Potentials of Self-powered Residential Communities to Achieve net zero Emission, Modeled case from Oman

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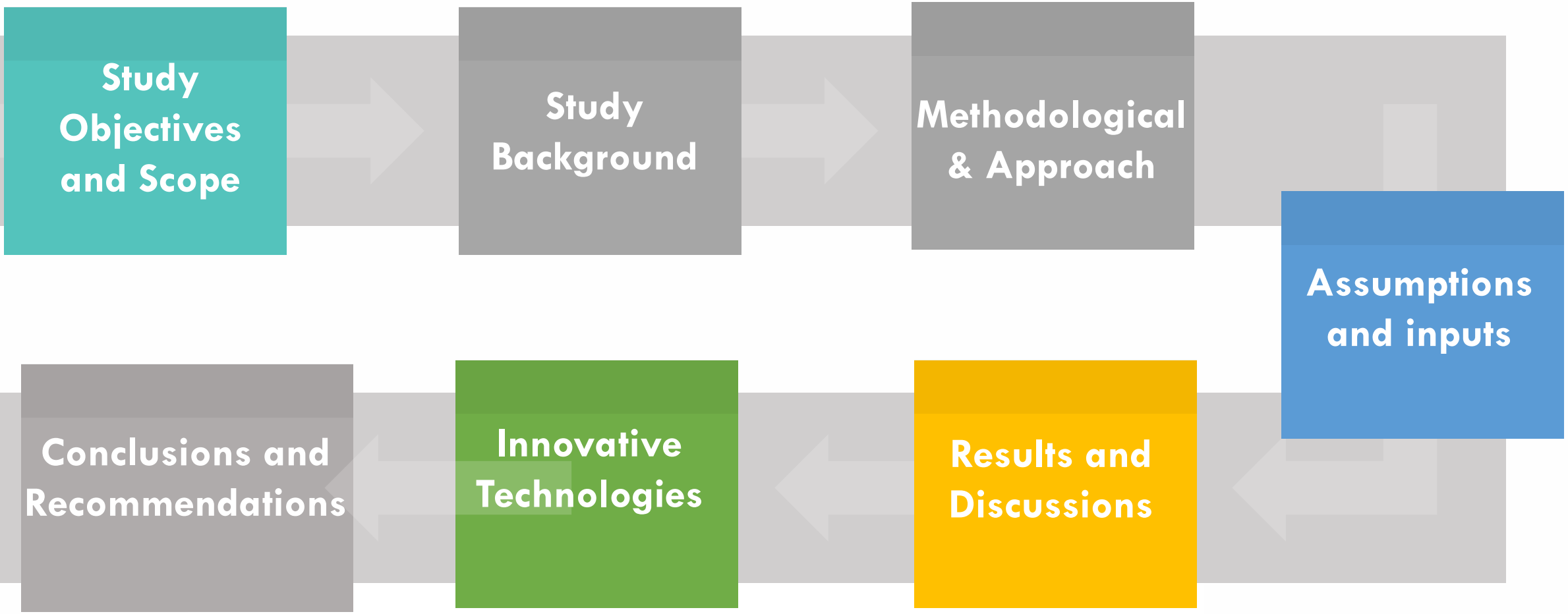
Outline


Study Objectives and Scope
Study Background
Methodological & Approach
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Results and Discussions
Innovative Technologies
Conclusions and Recommendations

Study Objectives and Scope

Objective

Develop a self-powered building under **the hot climatic** conditions as in Oman. The study will mainly focus on the areas of self-power generation systems in the residential buildings and to assess their impact on the development of the buildings self-powered using modelling approach.

Scope

- Identify the electrical consumption of the residential building
- Compare typical Oman villas/house with the international benchmarking
- Propose methods to reduce electricity
- Propose maximum solar system capacities (PV, BIPV, solar heater, solar light)
- Predict the annual consumption and verify solar PV to match the annual power consumption.

Study Background

KUWAIT: 2030: **15%** | **2060**

SAUDI ARABIA: 2030: **50%** | **2060**

BAHRAIN: 2025: **5%** | **2050**

QATAR: 2030: **200-500 MW** | **2050**

EMIRATES: 2050: **44%** | **2050**

OMAN: 2030: **20%**, 2040: **35-39%** | **2050**

Renewable Energy Targets

Net Zero Emission

Figure. Target for RE and NZE in GCC.

The Sultanate of Oman's National Strategy for an Orderly Transition to Net Zero, Nov 2022

