68TH AMEU CONVENTION 2022

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A JUST ENERGY TRANSITION ("JET") FOR SOUTH AFRICA

THE IMPORTANCE OF GRID IMPACT STUDIES FOR MUNICIPALITIES

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OVERVIEW

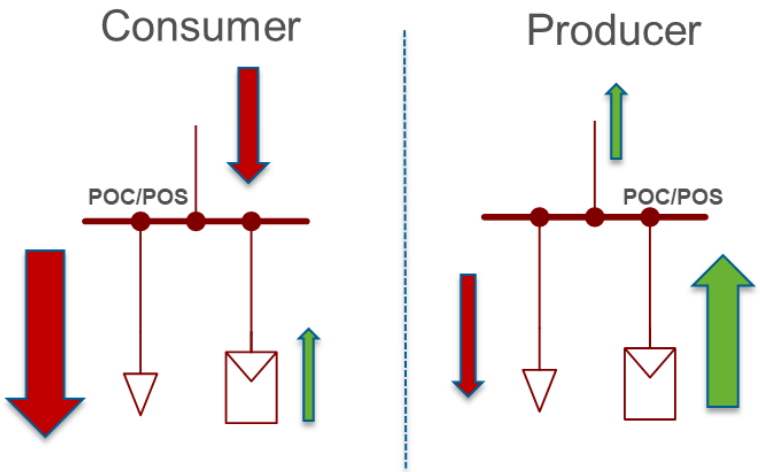
- Where did the need for grid impact studies come from?
- Consumer to Prosumer
- Studies & Responsibility
- Grid impact studies and evaluation
- Network Studies
- Summarising the importance

Where did the need for grid impact studies come from?

- The Family Meeting
- Embedded Generators (EGs) up to 100MW, FOR OWN USE, do not require a generation license.
- EG Still needs to comply to grid codes & municipality responsible for assessing compliance & impact on the network

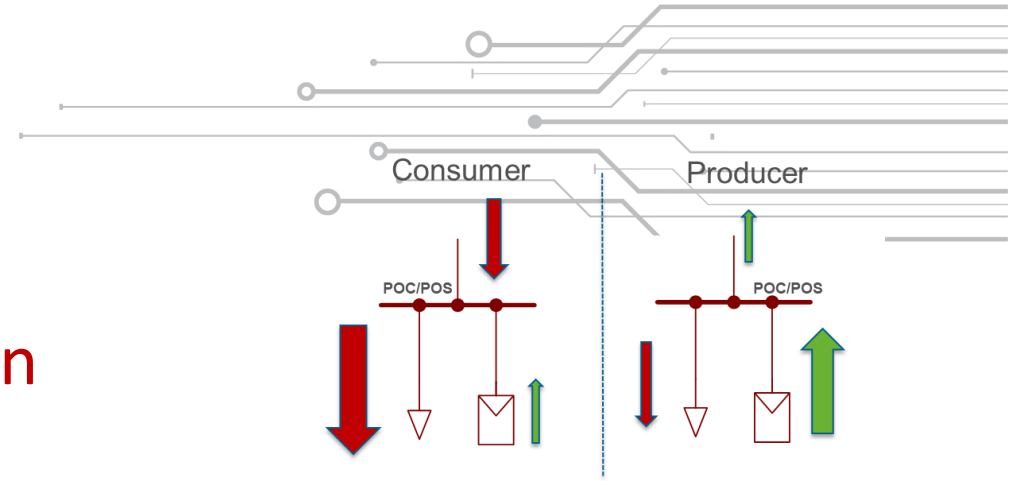
Consumer to Prosumer

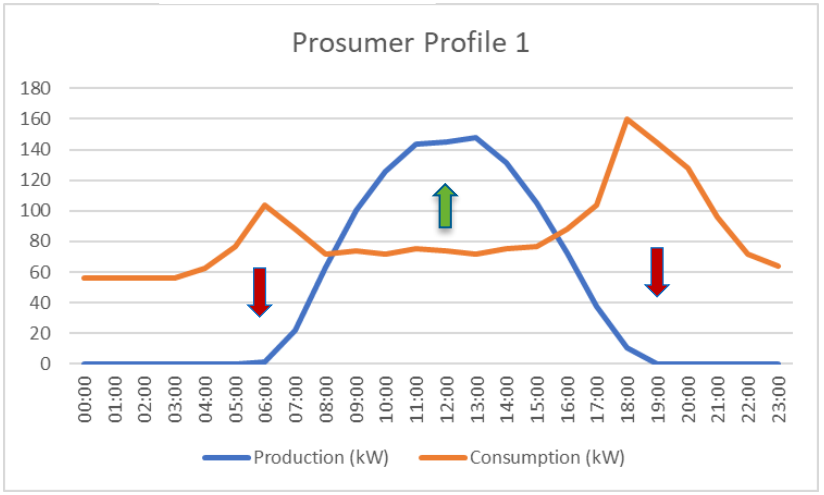
- Prosumers are customers that both PROduce and conSUME electrical energy from the network.
- Analysis of this type of customer, from a municipal perspective, is not as straight forward.
- **Need to understand their energy behaviour.**



