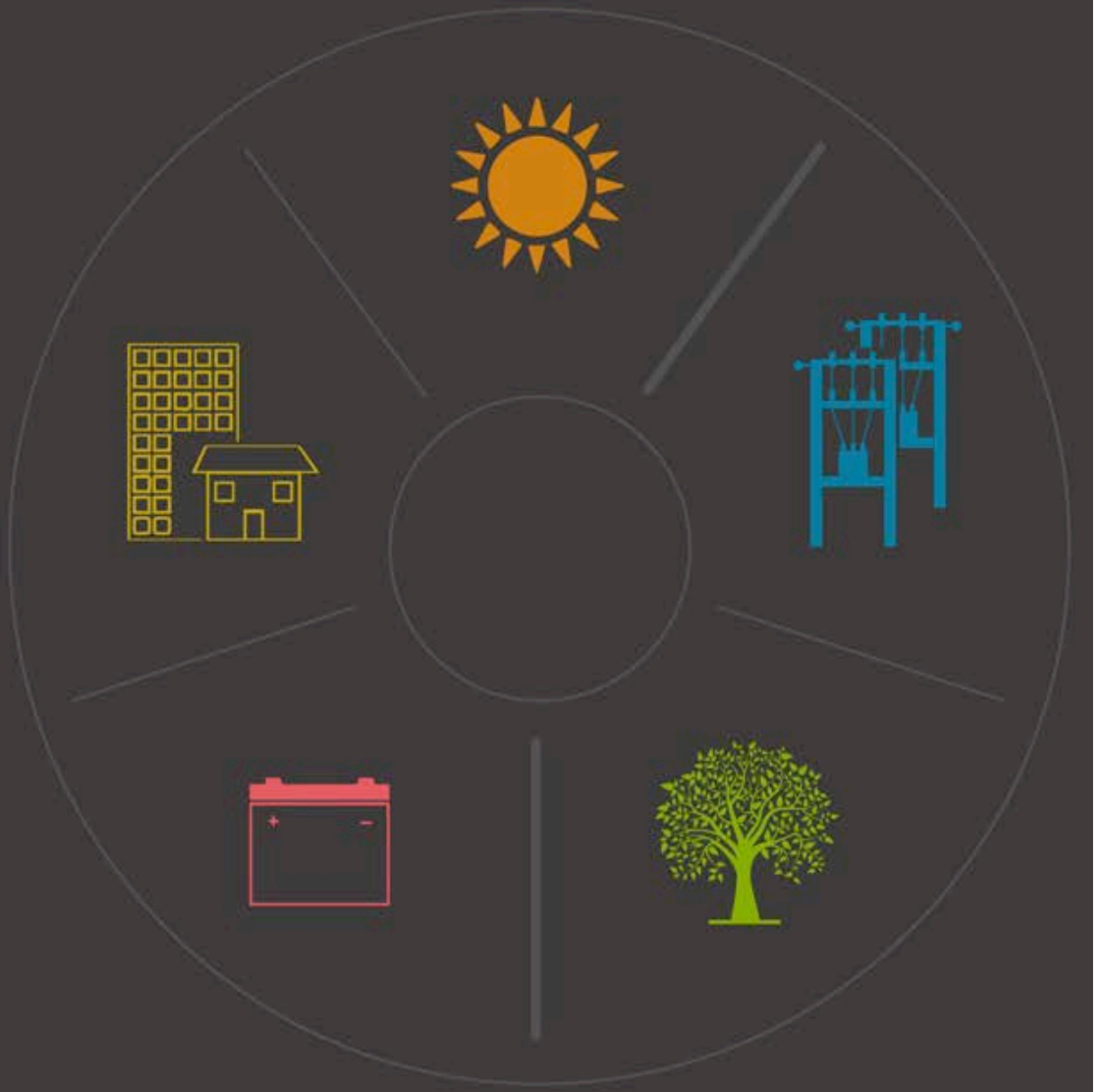
A study on Energy Sourcing and Storage

Auroville, India



Scope of the study:

- Analyse different energy system configurations in Auroville
- Study the viability for Lithium Ion batteries
- Analyse energy systems in a sample of Greenbelt Communities
- Estimate the cost of improving energy systems in the Greenbelt

