69TH AMEU CONVENTION

1 – 4 October 2023

CSIR International Convention Centre

Confronting South Africa's Electricity Crisis in the context of a 'Balanced Just Energy Transition' (BJET) and the need for a reliable and resilient national electricity grid

The Impact of Large-scale solar generation on utility revenue

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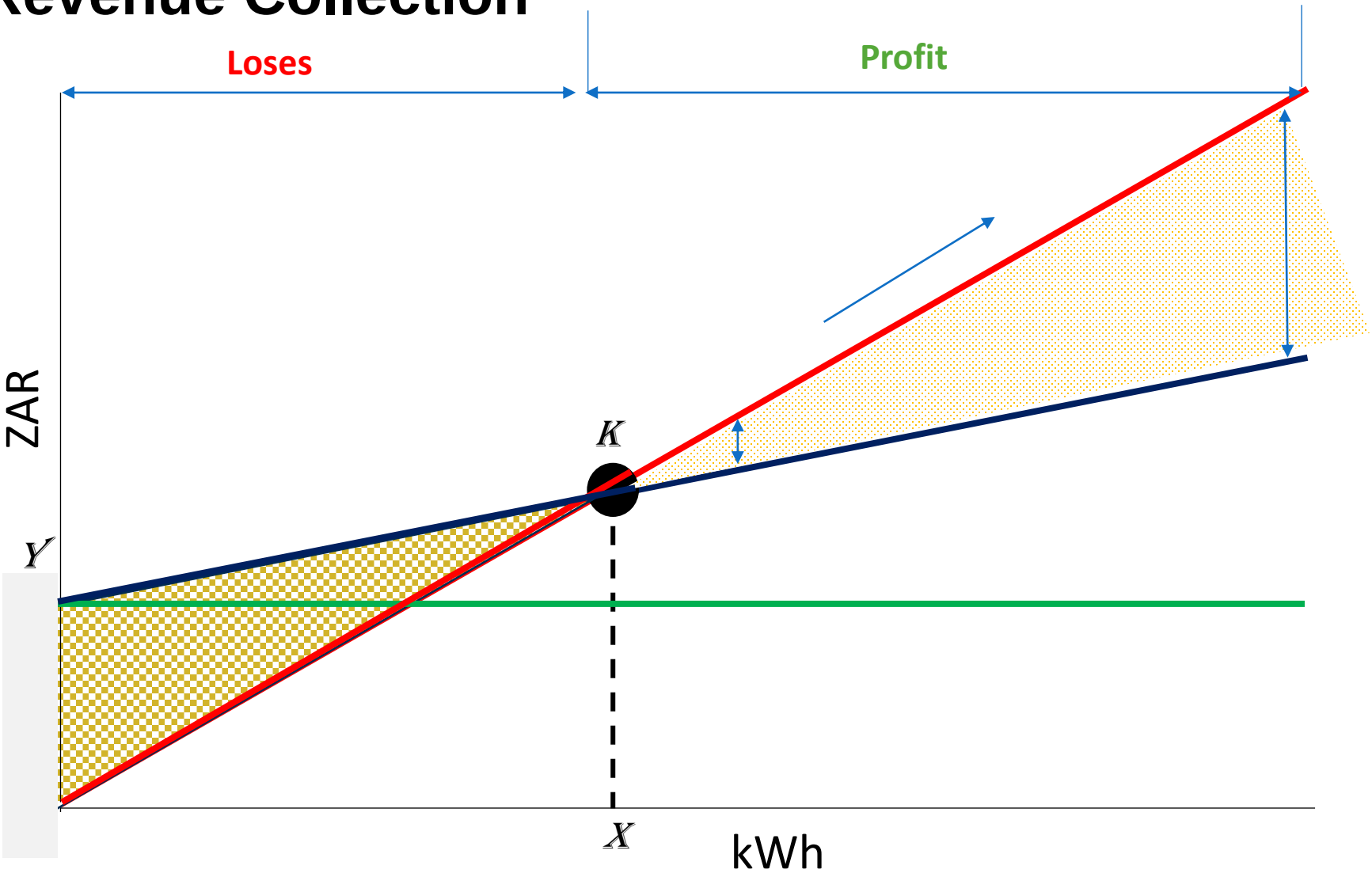
City of Tshwane