Prosumer Profile #1

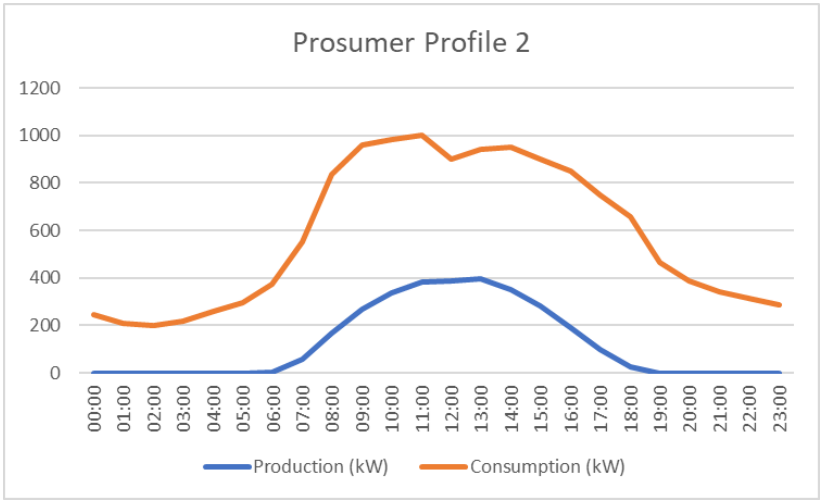
- EG matches maximum consumption.
- No coincidence between production and consumption peaks.
- In a day, this customer will be a producer to the network from 08:00 until 16:00 and a consumer for the remainder of the time