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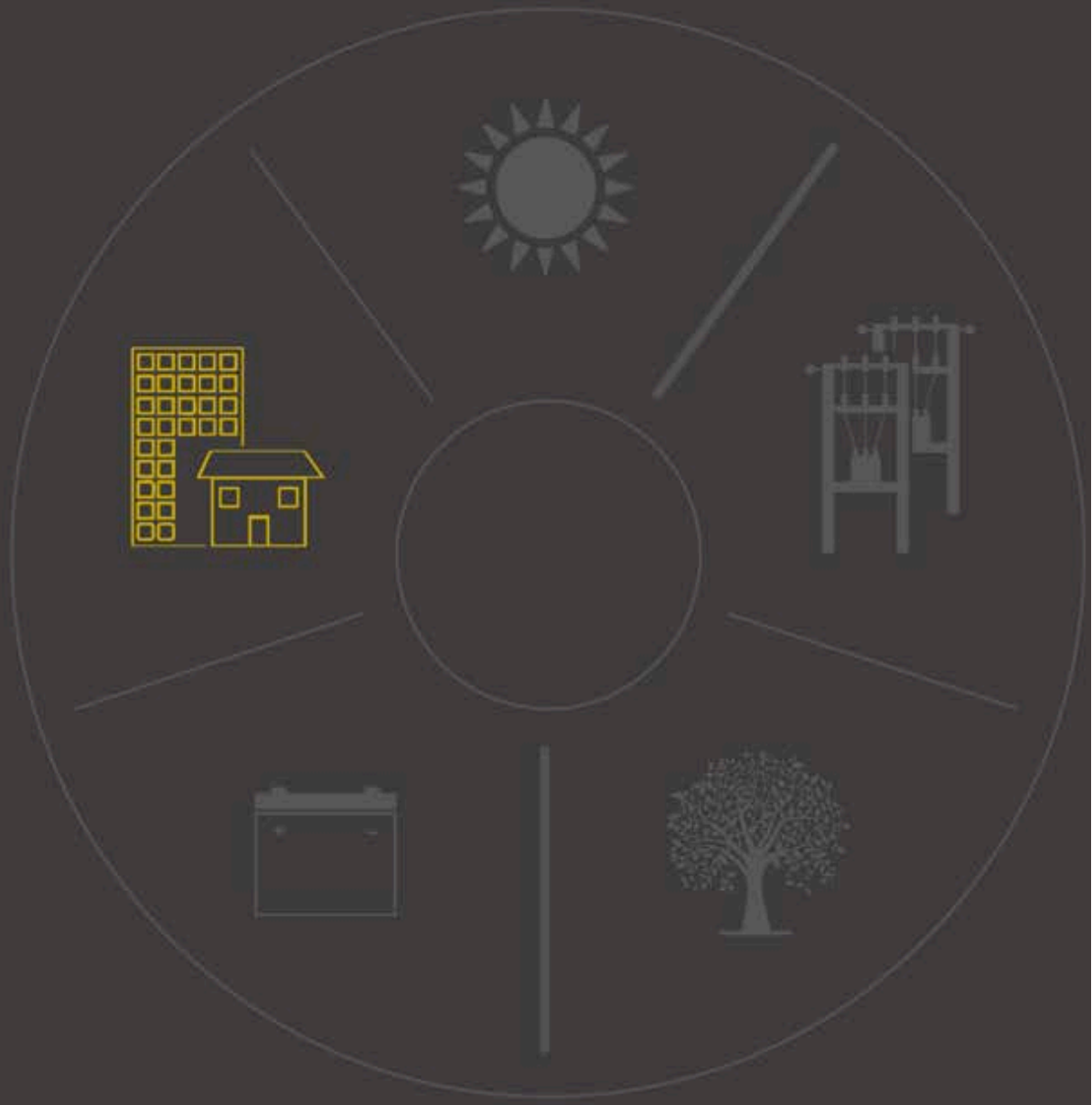
Cost-benefit analysis of different configurations of energy systems



Types of energy systems

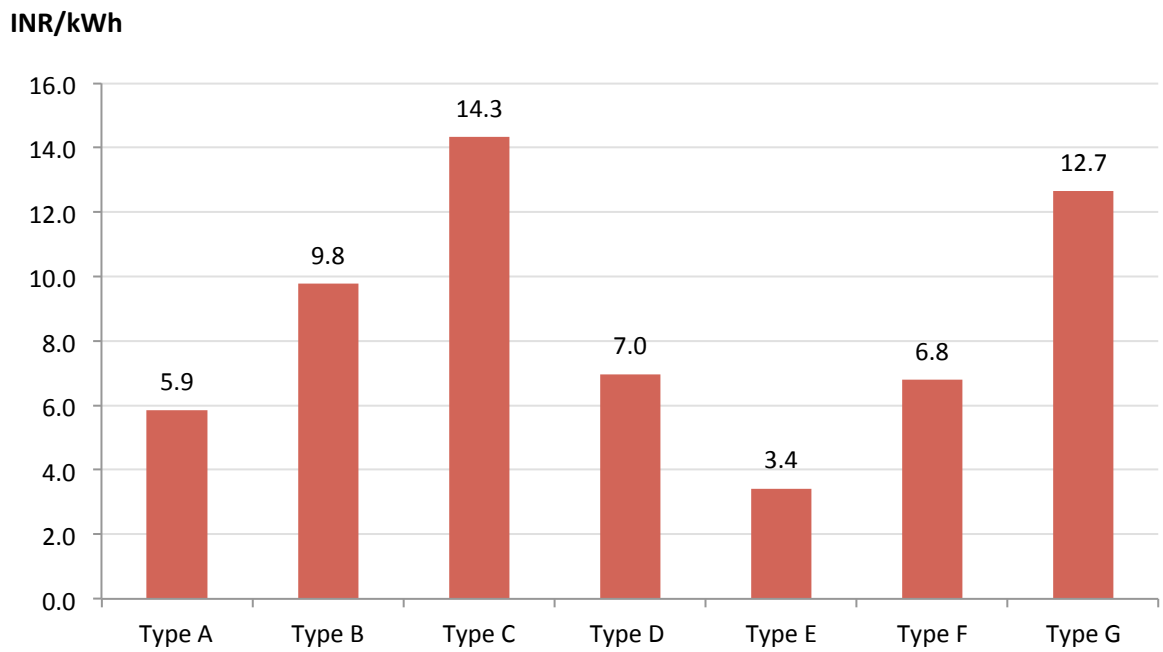
Type	Grid	Solar panels	Inverter	Batteries	Generator
A	✓		✓	✓	
B	✓ (primary)	✓ (backup)	✓	✓	
C		✓	✓	✓	
D	✓ (backup)	✓ (primary)	✓ (grid tied)	✓	
E	✓	✓	✓ (grid tied)		
F	✓	✓	✓ (grid tied)	✓	
G	✓	✓	✓ (grid tied)	✓	✓

Technical parameters – Our findings

	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Domestic load profile							
Efficiency of the system (%)	75	69	57	46	84	82	83
Downtime (min/week)	0	0	791	0	284	0	0
Office load profile							
Efficiency of the system (%)	79	88	87	89	91	91	91
Downtime (min/week)	0	0	0	0	154	0	0

- Efficiency of batteries = 70 to 80%
- Efficiency of inverter (DC to AC conversion) = 75 to 90%
- Efficiency of inverter (AC to DC conversion) = 70 to 90%

