2024 ENGINEERING INSTITUTION OF ZAMBIA SYMPOSIUM

DETERMINISTIC & STOCHASTIC ASSESSMENT OF SIMULTANEOUS ELECTRIC VEHICLE'S CHARGING HOSTING CAPACITY AS A TOOL FOR DISTRIBUTION NETWORK PLANNING

AUTHORS : Dr. Enock Mulenga & Chiza Leonard Nyirenda

PRESENTER : Chiza Leonard Nyirenda

DATE : Friday 19th April 2024

Avani Victoria Falls Resort, Livingstone, Zambia

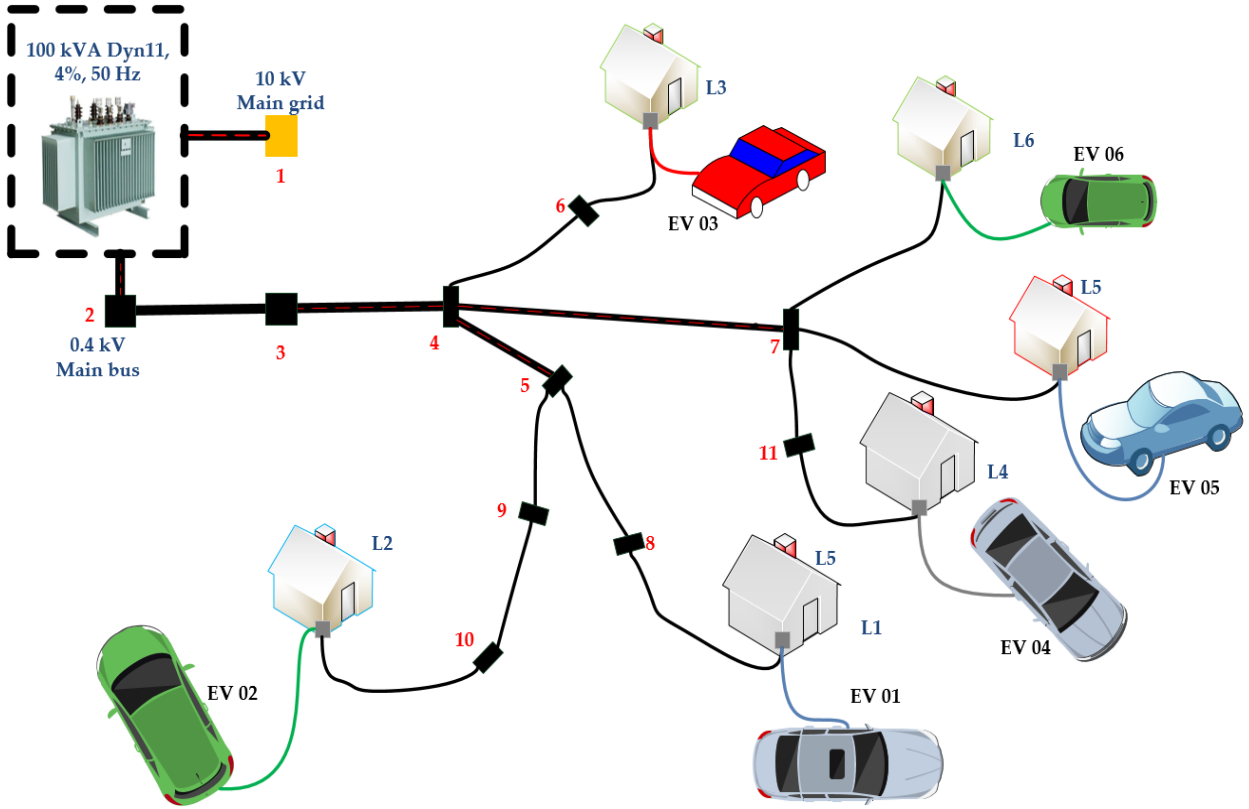
TABLE OF CONTENTS

1. INTRODUCTION
2. CONCEPT OF HC & OVERLOADING
3. METHODOLOGY
4. RESULTS
5. DISCUSSIONS & RECOMMENDATIONS
6. CONCLUSION

1.0 INTRODUCTION

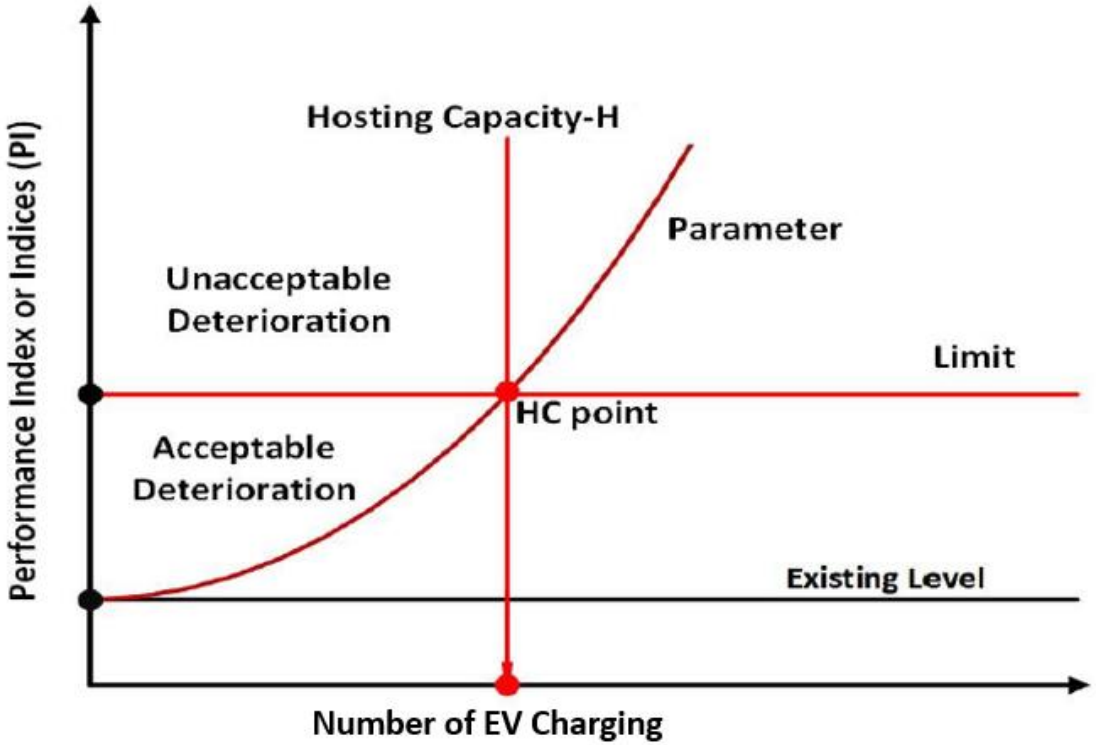
- Global increase in share of Electric Vehicles (EVs)
- The EV Landscape increasing in Africa & Zambia also.
- Charging Stations in Distribution Networks Needed.

- Distribution network with 6-customers and EV charging possible at each location