Study Background

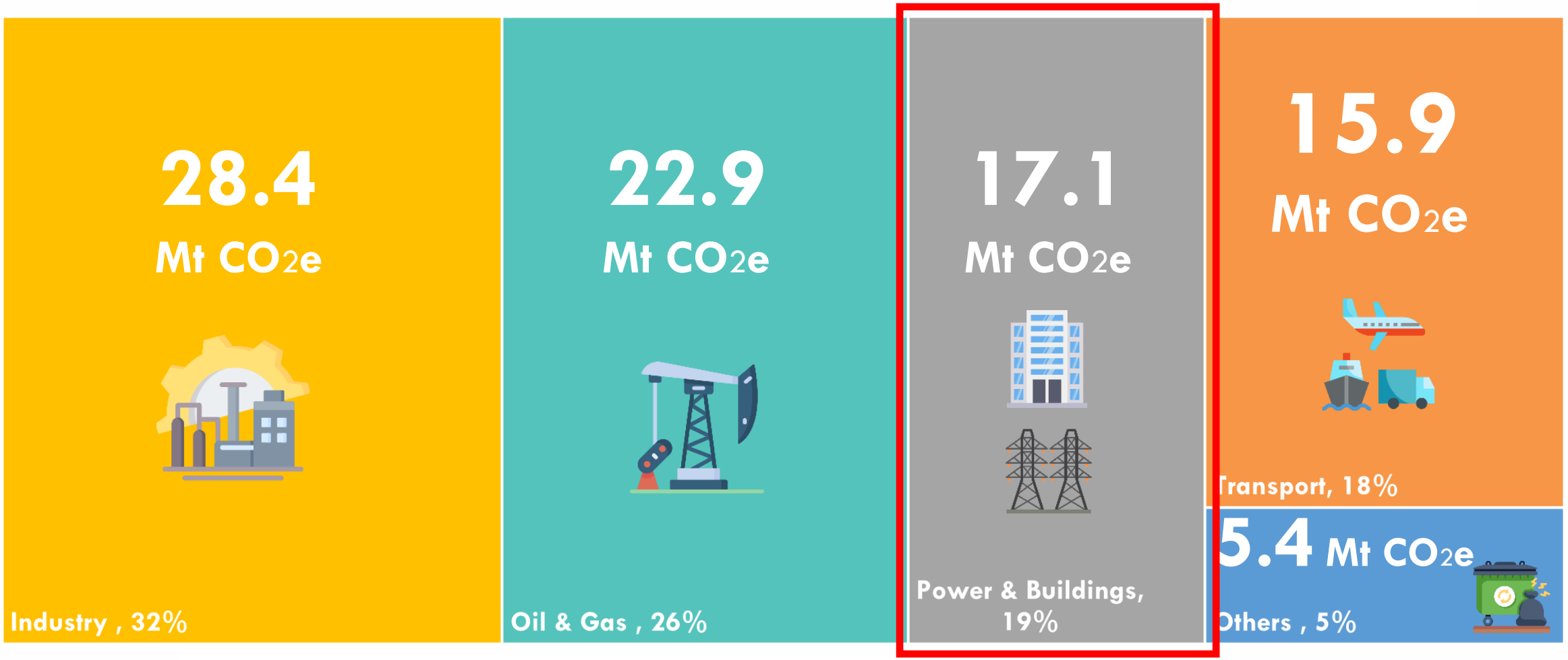


Figure. Oman's net carbon emissions.

The Sultanate of Oman's National Strategy for an Orderly Transition to Net Zero, Nov 2022

Study Background

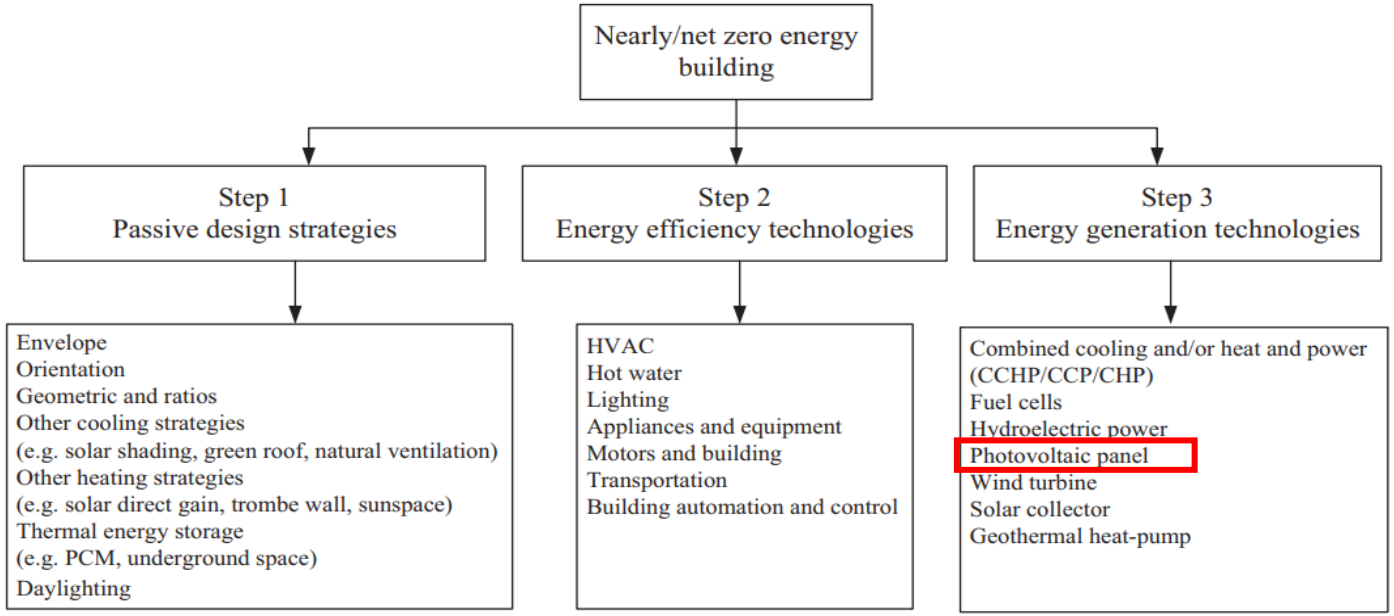
The building sector has no direct emissions as it is fully electrified.

The sector consumes **80%** of power demand (2021)

= CO_2 indirectly accounts for ~**13.5 Mt CO_{2e}**

= **15%** of total Oman emissions

- Approaches to self powered existing buildings:



*The Sultanate of Oman's National Strategy for an Orderly Transition to Net Zero, Nov 2022

*Design optimization and optimal control of grid-connected and standalone nearly/net zero energy buildings