Background

- In the past decade, sales of photovoltaic systems have increased in SA, whereas the energy crisis deteriorated, and municipalities continued to suffer losses.
- The apparent reason is that the PV system may threaten the utility's energy business if not correctly integrated.
- This study interrogates the impact of high penetration by zooming in one residential PV system.

How does the high penetration of photovoltaic systems affect the business/ revenue (Positive and negative impact)?

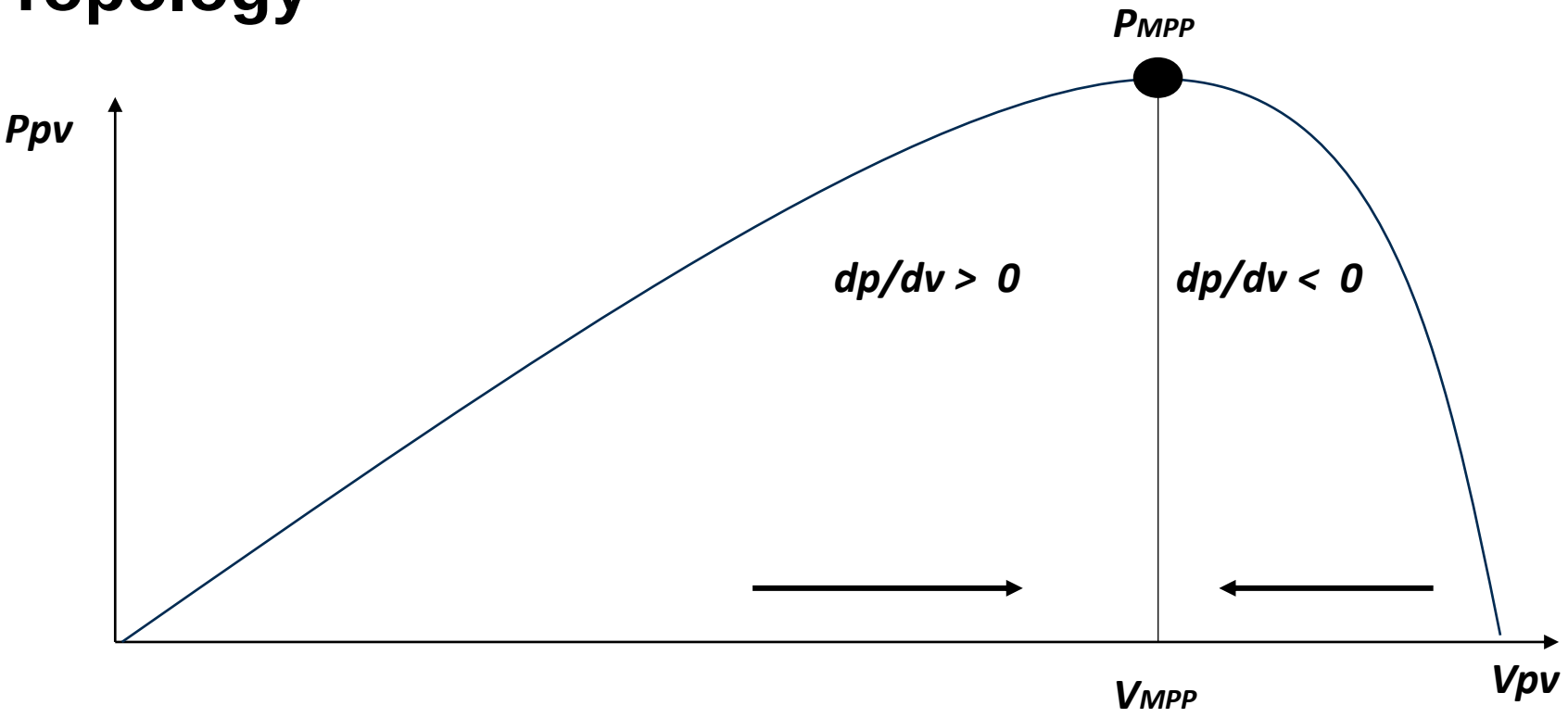
Revenue Collection



Methodology: Case study

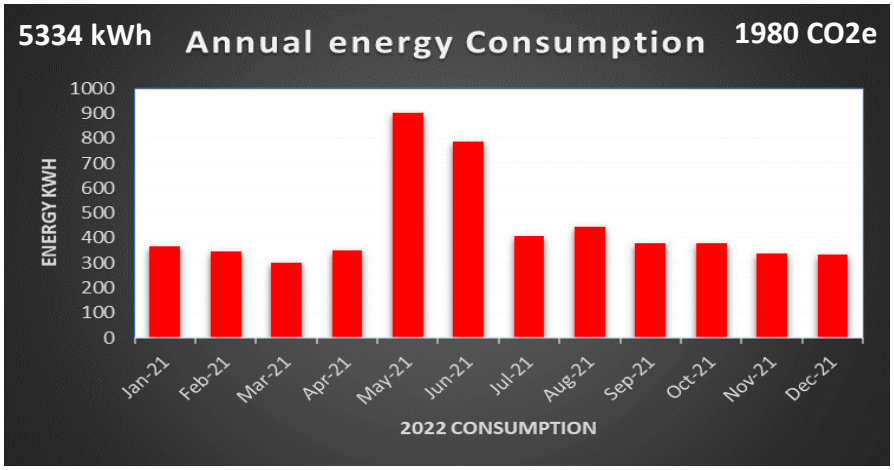
- **Approach** – Case study (Qualitative & Quantitative analyses)
- **Case selection** – PV Residential average customer
- **PV selection** - Off-grid System
- **Size** – 3.2 kWp, 7kWh storage, 5kW static converter
- **Data harvesting** – Historical consumption (repository), Invertor's Cloud repository