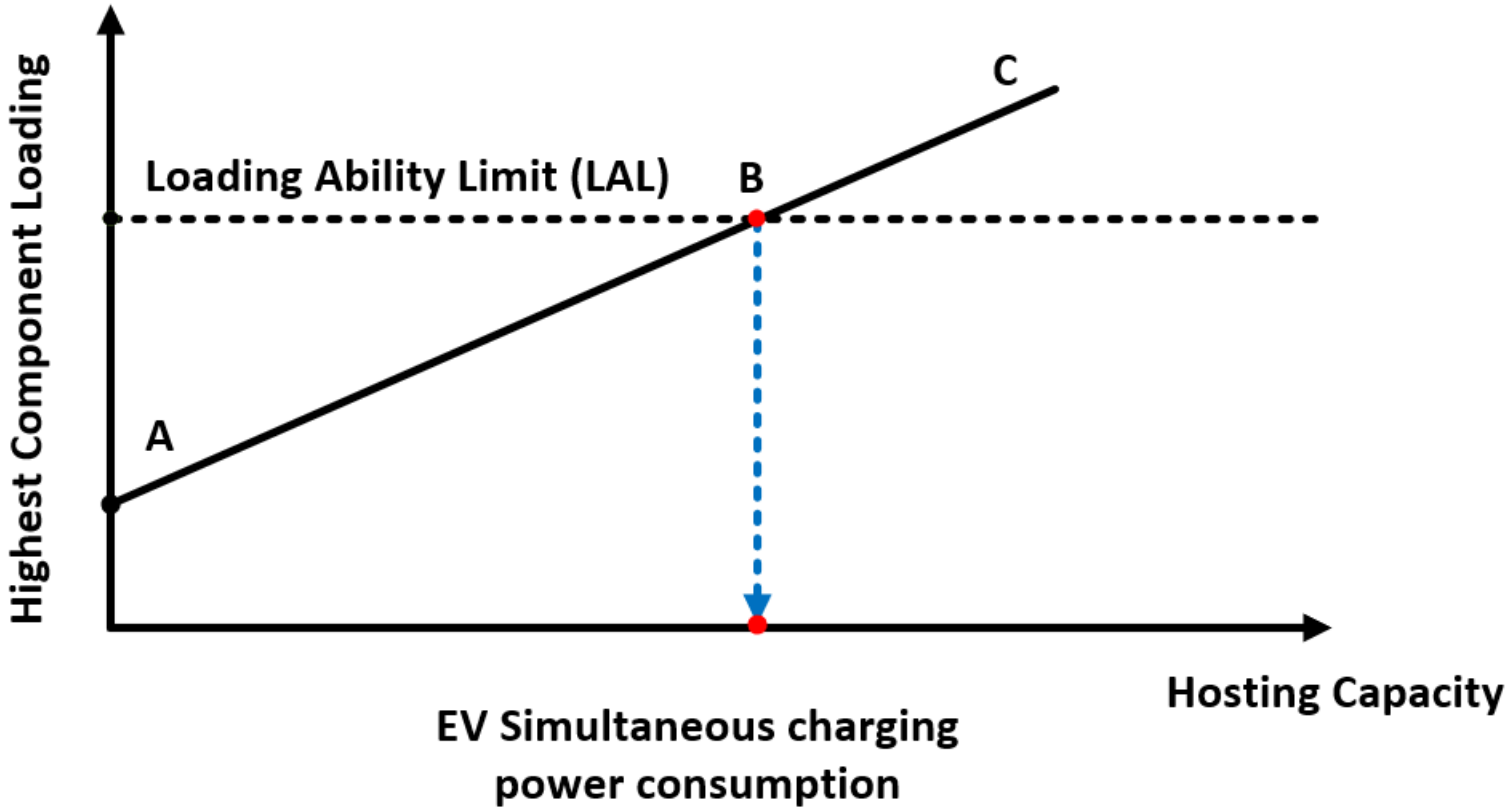
2.0 CONCEPT OF HOSTING CAPACITY & OVERLOADING

- Hosting Capacity - HC (General): Acceptable amount of new consumption or production that does not cause unacceptable deterioration in the power quality delivered (Wind Power, Photovoltaics-PV, Electric Vehicles - EV, Heat Pumps).



- HC – EV: The number of EVs charging (simultaneous) that does not cause unacceptable deterioration in the power quality delivered.

2.0 CONCEPT OF EV Charging, HC & Overloading



- Point – A: Background and starting level.
- Consumption increase along Line AB to point B. EV Charging.
- Point – B: LAL reached and hosting capacity (HC)
- Consumption increase along line BC beyond B – HC Exceeded: Overloading

3.0 METHODOLOGY- DETERMINISTIC APPROACH

- Hosting Capacity can be estimated using Deterministic, Stochastic and time-series
- Deterministic Approach (DA):
  - Fundamental Method
  - No uncertainties considered

$$n_{mEV} = \frac{S_{maxlt} - S_{cmax}}{P_{EVC}}$$

- The maximum number of EVs.