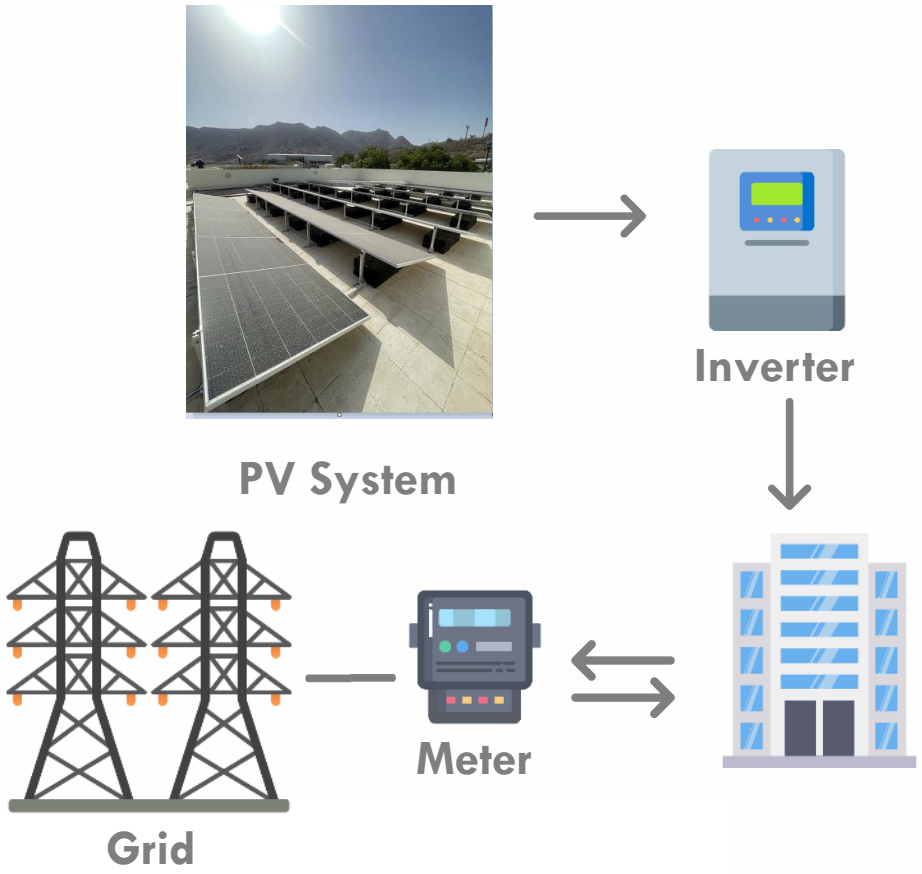
Study Background

- Current Electricity generation from PV:

Limitations:

- Installed capacity
- No batteries
- No Cash payments.

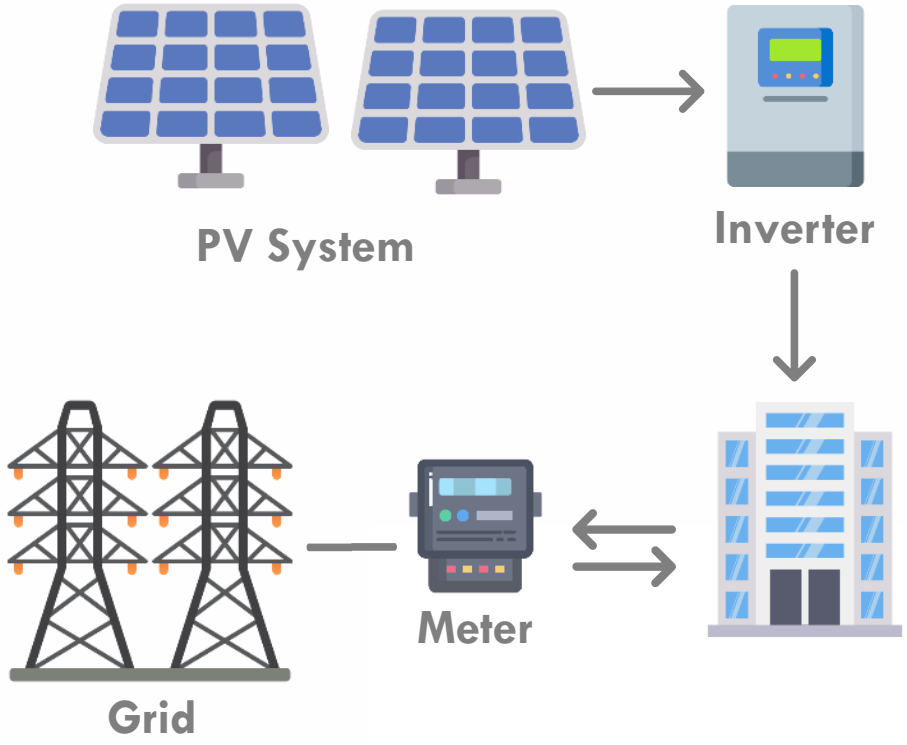
Ensuring grid stability/safety and maintain conventional generation systems to the acceptable utilization (day/night and summer/ winter).