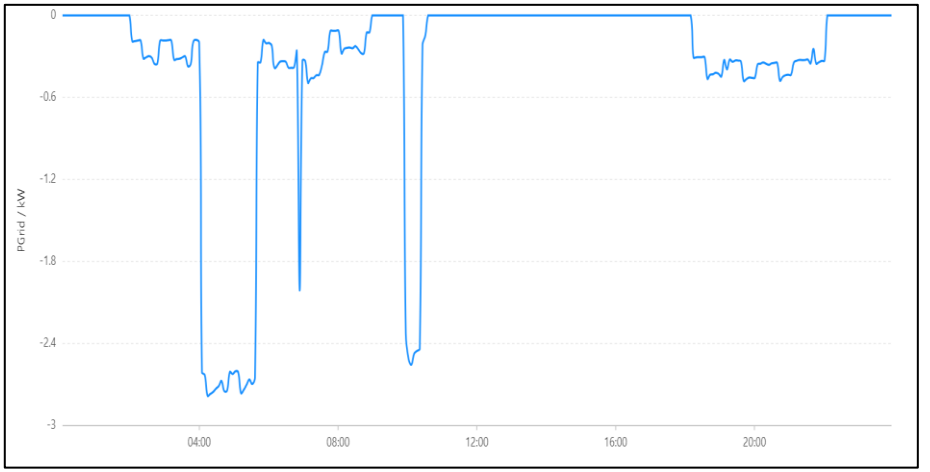
Topology

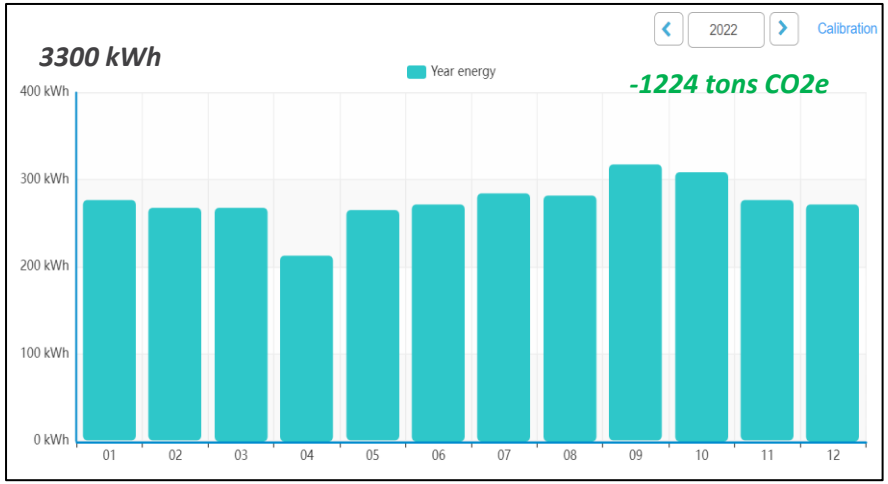


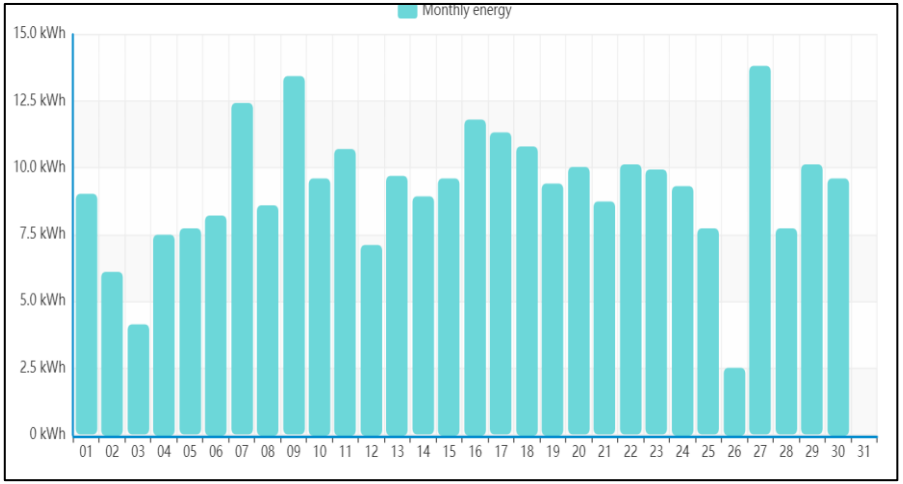
$$i_{load} = \begin{Bmatrix} i_{pv} + i_{batt}, if\, i_{load} < \left(i_{pv} + i_{batt}\right) \\ i_{grid}, if\, i_{load} \geq \left(i_{pv} + i_{batt}\right) \end{Bmatrix}$$