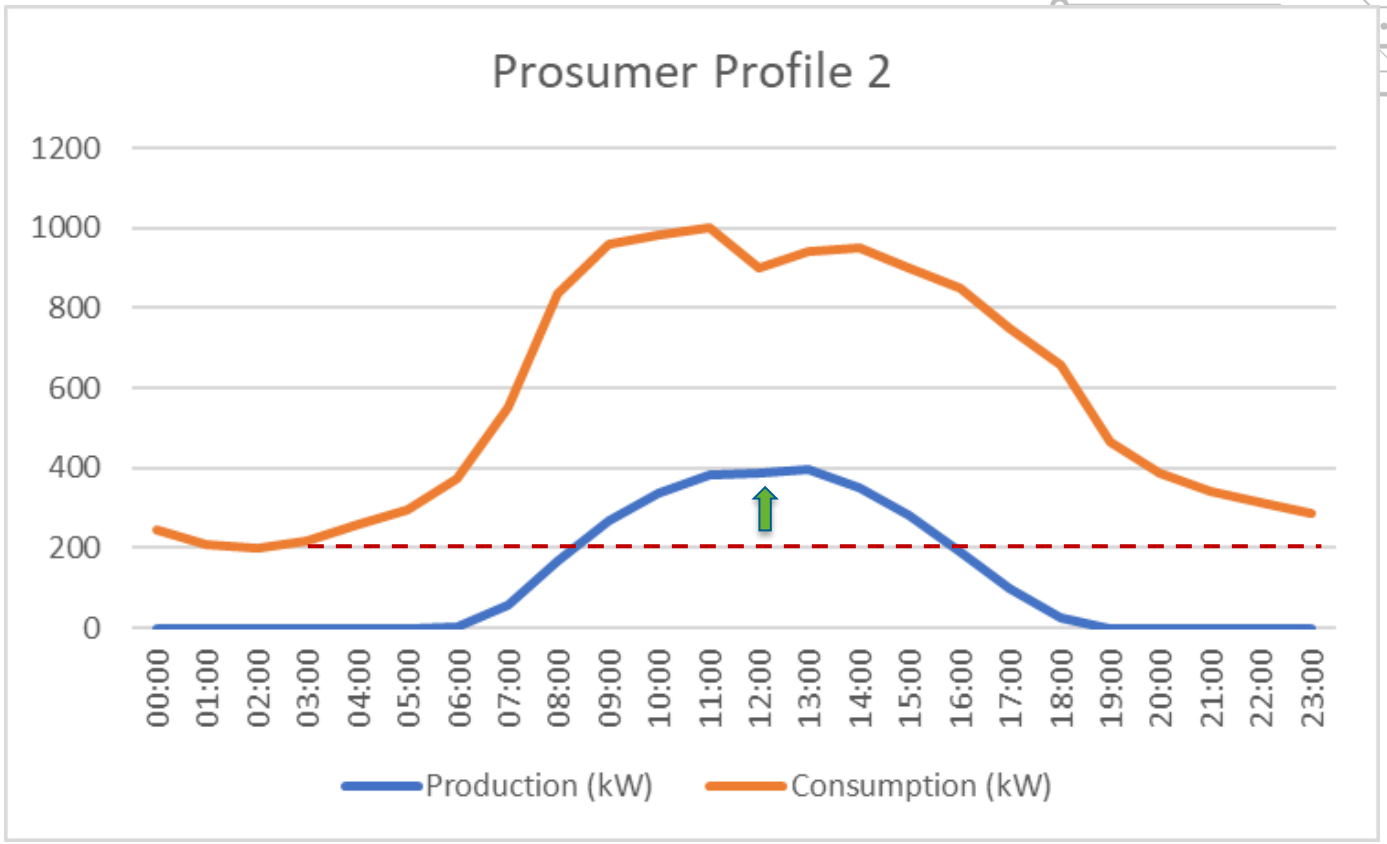
Prosumer Profile #2

- EG is approximately 40% of peak demand
- Coincidence between production and consumption peaks
- Certainly this customer will not feedback into the network??



Prosumer Profile #2

Prosumer Profile #2

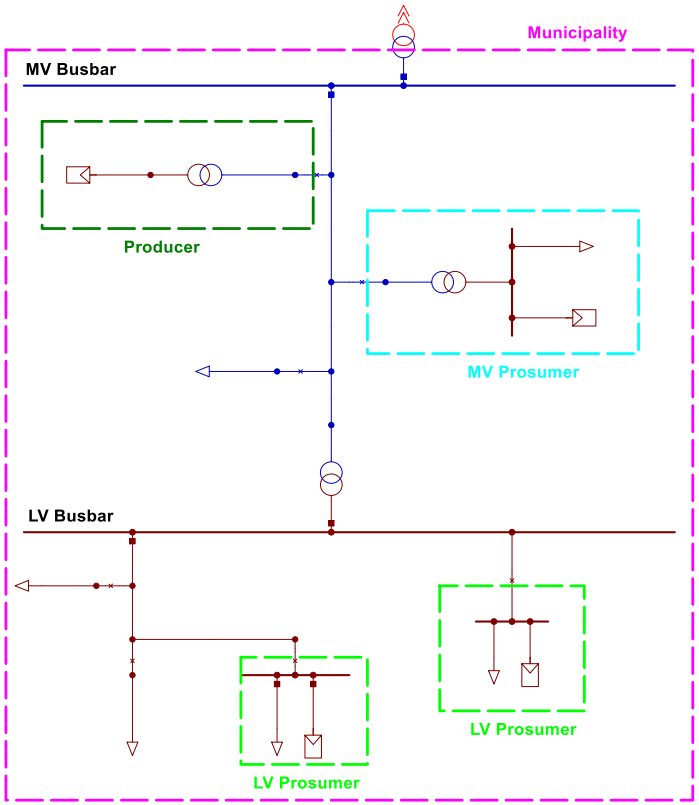


Who is responsible for grid impact studies?

- Due to large number of applications, it is impractical for municipalities to perform grid impact studies for each application
- **Can the municipality ask the customer, to conduct a study on the impact the customer's EG will have on the municipal network?**

Provided that sufficient network data is given to the client, in order to assess the impact at the POC / POS or at the feeder infeed.

