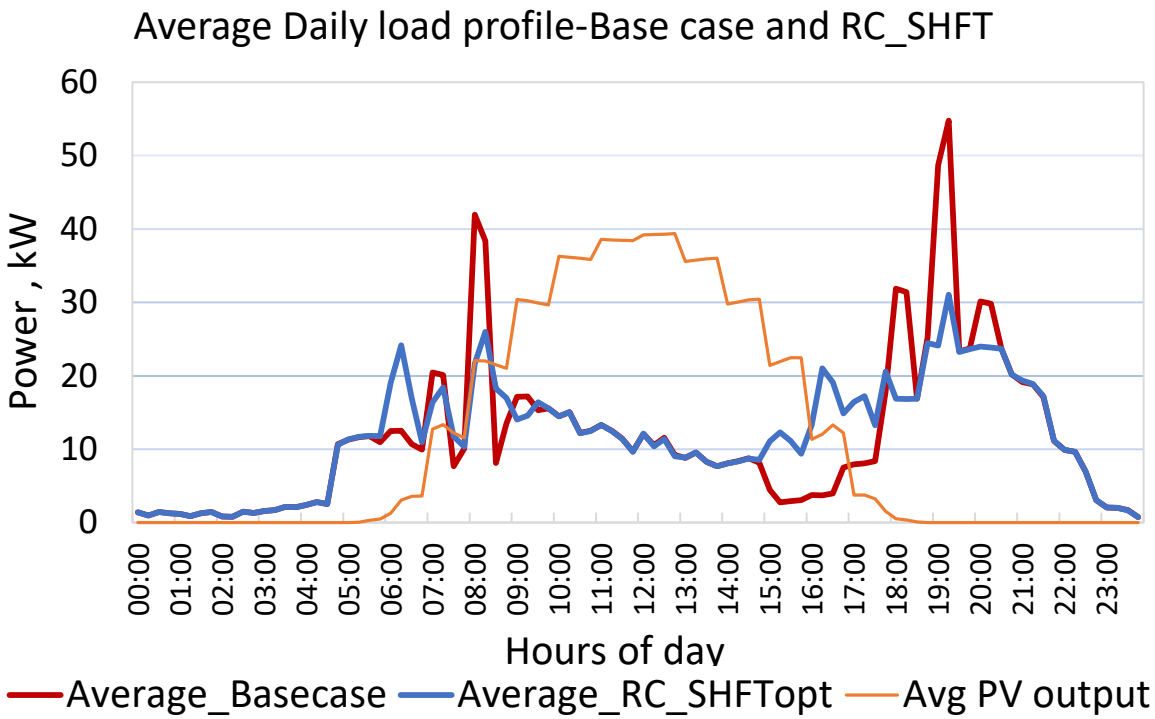
# HOMER Pro for optimisation of energy supplies




Scenarios:

1. Base case (survey data)
2. Rice cooker as a flexible load
    - Rice cooker capacity- 650 Watt
    - Operating time- 30 min ( full power consumption)-
    - Evening Rice cooker - shifted by 3 hours and morning by 1-2 hours
3. Application of Energy Efficiency measures: ( Light 7 W, TV- 40 W, Refrigerator-80 W)

# Result from HOMER Pro modelling: Rice cooker shifting




| | PV (kW) | Diesel Gen (kW) | Battery, kWh (LA) | Converter (kW) | Cost of Electricity Cent/ kWh | NPC ($) | RE fraction, % |
|---|---|---|---|---|---|---|---|
| **Base case** | 60 | 45 | 175 | 20 | 58 | 638,625 | 58 |
| **After Rice Cooker shifting** | 63 | 25 | 160 | 20 | 53 | 587,783 | 61 |