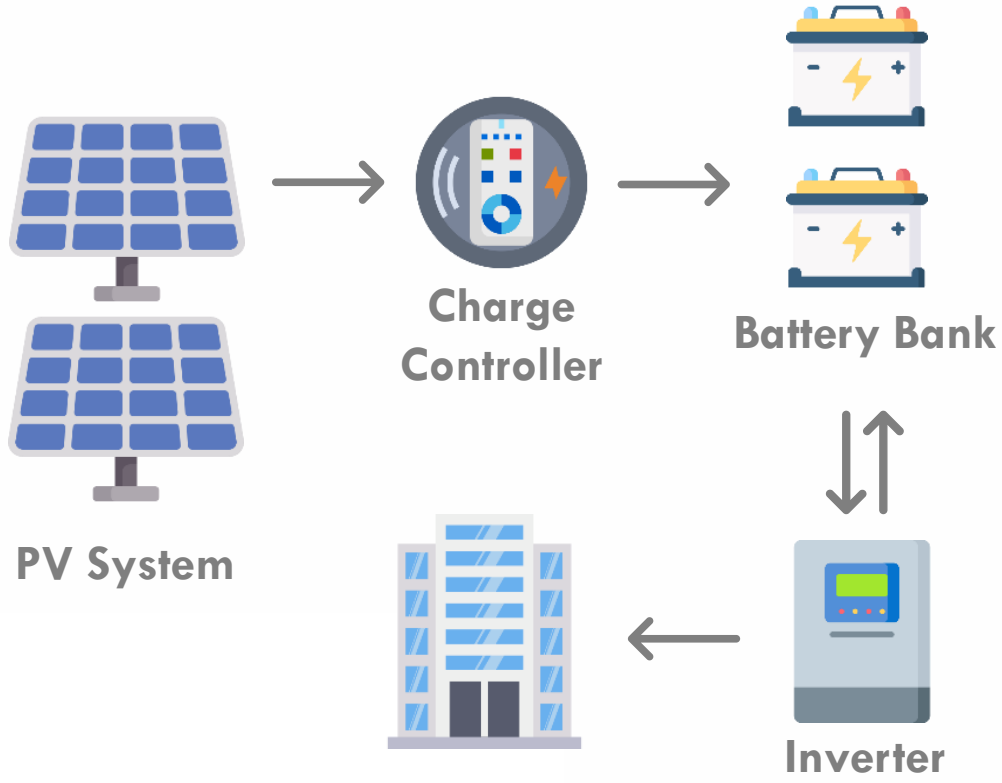
Study Background

- Concepts of self powered buildings:

Zero net metering



Self generation

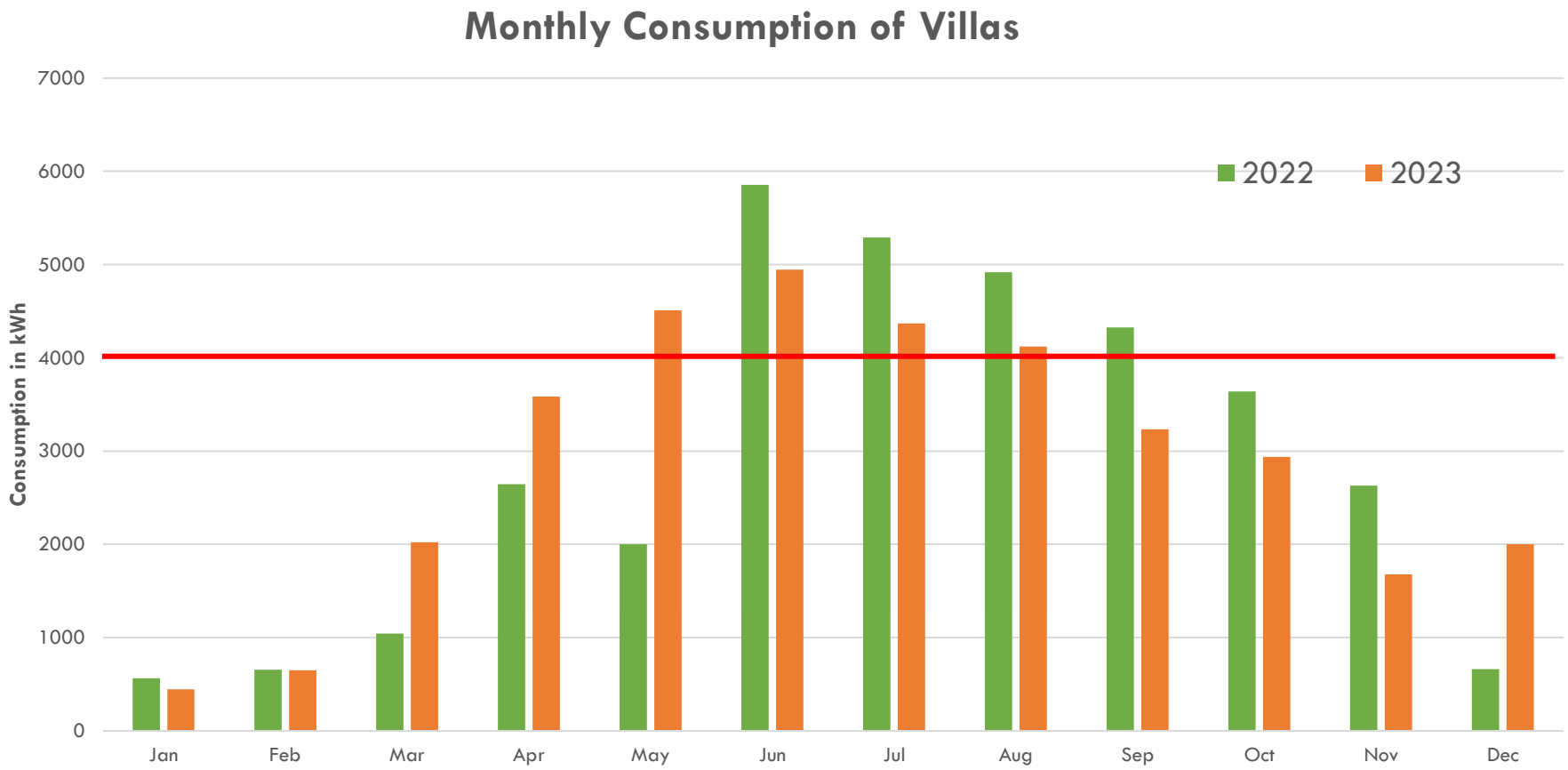


Study Background

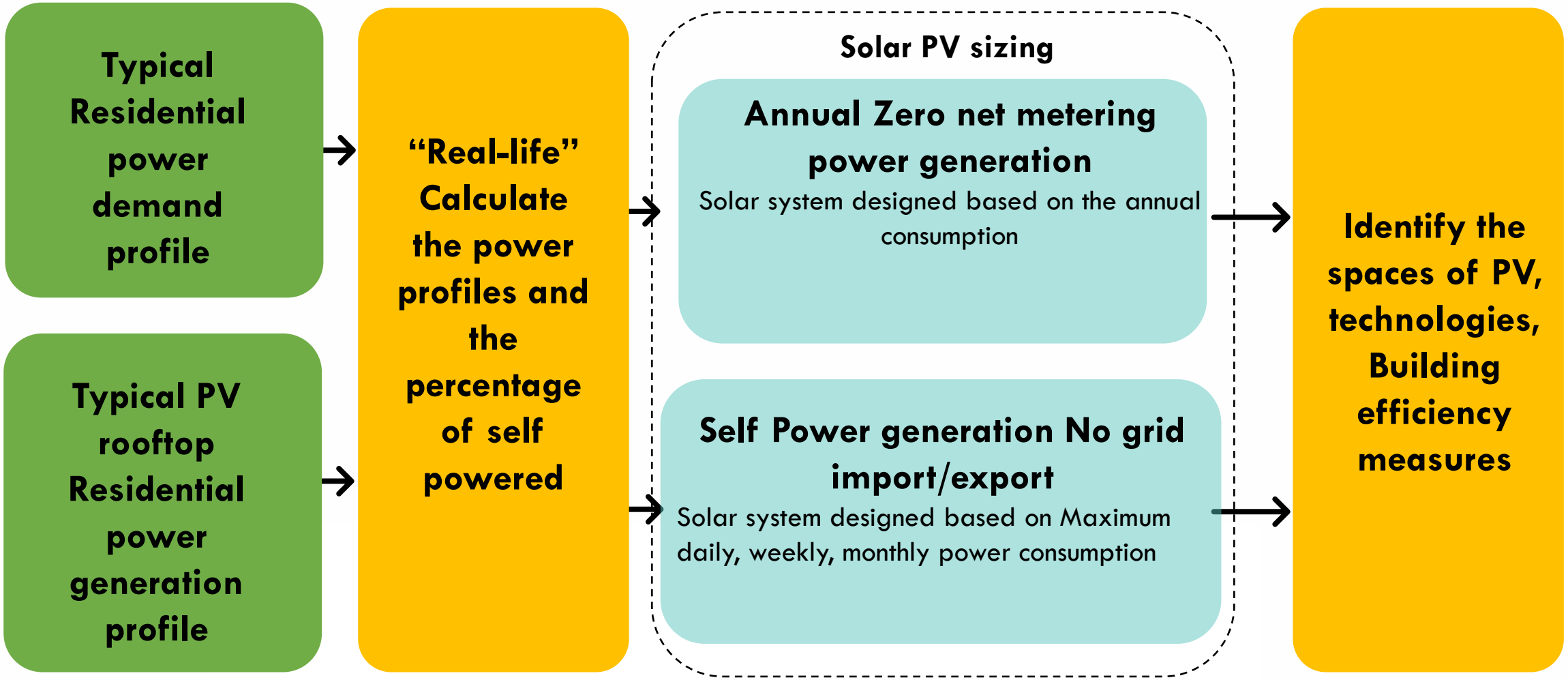
- Typical Residential villa power demand profiles

Variations:

- Day/night
- Summer/Winter

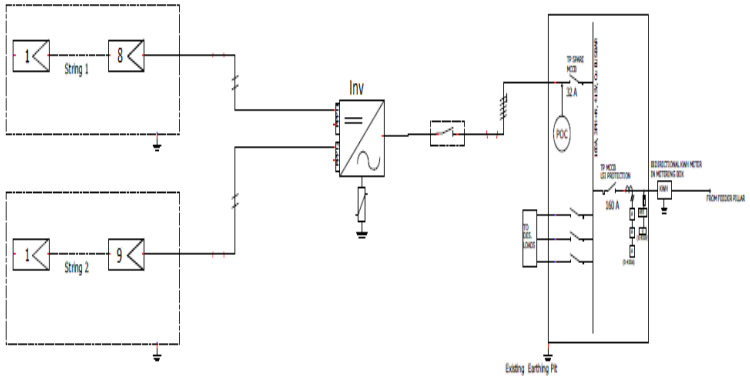


Methodological & Approach



Assumptions and inputs

Base Case inputs

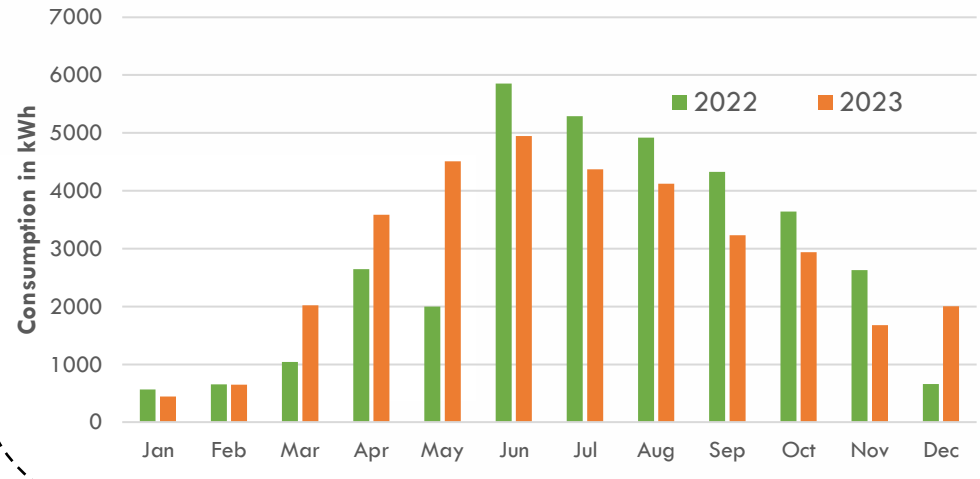


Assumed PV module wattage (W)	660
Module dimensions (w × h)	1.303 × 2.384
Average solar PV capacity in Omani house (kWp)	11.16