Studies and Responsibilities



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NETWORK STUDIES (Municipality)

- Network Analysis (Load flow, power factor, Losses)
- Feeder Analysis (LV and MV) : voltage profiles
- Hosting Capacity
- Protection Studies
- Rapid voltage change (RVC) Studies
- Short Circuit Currents / Fault Levels
- Power Quality
- Approval of studies and documentation

MV PROSUMER

GRID IMPACT STUDY (Client)

- NRS certification
- RVC
- Load Flow
- Short circuit
- Protection
- Power Quality

PRODUCER

GRID CODE COMPLIANCE (Client)

- Grid code compliance studies e.g. LVRT
- Compliance Testing
- Comms and SCADA
- Documentation

LV PROSUMER

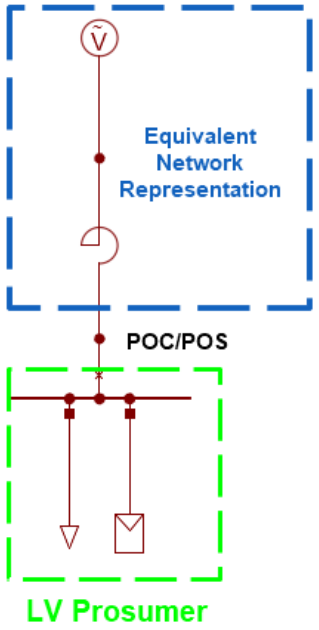
(Client)

- Documentation
- Certification

Data Exchange

In order for the customer to evaluate the impact their EG will have at the POC/POS, the customer will need to know;

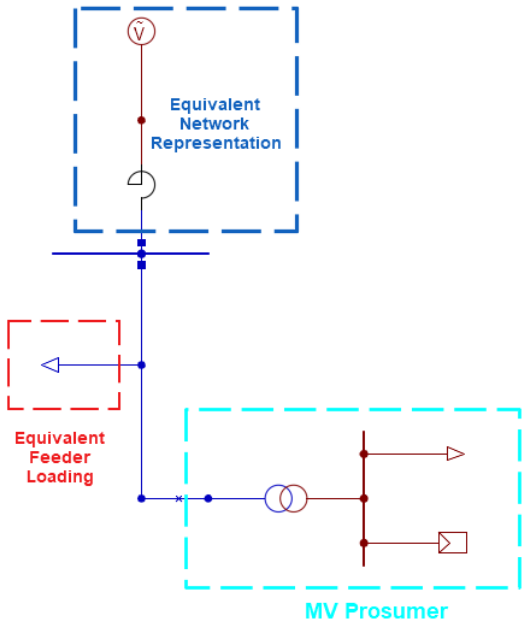
1) **Fault level** / Short circuit current (in MVA or kA)
2) **Equivalent network impedance** (X, R) from the customer POS/POC looking back into the municipal network



Data Exchange

If municipality requires that the customer also evaluate the impact the EG will have on the feeder the following information should be supplied,

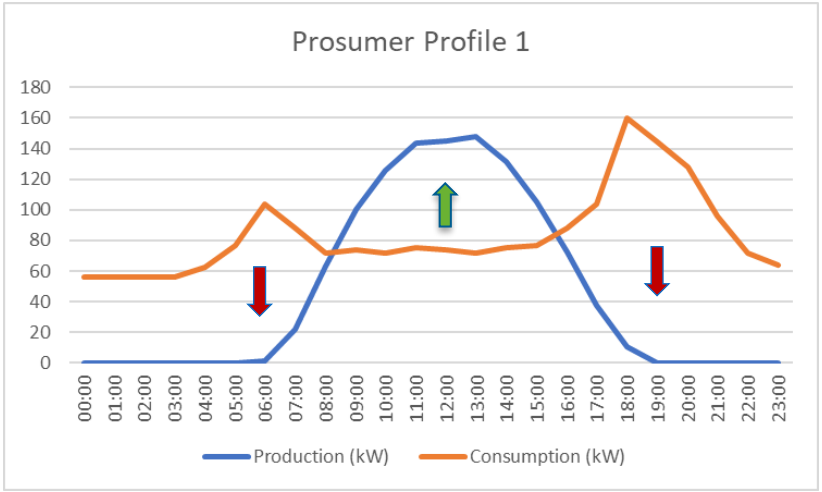
1. **Fault level** at the infeed to the feeder
2. **Equivalent network impedance** (X, R) from the feeder infeed looking back into the municipal network.
3. Feeder **cable**(s) used and **lengths**
4. Typical feeder maximum and minimum **loading** including power factor



Grid Impact Studies: Load Flow

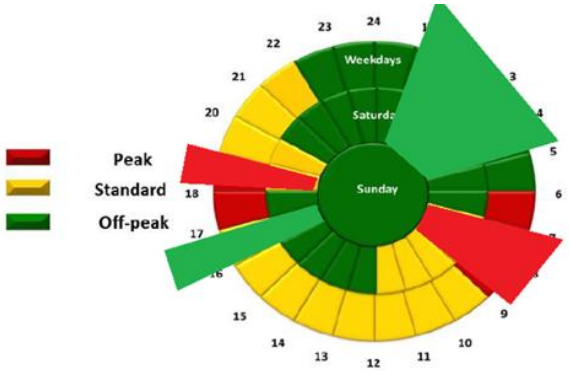
At least 4 scenarios will need to be studied by the customer i.e.