Economic parameters – Our findings



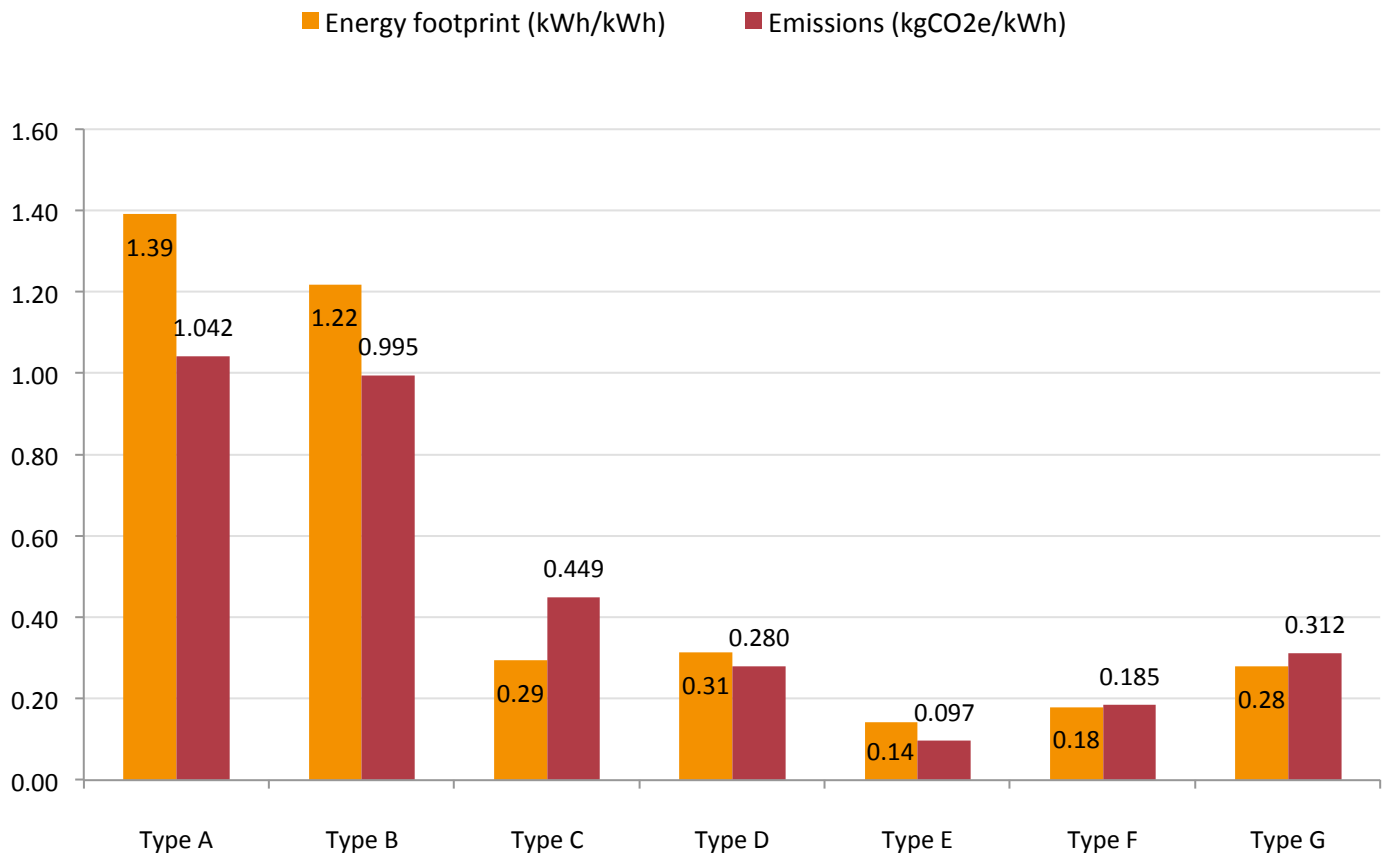
Cost per kWh delivered by the system

Social parameters – Our findings

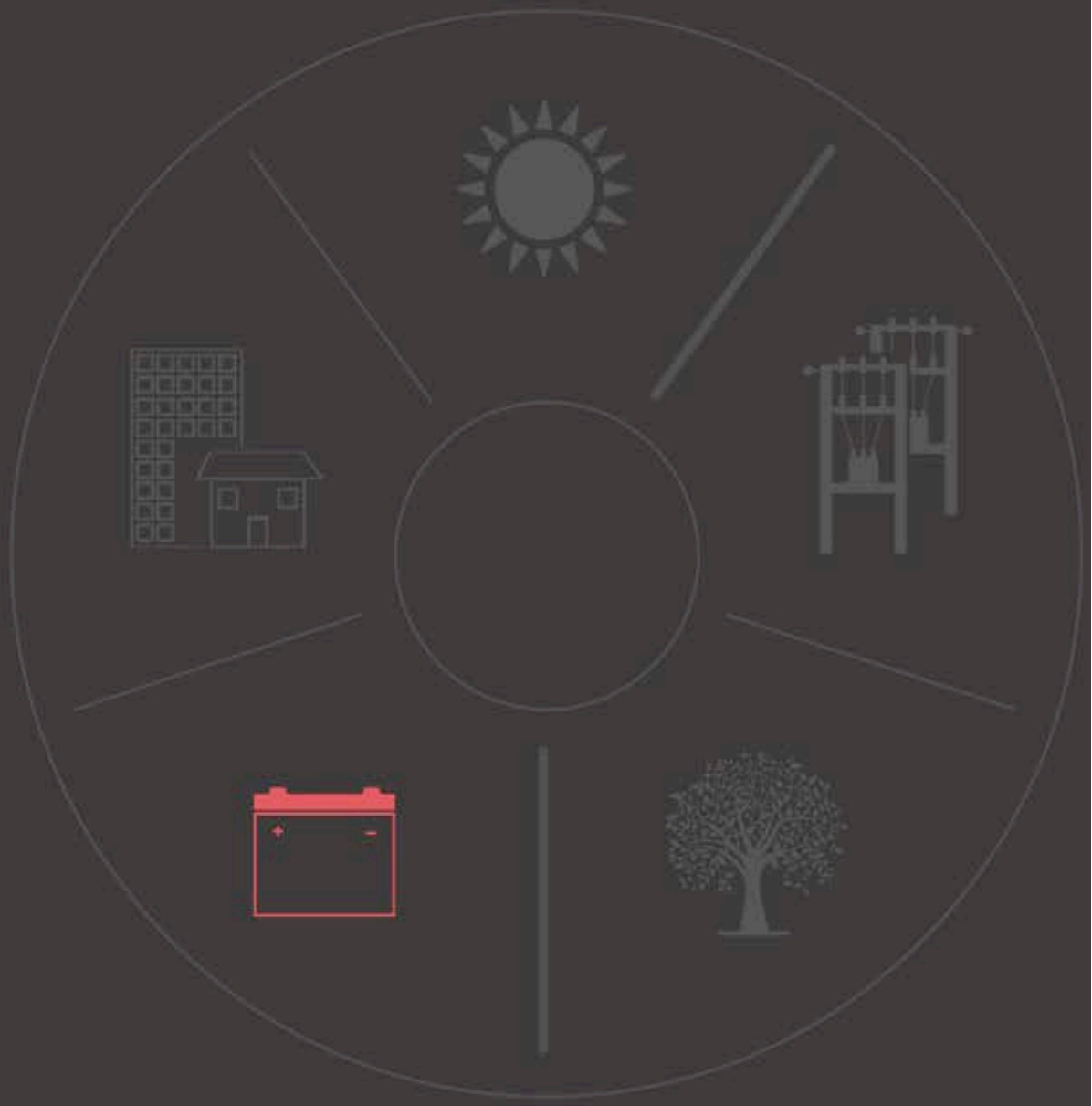
System type / Ranking	*Type A*	*Type B*	*Type C*	*Type D*	*Type E*	*Type F*	*Type G*
Lifestyle	*1*	*2*	*3*	*4*	*2*	*1*	*5*
Acceptability	*5*	*4*	*3*	*5*	*3*	*2*	*1*
Level of comfort	*5*	*3*	*4*	*3*	*5*	*1*	*2*
Energy security	*1*	*2*	*2*	*1*	*3*	*1*	*1*