$$EV_{hc} = \frac{S_{maxlt} - S_{cmax}}{n_m}$$

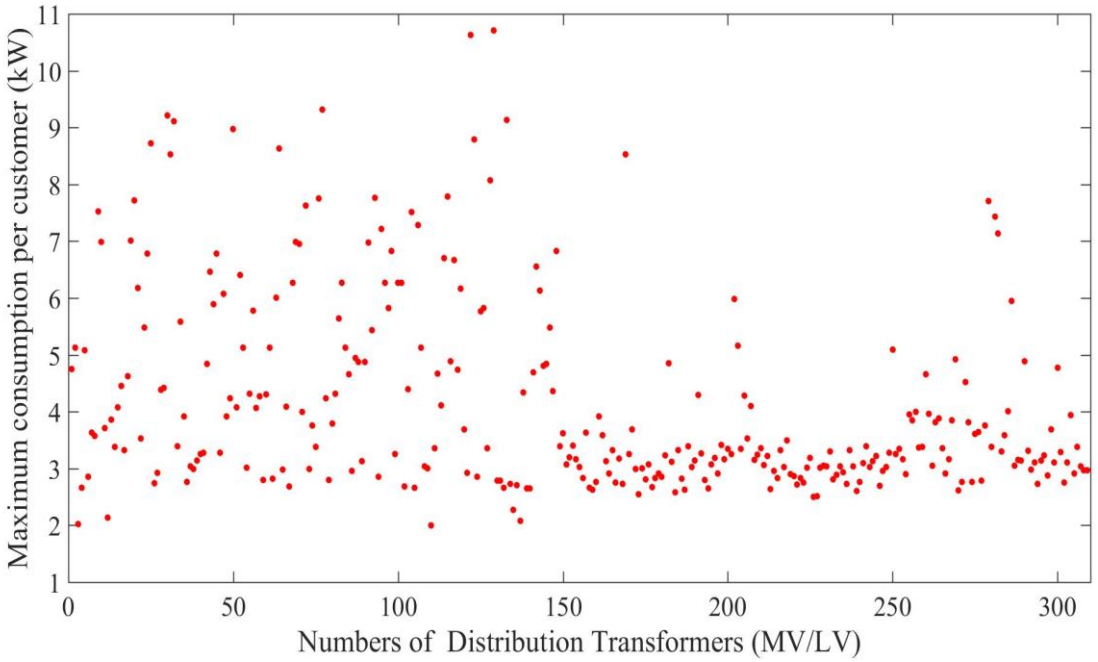
- The maximum charging power.