- High generation, High Load (HGHL)
- High generation, Low Load (HGLL)
- Low generation, High Load (LGHL)
- Low generation, Low Load (LGLL)



Grid Impact Studies: Load Flow

- Clients with storage (e.g. batteries) should also consider
  - Charging
  - Discharging
  - Time of day operation
- **The client should study every possible operating condition of their EG (+ storage)**



Grid Impact Studies: Load Flow

Load Flow Studies are used to determine

- Voltage profiles
- Current loading
- Maximum export to network
- Maximum consumption from network
- Power Factor at the POC

Inverters at fixed power factor of 1				
	HGHL	HGLL	LGHL	LGLL
Voltage @ POC (kV)	11	11	11	11
Voltage @ POC (pu)	1.00	1.00	1.00	1.00
POC				
P(kW)	289	-144	544	111
Q(kVAr)	210	62	219	61
PF	0.81	0.92	0.93	0.88
PV				
P(kW)	325	325	65	65
Q(kVAr)	0	0	0	0

Grid Impact Studies: Load Flow

- **When the customer is a consumer:**

Customer to comply to supply agreement

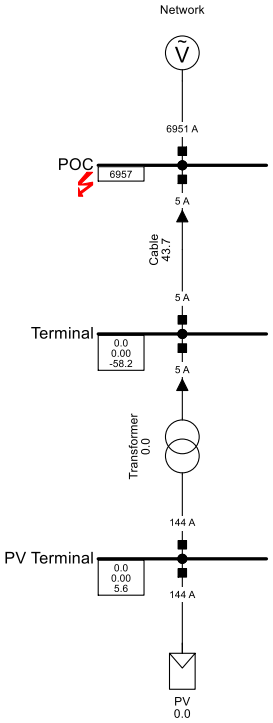
  - NMD not exceeded
  - Power factor at POC/POS is within acceptable limits

- **When the customer is a producer:** full control must be maintained over the EG as per RPP Grid Code.

Control of power factor at the POC/POS becomes essential as it is a requirement as per the RPP grid code. The power factor limits that need to be achieved are dependent on the total installed capacity of the EGs on site (category of RPP)

Short Circuit Current Contribution

- Generators contribute to the fault current in the network hence its important to ensure that all equipment can withstand increased fault currents.
- Typical contributions (rated current)
  - **Inverter based technology: 1 to 1.2x**
  - **Synchronous machines 6 to 7 x**
- Impact of increased short circuit current on protection must be checked



Rapid Voltage Change (RVC)

- A rapid voltage change study is the analysis of the instantaneous (step) change in voltage before and after a switching event.
- In the case of grid impact studies, the event considered would be the trip/loss of all the EGs on a customer's site, simultaneously.

Table A.5 — Indicative planning levels for rapid voltage changes as a function of the frequency of repetition

1	2	3
Repetition rate of changes in a period of time r	**Rapid voltage change as a percentage of nominal voltage** $\Delta U/U_N$ %	
	MV	HV/EHV
$r \leq 1$ per day	6	3-5
$1 < r \leq 4$ per day	5	3-4
$r \leq 1$ per hour	4	3
$1 < r \leq 10$ per hour	3	2,5

NOTE 1 At HV/EHV, the permissible voltage change has a wide range due to the significant range of voltage levels covered (e.g. >35 kV to 500 kV).

NOTE 2 Higher values may be permitted under abnormal system conditions.

Rapid Voltage Change (RVC)

- RVC studies should be conducted for both loads and EG.
- Typically half of the NRS limits are used as acceptable limits for planning.