Output Data

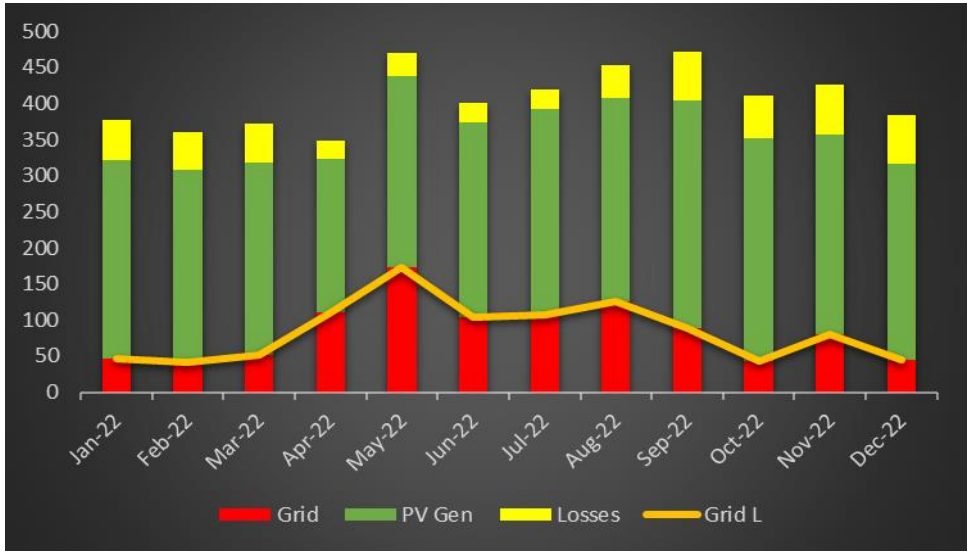

5334 kWh
Annual energy Consumption
1980 CO2e
ENERGY KWH
1000
900
800
700
600
500
400
300
200
100
0
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
2022 CONSUMPTION