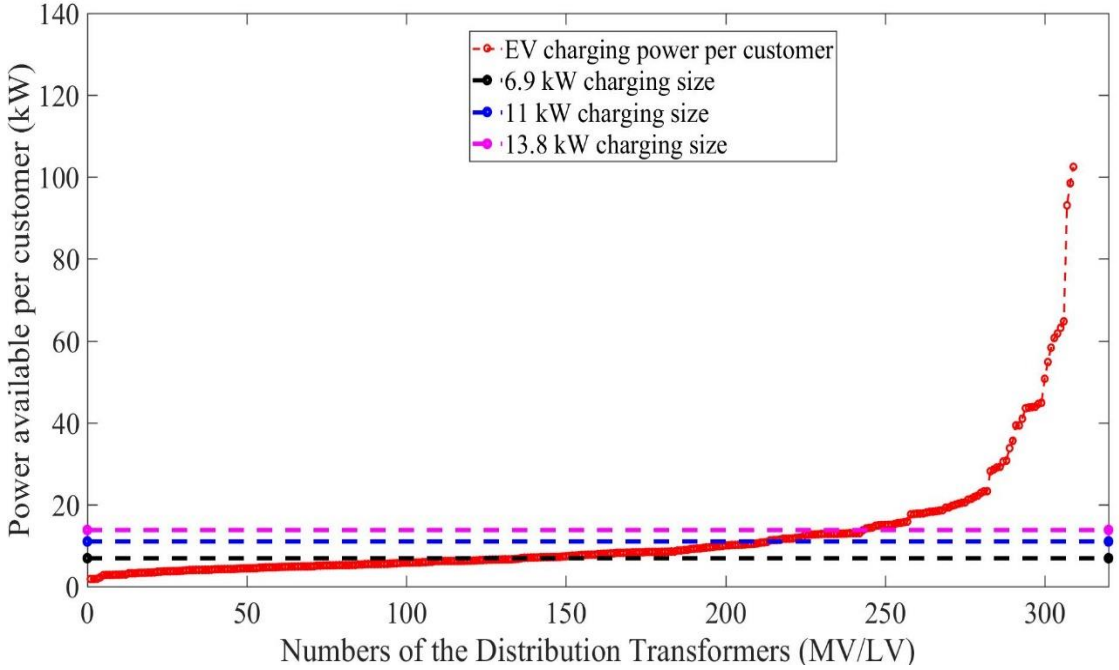
STOCHASTIC APPROACH

- Stochastic Approach (SA):
  - Uncertainties Included: Aleatory (Probabilistic Based) and Epistemic (Knowledge/Information/Evidence/Possibilistic Based)
  - The number of uncertainties determines the complexity.
  - The number of EV charging takes the Model of Binomial Distribution (Other Models can also be used).
- Aleatory Uncertainties
  - Power consumption, voltage level (background).
- Epistemic Uncertainties
  - Number of customers charging EV, Charging Power (6.9 kW), Phase Type/Connection