Economics	*3*	*4*	*4*	*2*	*1*	*4*	*4*
Final ranking	*4*	*4*	*5*	*4*	*3*	*1*	*2*

Legend: 1 is most optimum, 5 is least optimum

Environmental parameters – Our findings



A comparison of two battery chemistries



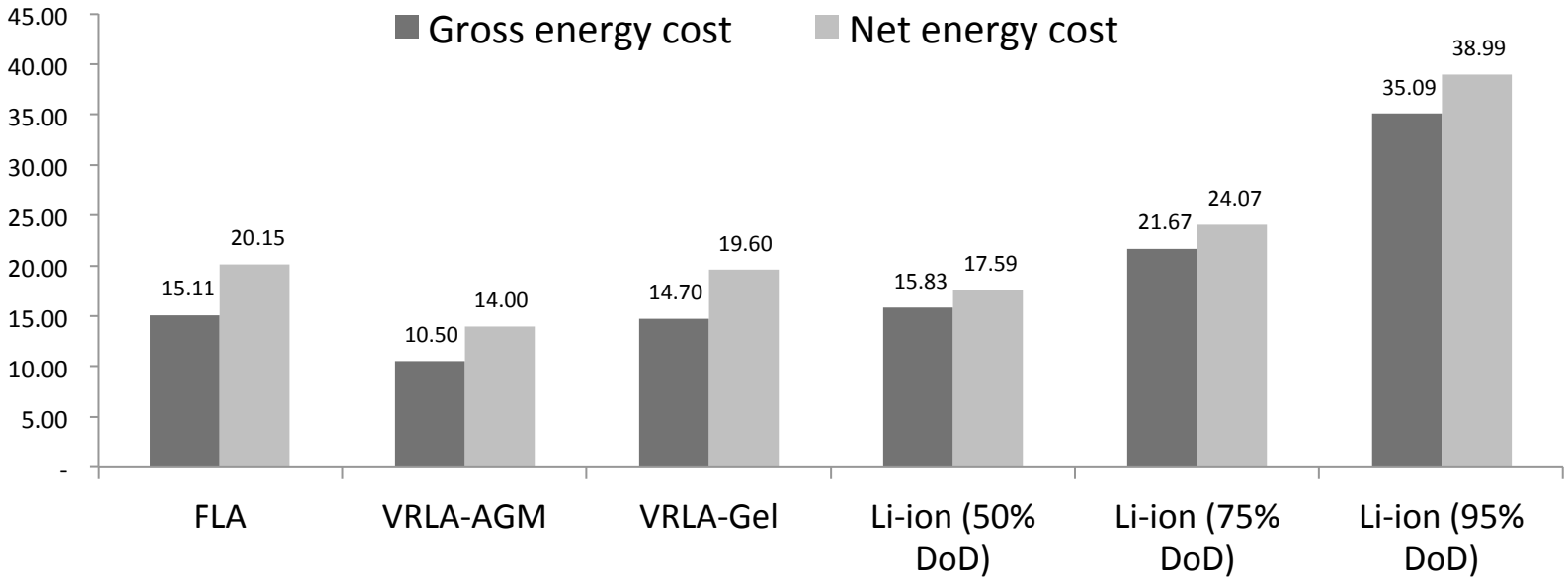
Batteries selected for comparison:

- Flooded Lead Acid batteries (“FLA”)
- Sealed Lead Acid or Valve-Regulated batteries (“VRLA”)
- Lithium-ion batteries (“Li-ion”)