	2022	**2023**
Energy generated per interval (normalized) kWh/kWp	1499.39	1444.34

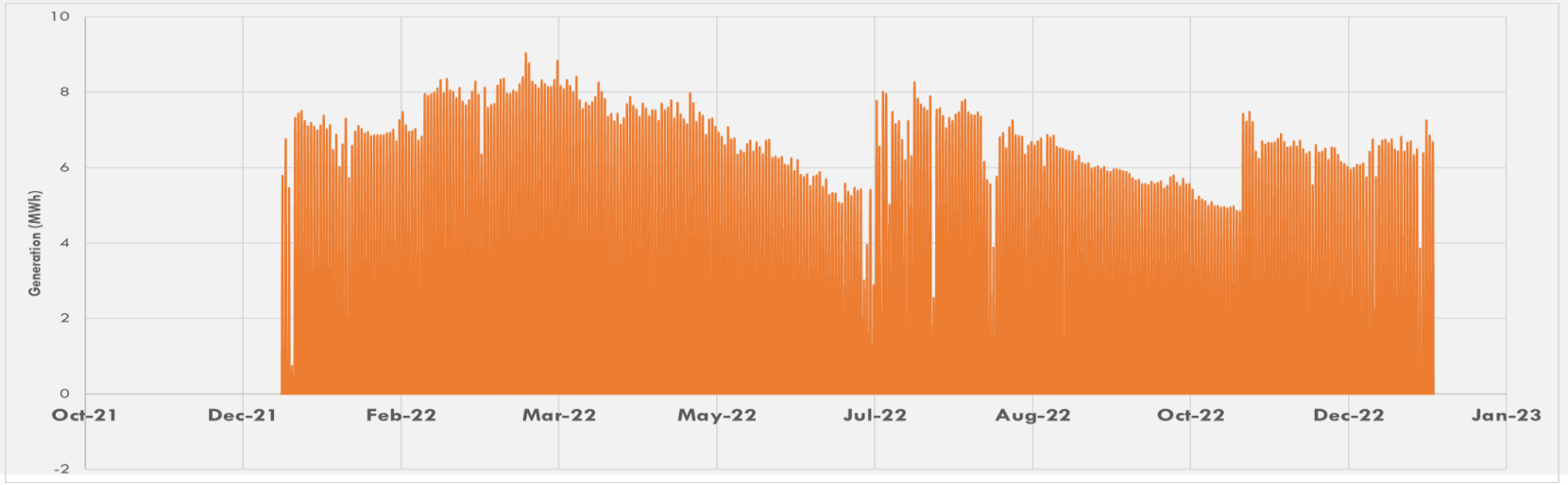
Assumed Villas monthly consumption (kWh) for two years:

	2022	**2023**
Jan	565	444
Feb	654	650
Mar	1044	2023
Apr	2646	3585
May	2000	4509
Jun	5854	4945
Jul	5289	4369
Aug	4919	4121
Sep	4327	3234
Oct	3640.7	2937
Nov	2628.3	1679
Dec	661	2002
Total	**34227**	**34498**



Assumptions and inputs

Actual Solar hourly generation profile ($11kW_{p,dc}$)



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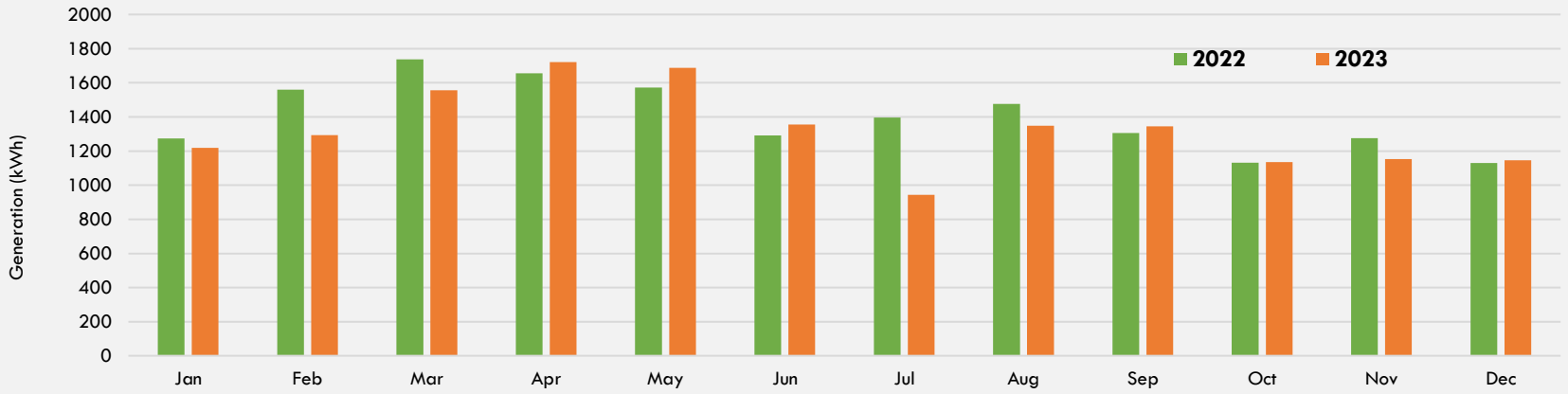
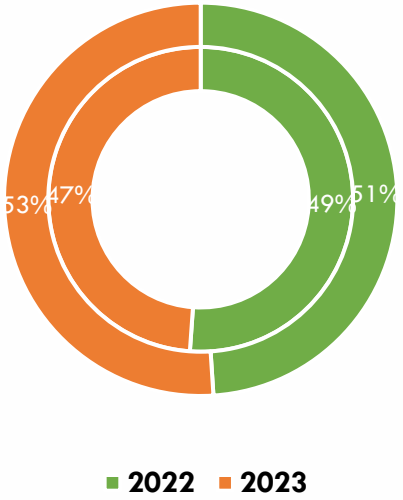
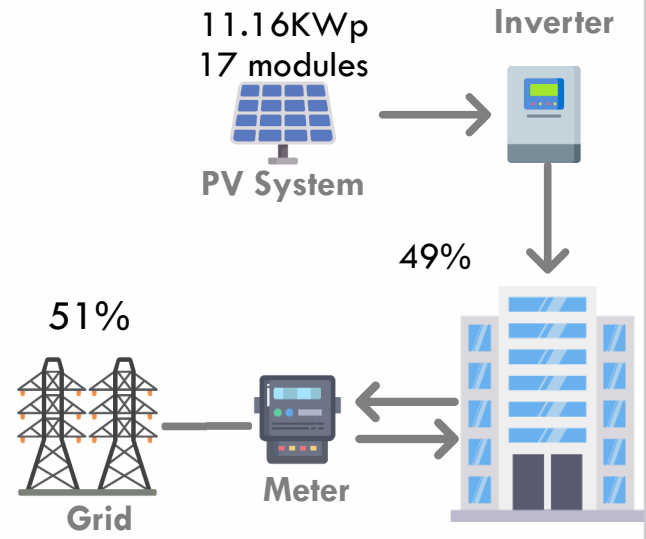