$$Pr\{X > n_{mEV}\} = \sum_{n=n_{mEV}+1}^{n_m} P \sim bin(n,p)$$

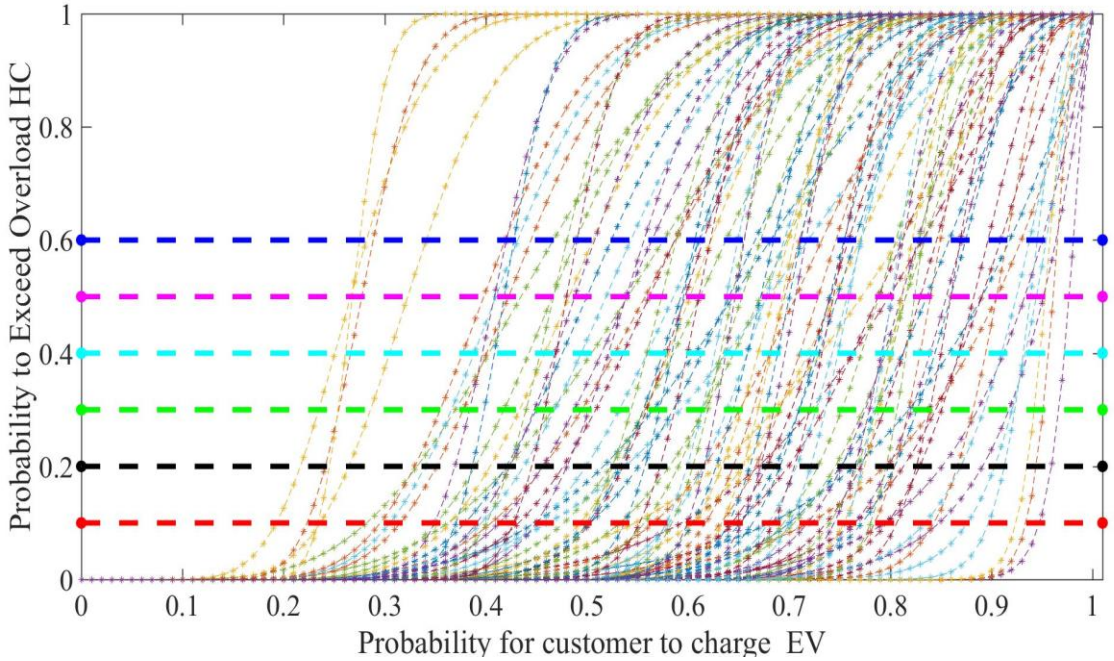
4.0 RESULTS

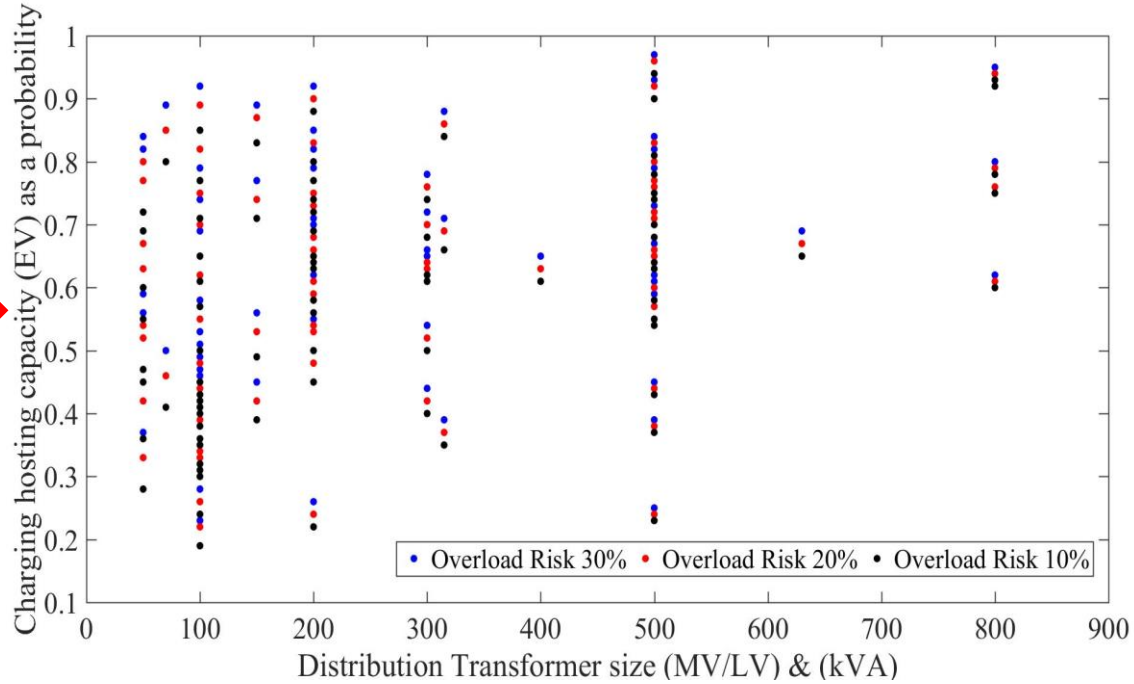




- Consumption data of transformers and customers.
- The highest consumption per customer is obtained. It is important for HC estimation.
- EV Charging power per customer available.
- The charging power size of 6.9, 11- and 13.8-kW limits.

4.0 RESULTS





- Implementation of SHC yield different hosting capacities for a transformer with different risk.
- Each probability to exceed the Overload gives a different hosting capacity.

- HC as a function of probability.
- With the same transformer size, different risk and different hosting capacity.
- Risks other than 10%, 20% and 30% can be assessed.

4.0 RESULTS

Table 1: *The Planning Table Guide for DSO shows the expected number of customers as the hosting capacity of the stochastic approach.*

Transformer Size (kVA)	Downstream Customers (n_m)	Hosting C (Det.)	Hosting C (Stoch).
50	7	5	4
50	7	6	5
50	8	5	4
100	14	13	12
100	22	13	12
100	32	13	11
200	33	27	25
200	38	28	26
200	46	27	25
300	52	42	40
300	62	42	39
300	74	42	38
500	73	71	70
500	94	71	68
500	112	71	67
800	120	115	113
800	144	115	109
800	177	115	108

- 10% Probability to exceed the HC

$$HC_{stoch}(10\%) = 0.9527 \cdot HC_{det} - 2.1762$$

- 30% Probability to exceed the HC