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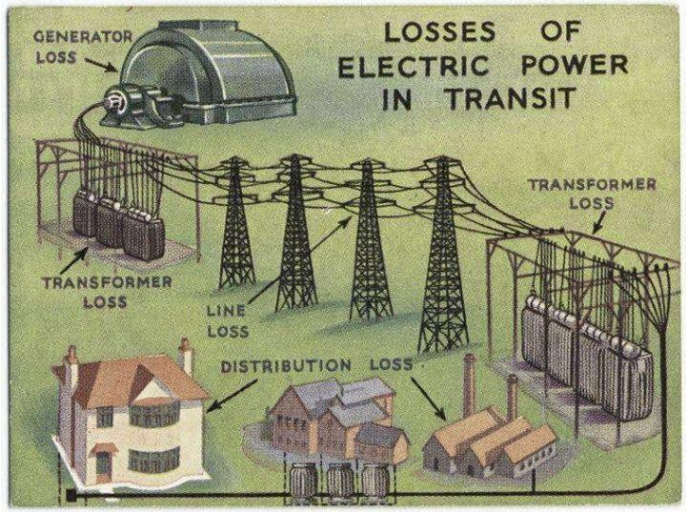
Feeder Losses

- Needs to be analysed as this has direct influence the tariff.
- There are 2 types of technical losses
  - Variable technical losses (2/3): dependent on the amount of energy being distributed
  - Fixed losses (1/3): Do not vary due to current

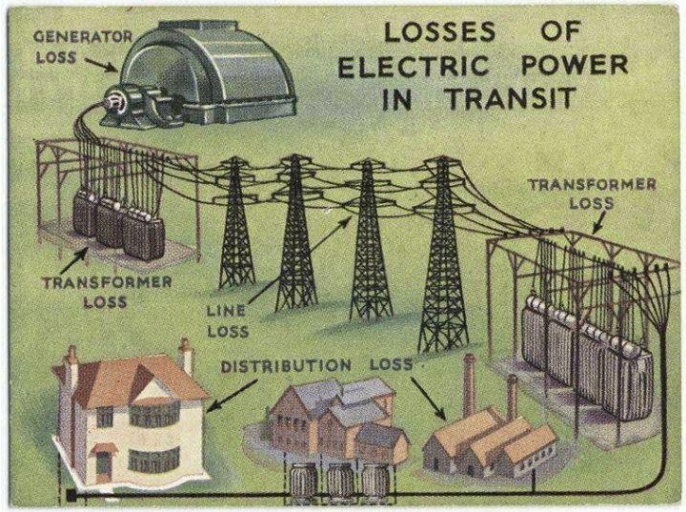


Feeder Losses

- Since variable losses can make up the majority of technical losses, the management of the energy flow is directly affected by the EGs operating within the network.

- Where EGs have low penetration, the reduced energy consumption leads to reduction in losses.

- Large feed back from EGs into the network can lead to increased losses.

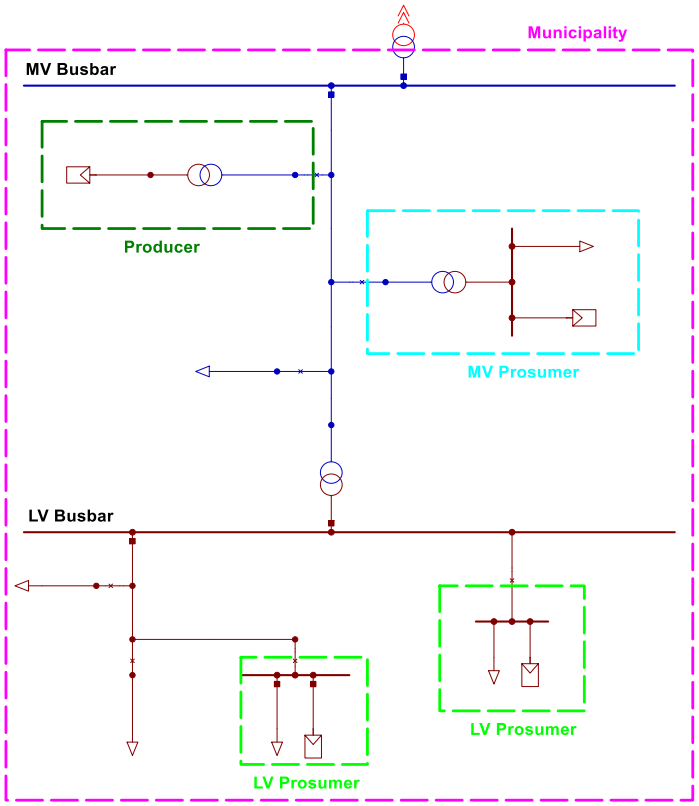


Power Quality

- Whilst RPPs use a clean source of energy,

  they are not necessarily a clean source of electricity.
- Where **the total installed EG capacity exceeds 5MW, power quality assessment is required** as per the Renewable Power Plant (RPP) gride code.
- Assessment is done by means of measurement at the POC.
- The **municipality would be required to provide the customer with apportioned harmonic limits** to check against.