Results and Discussions

Real life case

	2022	2023
PV generation from the average capacity from the average capacity of 11.16KWp (kWh)	16733.19	16118.83
Percentage of self powered (%)	49%	47%
Number of Modules	17	17
Required Active Area for PV (m2)	52.81	52.81
Grid annual contribution (%)	51%	53%





% Bill reduction percentage ≠ % Import/Export power

	Off Peak	Night Peak	Weekday	Weekend
			Day-Peak	Day-Peak
January – March	12	12	12	12
April	16	16	16	16
May – July	19	40	50	39
August – September	16	23	28	22
October	16	16	16	16
November – December	12	12	12	12

Rate Band	Time Period	Days of Week
Off-Peak	03:00 to 12:59 and 16:00 to 21:59	All days
Night-Peak	22:00 to 02:59 (following day)	All days
Weekday Day-Peak	13:00 to 15:59	Sunday to Thursday
Weekend Day-Peak	13:00 to 15:59	Friday and Saturday

- April-October Export ≥ Primary Account
- May-September: Export > Secondary Account
- Low demand at homes during working hours i.e higher saving.
- Reduce/eliminate the electrical subsidiary.

All prices are in bz/kWh. All rates are subject to change annually.
Ref: APSR 2024 CRT

Results and Discussions

Zero Electricity net metering

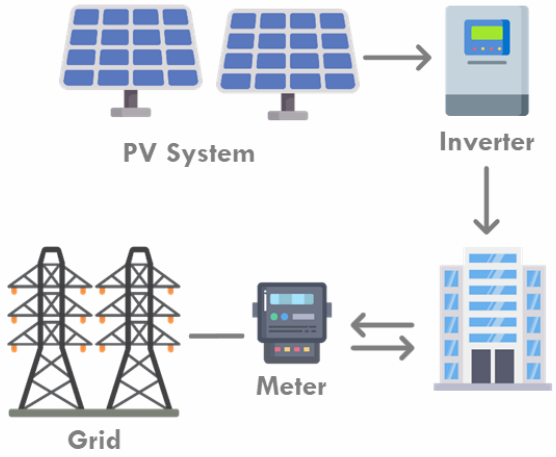
Approaches:

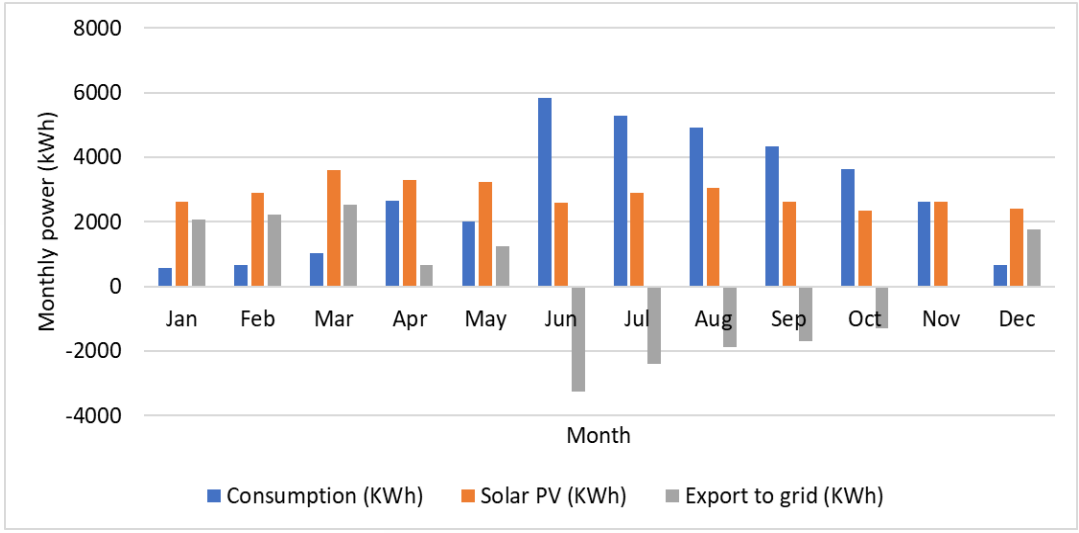
- ✓ Energy: Annual PV generation ≥ Annual demand.
- ✓ Cost/Bills: Annual credits=0

Design is based on Regulator and hourse load demand profile.

- ➢ Energy: Annual PV generation ≥ Annual demand (**34,227kWh**).