$$HC_{stoch}(30\%) = 0.9811 \cdot HC_{det} - 1.0048$$

- Planning Table Guide Formulation by DHC & SHC

- Planning Table Guide gives.
  - Relationship formulation for risk of exceeding the hosting capacity
  - Relationship can help estimate the stochastic hosting capacity
  - Same rating transformers and downstream customers can have different HC

5.0 DISCUSSIONS & RECOMMENDATIONS

- DSO need to consider simultaneous EV Charging in Distribution networks (DN)
- Loadability in DN = Bottleneck for EV Penetration
- Deterministic Approach, Stochastic Approach and Planning Table Guide tools for DN Planning.
- Relationship between DA Versus SA gives a planning tool useful to determine safe levels of EV simultaneous Charging.
- Investment needs must be captured in a planning method.

6.0 CONCLUSION

- Deterministic Hosting Capacity is the upper bound for overload likelihood
- Stochastic Hosting Capacity is the lower bound for the overload likelihood
- DHC presents a level that require investment for simultaneous EV charging.
  - New Transformer with larger capacity
  - New cables or transmission lines.
  - New generation units.
- SHC presents a limit that does not require investment.
- Planning for new consumption requires an approach that combines DHC and SHC to give limits at different points in a distribution network.

The End

THANK YOU FOR YOUR ATTENTION.