Studies and Responsibilities



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Grid Impact Studies / Network Studies

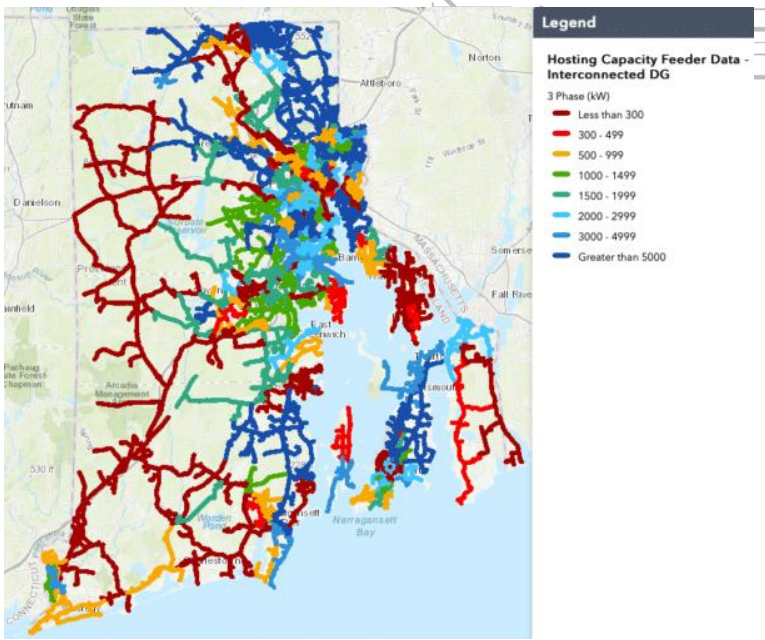
- Grid impact studies consider the **singular impact** on the network.
- It now becomes important for municipalities to **consider all the installed (and planned) EGs** and what **cumulative impact** this will have on the network.
- Will this assist municipalities with the planning and operation of the network and determine what are **maximum levels of EGs that can be accommodated in present networks**, without the need for further network strengthening

Network Studies

- NSP required to evaluate network considering all existing and planned SSEG. Studies include:
  - Feeder hosting capacity (planning)
  - Feeder Analysis
  - Load flow (thermal loading)
  - Voltage studies
  - Losses
  - Protection co-ordination studies
  - Power factor studies at main intakes
  - RVC studies
  - Short circuit current contribution
- Requires suitable representation of the NSP network model in power system simulation tool.

Hosting Capacity

Hosting capacity is generally defined as the amount of new generation or consumption that can be connected to the grid without violation of system constraints and without any network expansion

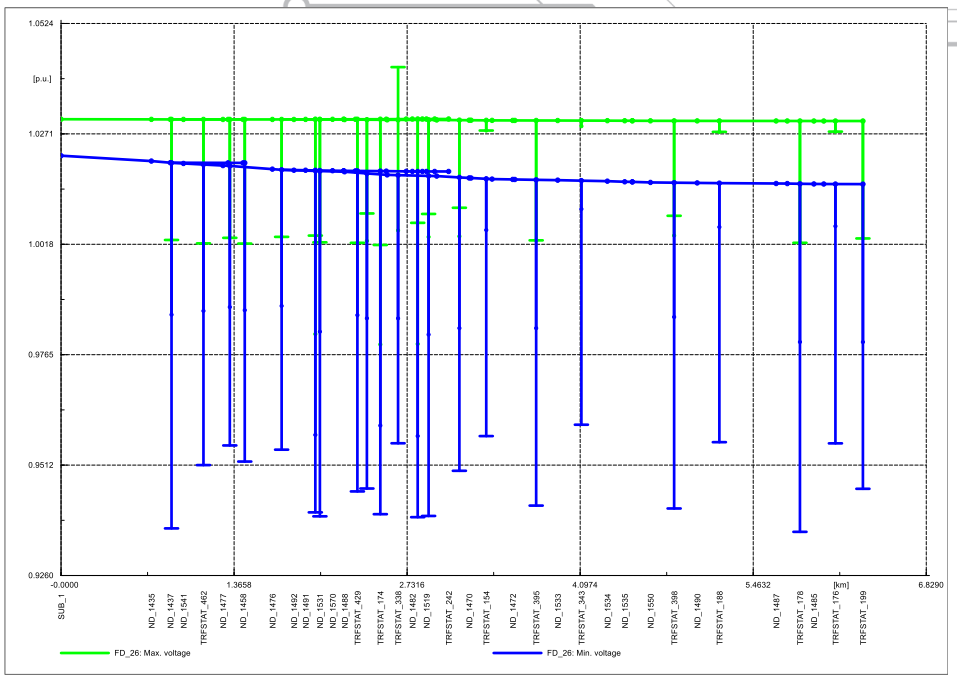


Hosting Capacity Map
https://pv-magazine-usa.com/2021/03/10/hosting-capacity-maps-a-gold-mine-for-solar-developers/