Technical parameters of Batteries

	FLA	VRLA	Li-ion
Weight of a 100Ah, 12V battery	23 kg	31 kg	14 kg
Gas emission	Oxygen & hydrogen	Gases are recombined & vented	No gas emission
Expected no. of cycles	1200 cycles @ 50% DoD	2000 cycles @ 50% DoD	3000-5000 cycles @ 80% DoD
Advised maximum discharge rate	C/20	C/5	C
Efficiency	72.90% (measured)	76.20% (measured)	>90%

Economic parameters – Our findings



Cost per kWh delivered by the battery

Social parameters

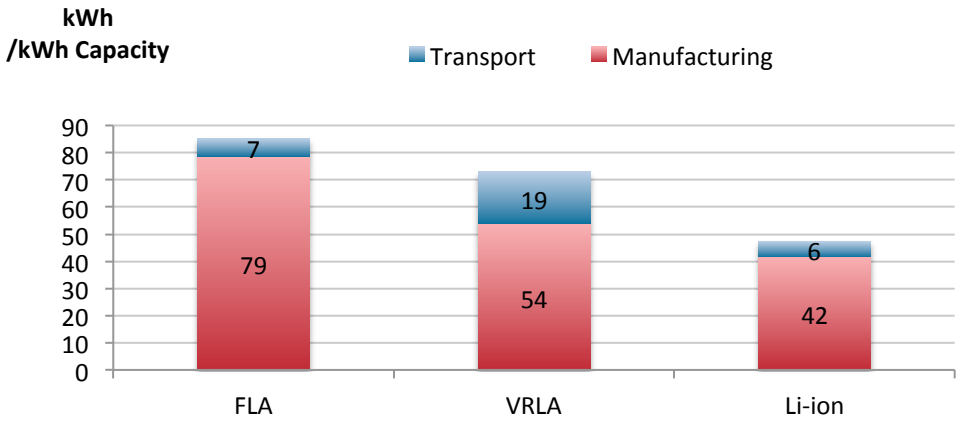
Parameter	FLA	VRLA	Li-ion
Max depth of discharge	50%	50%	Flexible
Minimum state of charge	80%	80%	Can be operated at shallow charge
Storage while not in use	High self-discharge, performance affected	High self-discharge, performance affected	Low self-discharge; performance not affected
Type of storage room	Ventilated room	Shaded space	Not applicable
Routine maintenance	Distilled water	None	None
Full top up charge	Monthly	Monthly	6 months

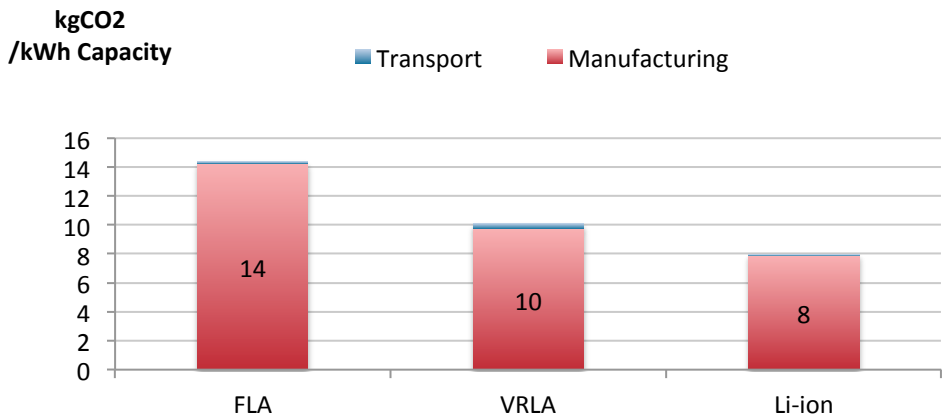
Environmental parameters – Our findings

On recycling:

- Industry dominated by small-scale and backyard recyclers
- Lead acid batteries broken down without following any regulation
- Prices of shipping batteries back to manufacturer is very high
- No recycling facilities for Li-ion yet in India
- Storage of Li-ion is not toxic, unlike lead acid batteries

Environmental parameters – Our findings





Our Recommendations

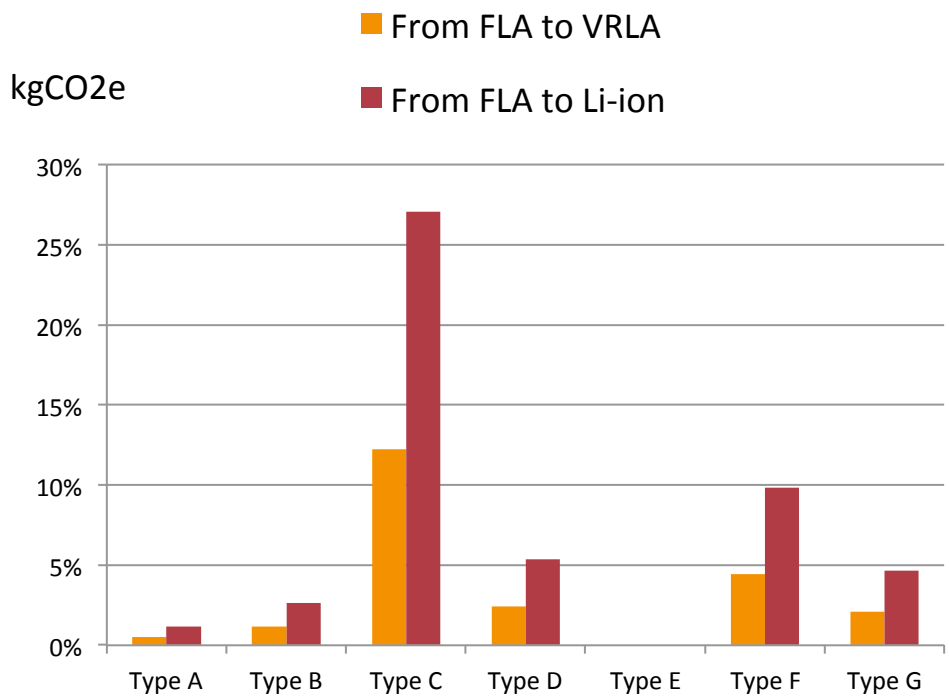
- Replace FLA batteries with VRLA batteries when they die out