PV size + 3%, Diesel Gen size –44%, Battery size - 9%, Cost of Electricity–9%,

NPC -8% RE fraction +3%

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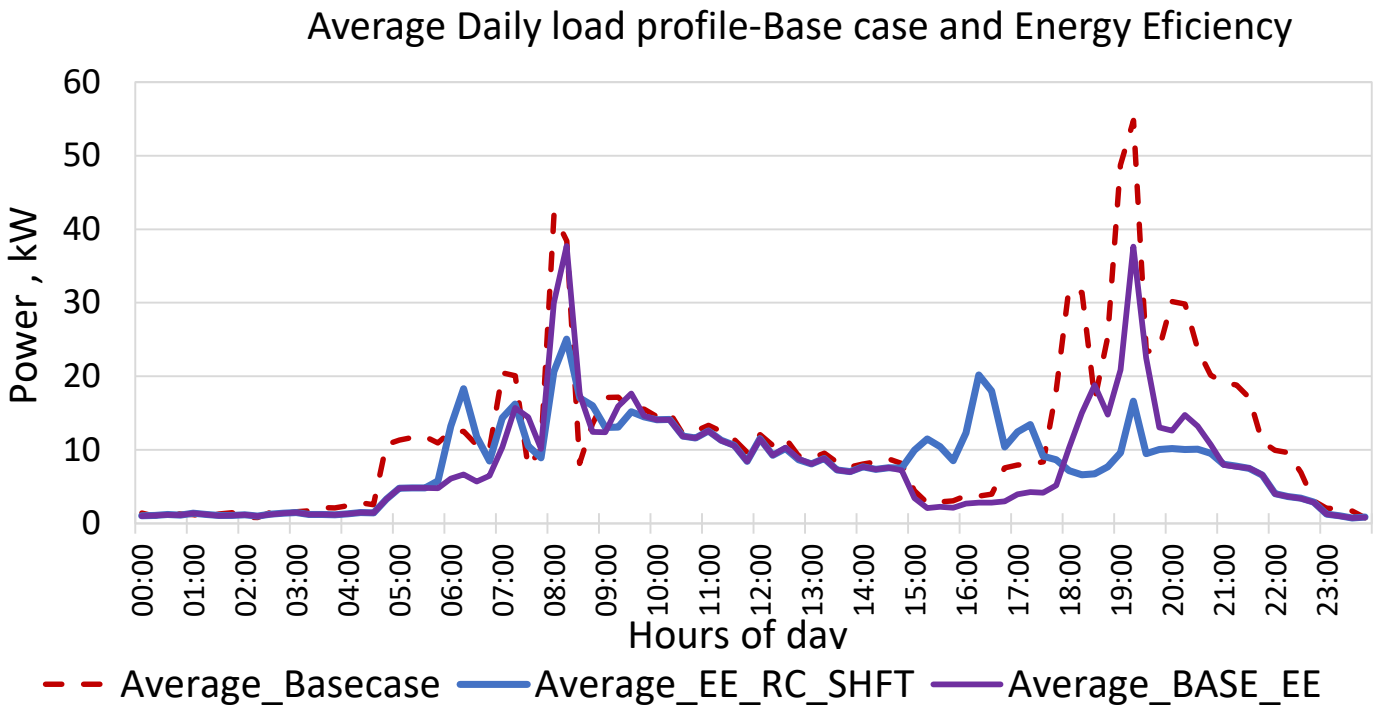
# Result from HOMER Pro modelling: Energy Efficiency




| | PV (kW) | Diesel Gen (kW) | Battery, kWh (LA) | Converter (kW) | Cost of Electricity Cent/ kWh | NPC ($) | RE fraction, % |
|---|---|---|---|---|---|---|---|
| **Base case** | 60 | 45 | 175 | 20 | 58 | 638,625 | 58 |
| **Energy Efficiency measure** | 50 | 30 | 160 | 20 | 56 | 422,325 | 74 |
| **EE_RC_Shift** | 53 | 20 | 170 | 20 | 52 | 403,275 | 82 |

PV size – 12%, Diesel Gen size – 56%, Battery size - 3%, Cost of Electricity–11%,

NPC -37%, REF 24%

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# Conclusion

- 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
- EE measure and load shifting has better impacts
- Financial incentives, awareness, metering and load control mechanisms are possible options for implementation of demand side management

# Thank you!

(Questions Please ?)