	2022	2023
PV capacity for full capacity (kWp)	22.83	23.88
Number of Modules	35	37
Required Active Area for PV (m2)	108.72	114.94





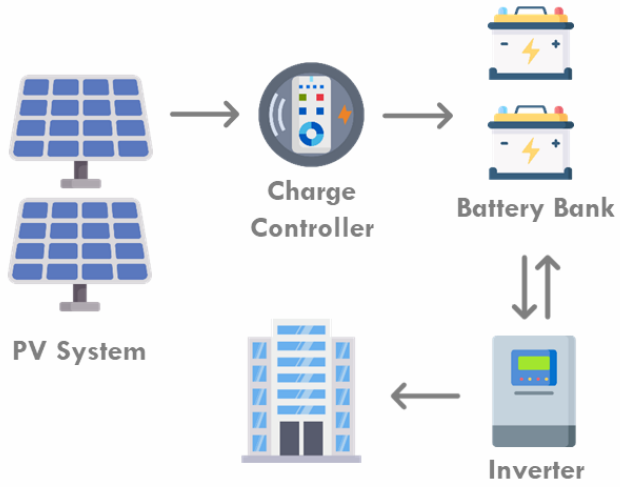
Results and Discussions

Self power generation

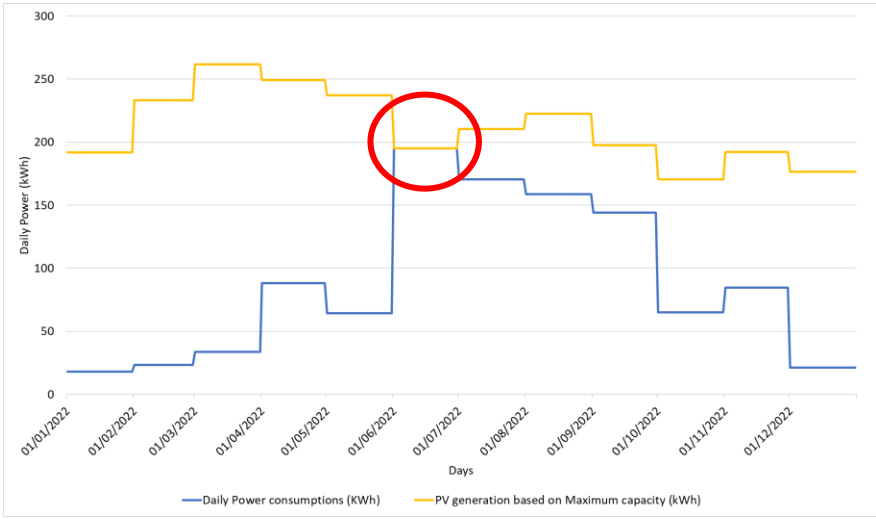
Self Power generation:

- ✓ No grid import/export
- ✓ Solar PV system with BESS designed based on Maximum daily, weekly, monthly power consumption.

Days of Autonomy → BESS capacity



0 day of Autonomy	2022
PV Capacity for self generation (kWp)	51.5
Number of Modules	78
Required Active Area for PV (m2)	242.30
Curtailed Power kWh (%)	44619 (58%)
Grid contribution %	0



Factors impacting existing houses Loads

Electric Vehicle

Make/model	BYD ATTO 3	Tesla Model S	VW ID.4
Range (km)	380	665	465
Battery capacity (kWh)	62	100	77
Home Charge power (kWAC)	11	11	11
Home charging time from 10% (hr)	5	8.1	6.3

Lifestyle and climate change

- Increase ambient temperature
- Less space occupancy

Independent Solar Equipment

Outdoor solar light

Solar water heater

Smart Homes

Smart Lighting and switches

Smart Thermostats

Motion sensors

Efficient Home appliances

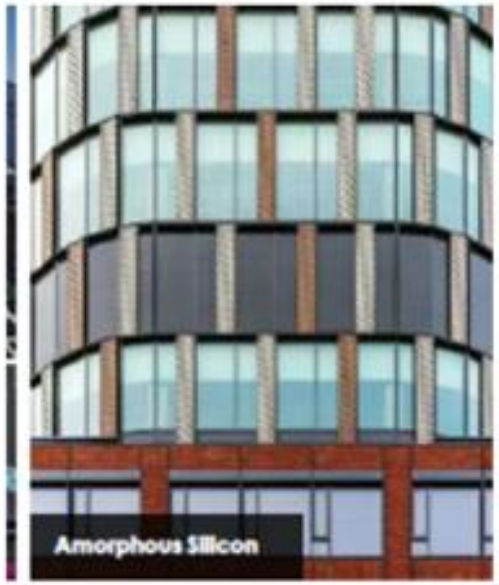
Innovative Technologies

Space restrictions to increase PV field

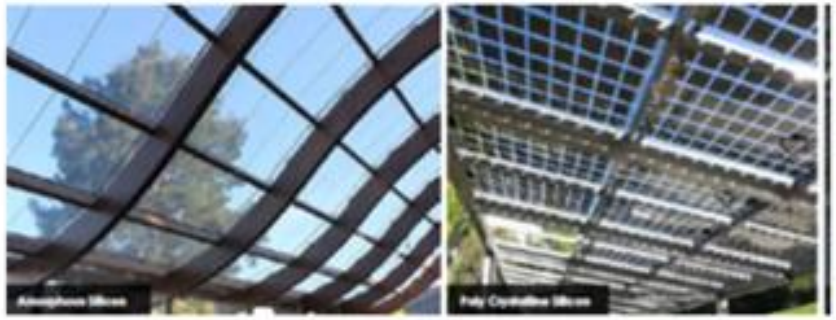
Building integrated Photovoltaics Technology. Utilize the followings to:

PV double skin

PV curtain wall



PV Canopy



PV Skylight

PV Brise Soleil

Conclusions and Recommendations

1. The PV installation in houses can be major role in achieving the NZE, impacting the structure of the power transmission and distribution and the power generation of countries.

2. Energy efficiency and the new technologies must be looked at for the specific regional geography and climate.

3. Further studies shall look into the role of the Electric vehicle in shaping houses energy demand and their impact on the different aspects.