- Whenever possible, connect the system to the grid to enable under sizing and maximise the use of each system

- Install a pilot centralized system of storage with Li-ion batteries

Our Recommendations

Annual gains of battery conversion for all system types, as calculated by us:



Auroville Consulting

Evaluating Solar Photovoltaic Systems in the Greenbelt

Assessment

Technical parameters, our findings:

- 16% of the solar panels are not cleaned regularly
- 46% of the panels do not have easy access for cleaning
- 40% of the installations have dust and dirt on the panels
- 20% of the installations have natural or man-made shade on the panels
- 90% of the installations use FLA batteries (inefficient, short life, toxic)

Economic parameters, our findings:

- Current value of systems in the sample communities is Rs. 32 lakhs
- Battery is the most expansive component, 70% of total cost
- Net investment for replacing all the systems estimated to 22 lakhs

Assessment

Social parameters, our findings:

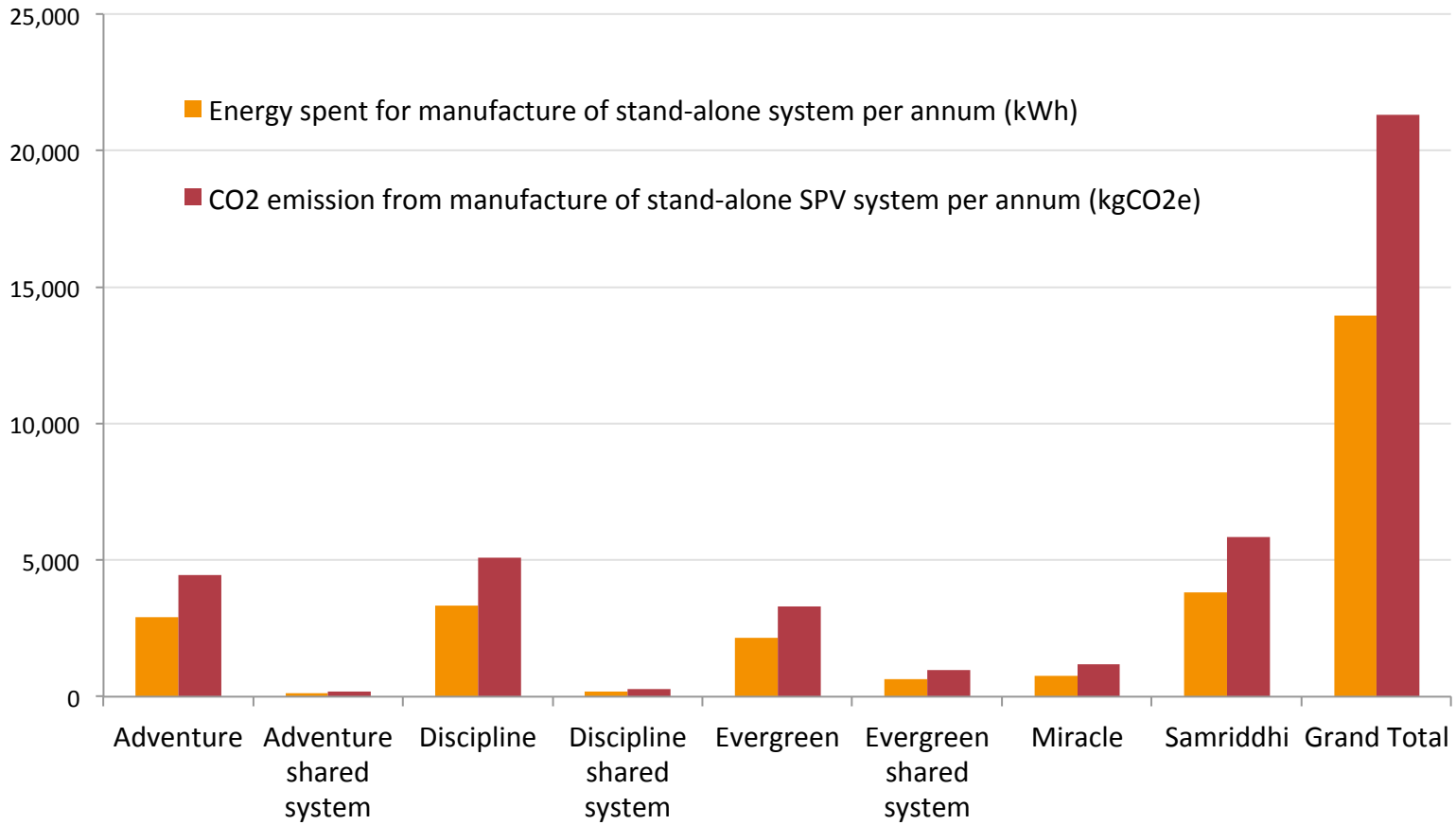
- Regarding system sufficiency:
    - System is not fulfilling energy needs for 12 residents (55%)
    - Suspected causes: lack of cleaning of the panels, incorrect angle, insufficient battery maintenance
- Regarding connecting to the grid:
    - 7 residents (32%) are against
    - 8 residents (36%) undecided
    - 7 residents (32%) favourable
- Regarding centralized system:
    - 6 residents (27%) are against a centralized system
    - 6 residents undecided
    - 10 residents in favour

Additional observations:

- No monitoring system
- No correlation between size of the system and no. of users
- Lack of security

Assessment

Environmental parameters, our findings:

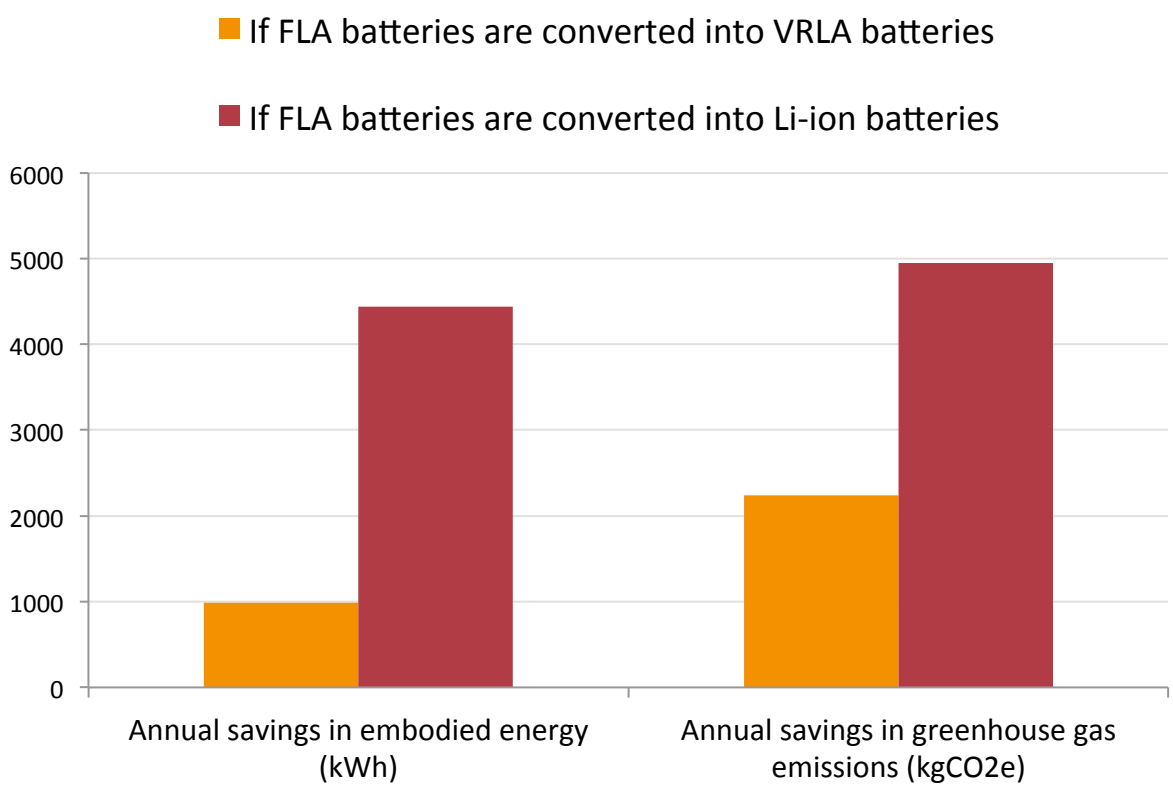


Our recommendations for the GreenBelt

- Install a monitoring system for each installation
- Sponsor maintenance of systems
- Strengthen Solar Fund
- Replace the FLA batteries
- Expand size of the system (if mandatory)
- Convert to grid-interactive system
- Centralized system of sourcing and storage at a community scale