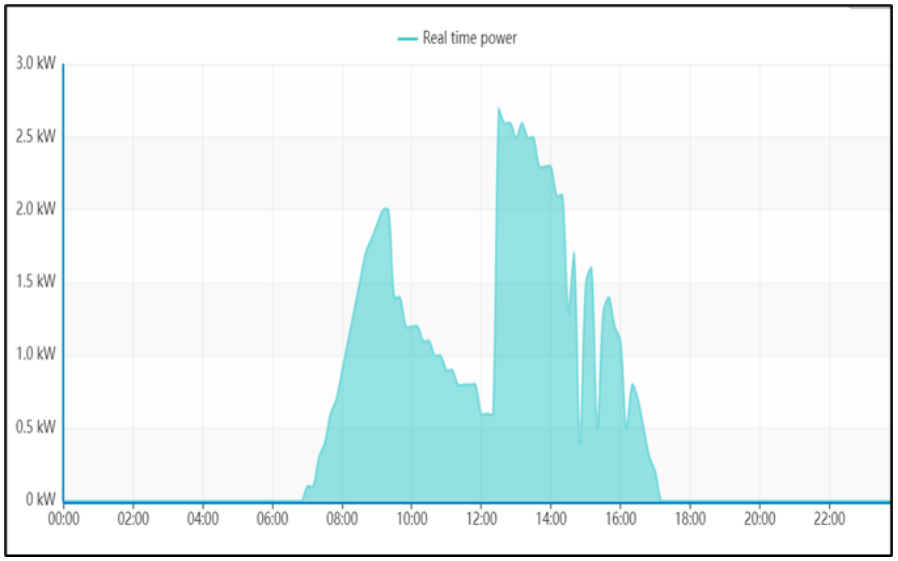

0
-0.6
-1.2
-1.8
-2.4
-3
PGrid / kW
04:00
08:00
12:00
16:00
20:00

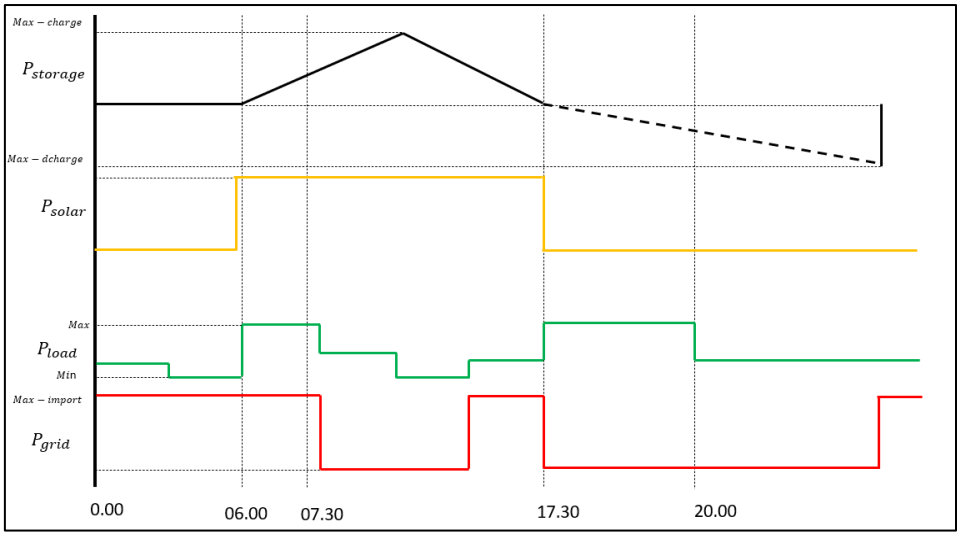

2022
Calibration
3300 kWh
Year energy
-1224 tons CO2e
400 kWh
300 kWh
200 kWh
100 kWh
0 kWh
01
02
03
04
05
06
07
08
09
10
11
12

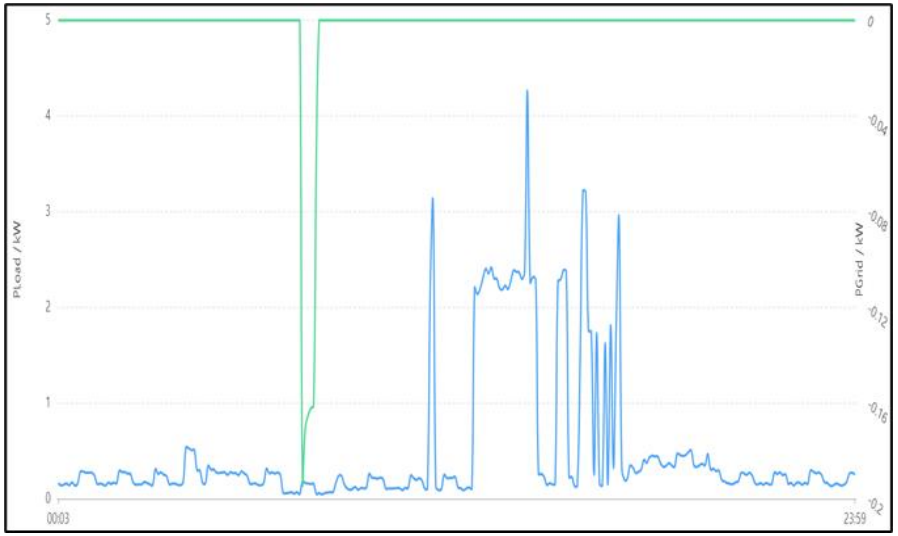

Monthly energy
15.0 kWh
12.5 kWh
10.0 kWh
7.5 kWh
5.0 kWh
2.5 kWh
0 kWh
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Data Analysis









Extended Work

Indices: i (Supply Authority)

j (PV customers)

Decision variable: Xij (Total energy export in kWh)

Zij (Total distribution loss in kVA)

Parameter: Cij (Consumption cost per Rand per kWh)

Objective:

Min $\sum i \sum j . C_{ij} . X_{ij}$ $(Minimise\ Utility\ cost)$

Constraints

$$\sum j . X_{ij} > \boldsymbol{K} \quad \forall_i \ (Import > min. kWh)$$

$$X_{ij} \geq 0 \quad \forall_{ij}$$

$$i, j \in \mathbb{N} \{0,1,2 \ldots\}$$

Related and Future Work

- Case studies of medium and high Renewable energy penetration: **2024**
- The ripple effects of embedded and alternative PV generation on a power grid: IEEE ICECET: **2023**
- Distribution Power Pool: **2023**
- Economic Load dispatch of Dispersed generation and centralized IPPs: **2023**

Conclusions

Municipal utilities' fundamental responsibilities:

- Keep good business relations with ESKOM and other IPP generators. Pay their dues
- Remain a replicable supplier to their customers by ensuring energy security and quality of supply
- As licensed distributors and a government to their residence, they should remain Compliant with the regulator and keep tariffs competitive and low
- Municipalities are obliged to **Service capital dept**, **Maintain**, and **Improve** the network; while **Embracing**, **adopting**, and **championing** the renewables and green technologies.