Network Studies: Voltage Profiles

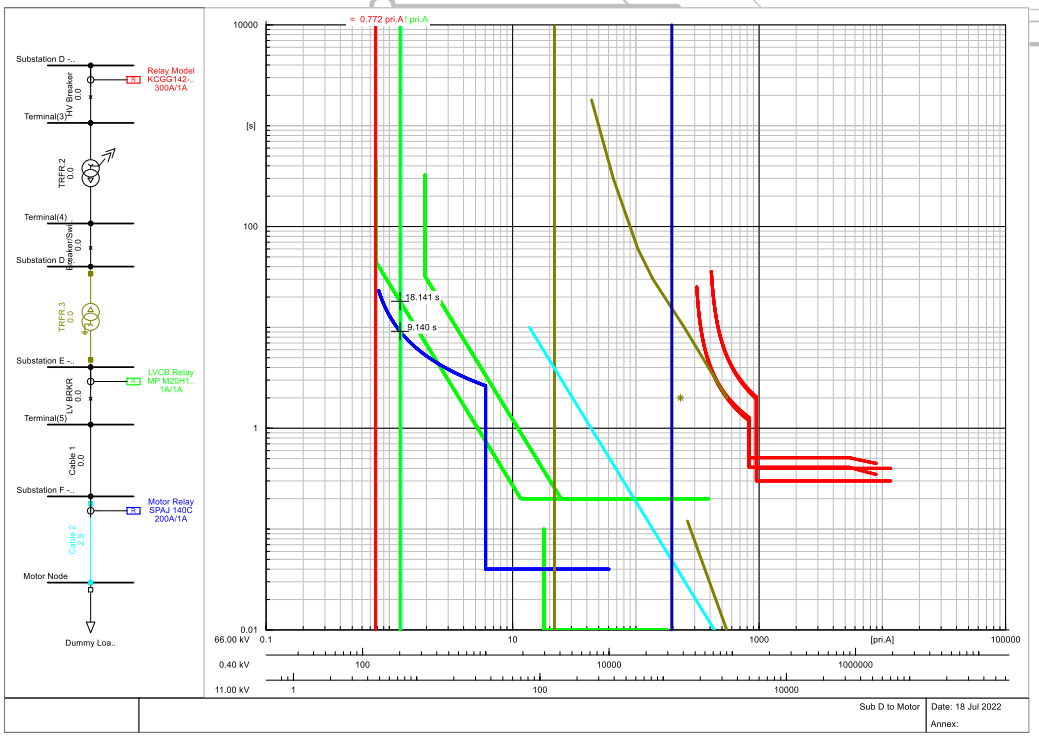
Voltage profile studies calculate the maximum and minimum voltages at a point along a feeder, when considering maximum generation and maximum consumption

Range of voltage operation



Protection

With increased short circuit current contribution from EGs, the impact on protection trip times and co-ordination needs to be evaluated.



Power Factor (at main infeed)

- Most SSEG installations are setup to maximise active power production. (Reduce electricity bill)

- RPP grid code also specifies, for SSEG up to 100 kVA, “(4) The default power factor setting shall be unity power factor, unless otherwise specified by the NSP or the SO.”

- The reactive power then becomes the network responsibility placing cumulative burden on power factor at main intake(s) points.

SSEG	P	Q	S	pf
kW	kW	kVAr	kVA	
	90	**10**	90.6	0.994
10	80	10	80.6	0.992
20	70	10	70.7	0.990
30	60	10	60.8	0.986
40	50	10	51.0	0.981
50	40	10	41.2	0.970
60	30	10	31.6	0.949
70	20	10	22.4	0.894
80	10	10	14.1	0.707
90	0	10	10.0	0.000

Importance of Grid Impact & Network Studies

Enable the municipality to:

- understand the customer's (prosumer's) behaviour.
- understand operational limits and develop operating strategies
- Identify potential risks to the network and how to mitigate it (e.g. protection co-ordination)
- Assess network capacity to accept new EG or loads, without need to upgrade the network
- Charge cost reflective tariff (losses analysis)

Now about the second question….

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Thank you

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