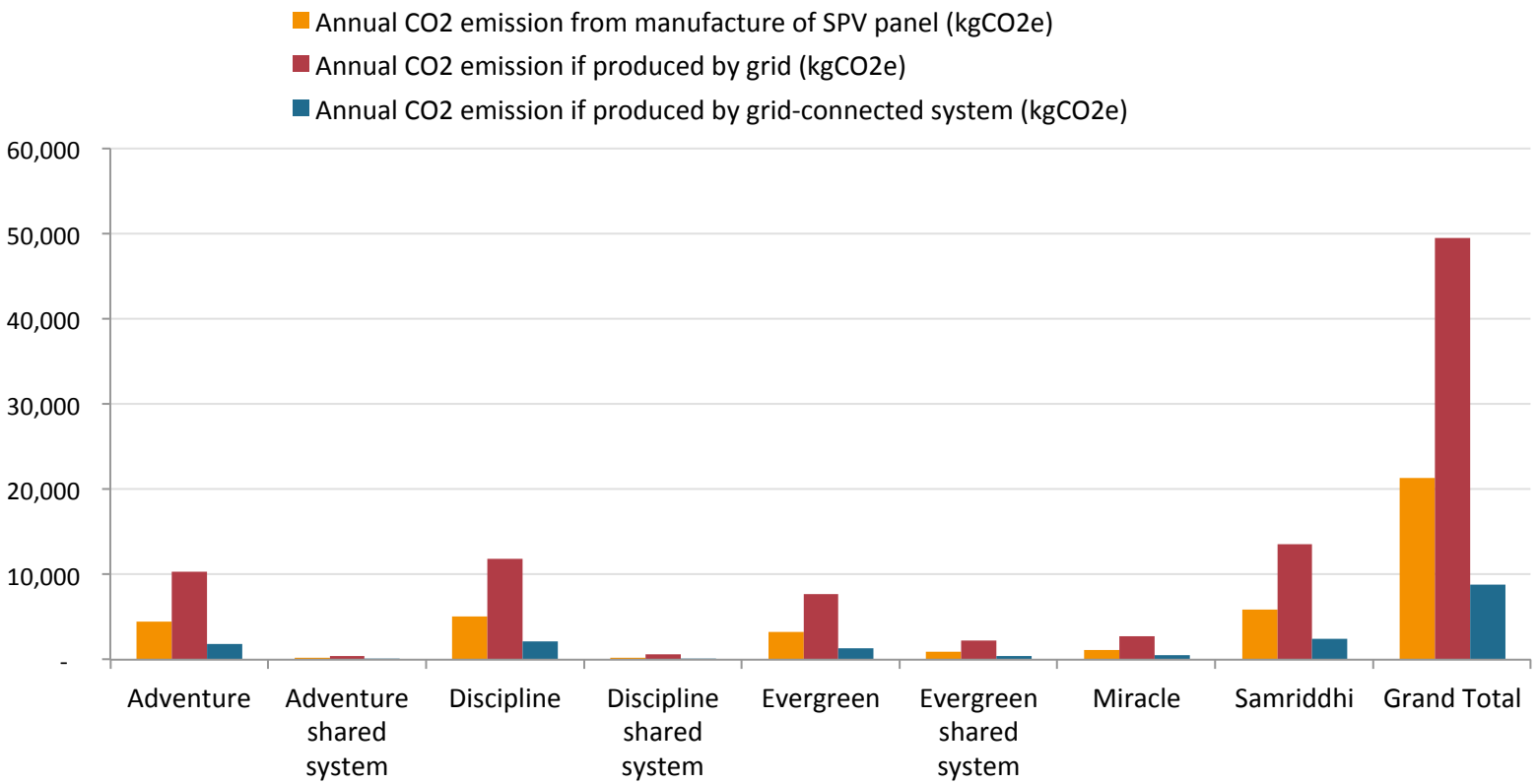
Our recommendations

Annual savings due to battery conversion in stand-alone systems

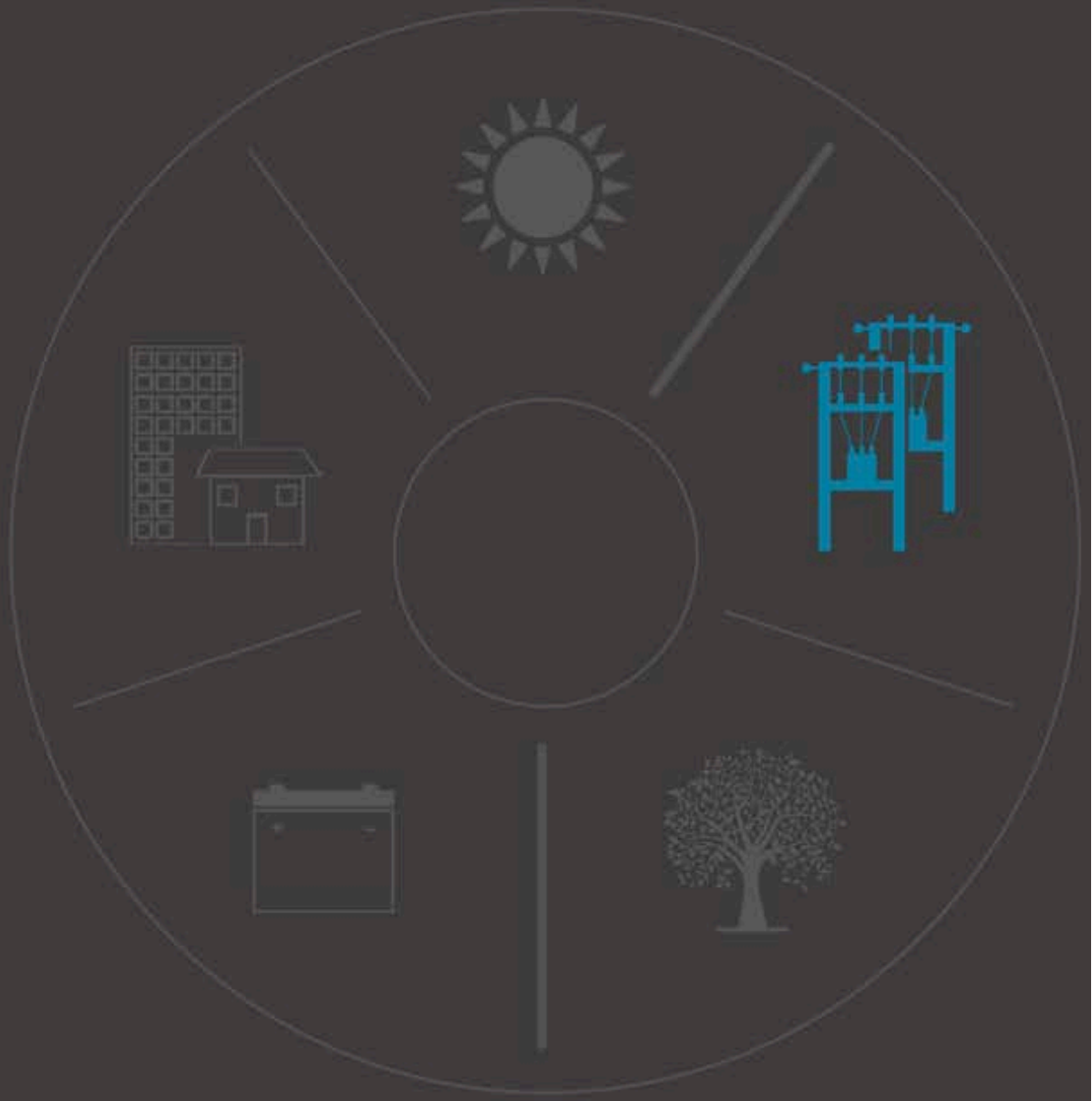


Our recommendations

Gains of conversion to grid-connected systems



Costing of interventions



Cost estimation for Greenbelt

Cabling: Rs. 40 lakhs (aerial) or Rs. 37 lakhs (underground)

Connecting to the grid: Rs. 1.7 crores (for 130 installations in the Greenbelt)

Replace all the batteries with VRLA: Rs. 88 lakhs

Install VRLA, audit each building, install monitoring systems: Rs. 1.15 crores

Create a pilot community with centralized storage (with Li-ion): Rs. 57 lakhs

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