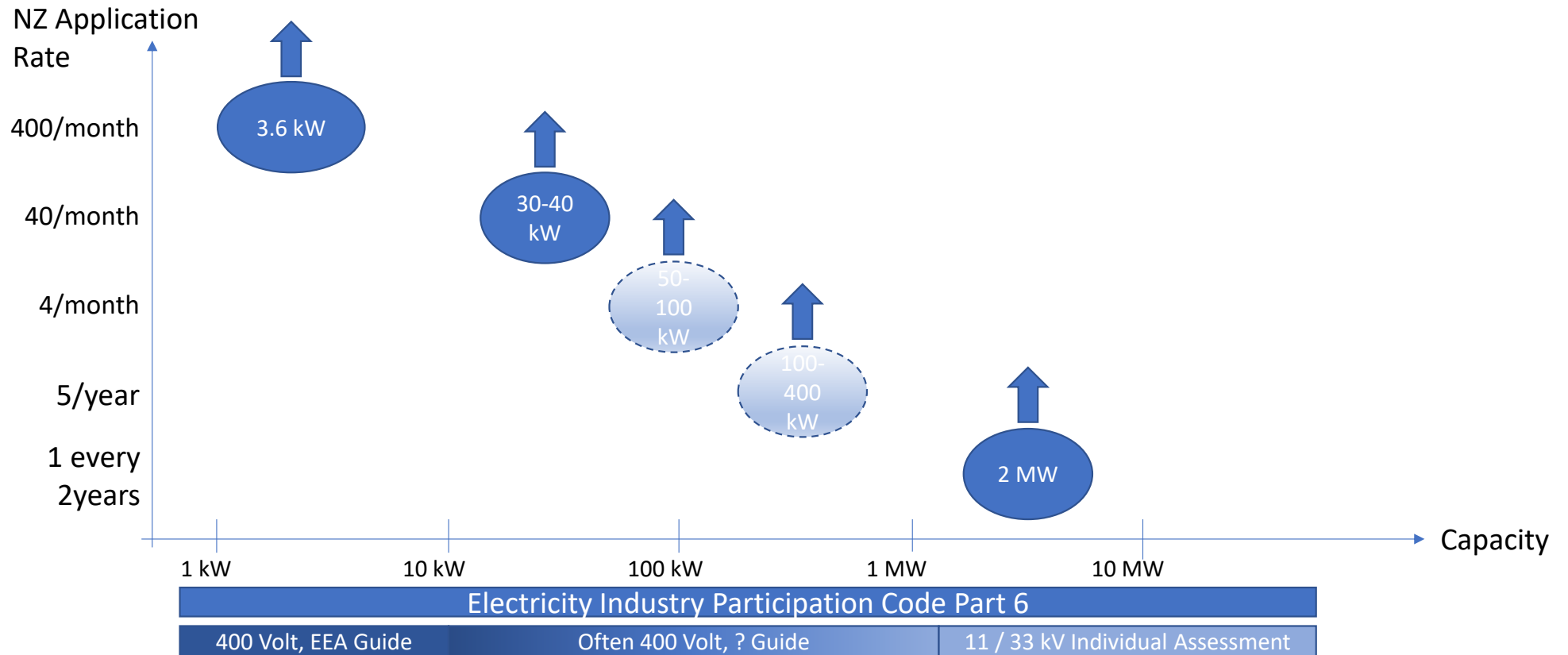# EEA Masterclass – Grid Connected Solar

Responding to an *Initial Application* by a multi-MW PV generator / Assessing Capacity

Monday 2 August 2021

Allan Miller

PV Installations

Challenge with Multi MW PV

- An EDB receives an initial application to connect a multi-megawatt solar farm

- What should the EDB do?
  - Within the $5,000 connection application fee
  - While also ensuring it will continue to provide a safe, reliable and quality supply to all connected consumers and generators

Contents

- Code Part 6 Process

- Determining Capacity – some scenarios

- Loss Factor

- Beyond the Initial Application to the Final Application

Code Part 6 Process
What should an EDB do before an application?

Important documents that a company applying to connect DG should be aware of and have:

- Electricity Industry Participation Code 2010
  - Part 6 (Connection of Distributed Generation).
    - Part 2 of Part 6 governs applications above 10 kW
  - Part 10 (Metering)
  - Schedule 6.2, Part 6 (Regulated Terms *)
- EDB Connection Information Pack *
  - 10 kW and under
  - Above 10 kW
- DG Initial & Final Application Forms *
- EDB Connection and Operation Standards *

* Required to be made publicly available by each EDB

Includes "a statement of the circumstances in with distributed generation will be, or may be, curtailed or interrupted from time to time in order to ensure that the distributor's other connection and operation standards are met"

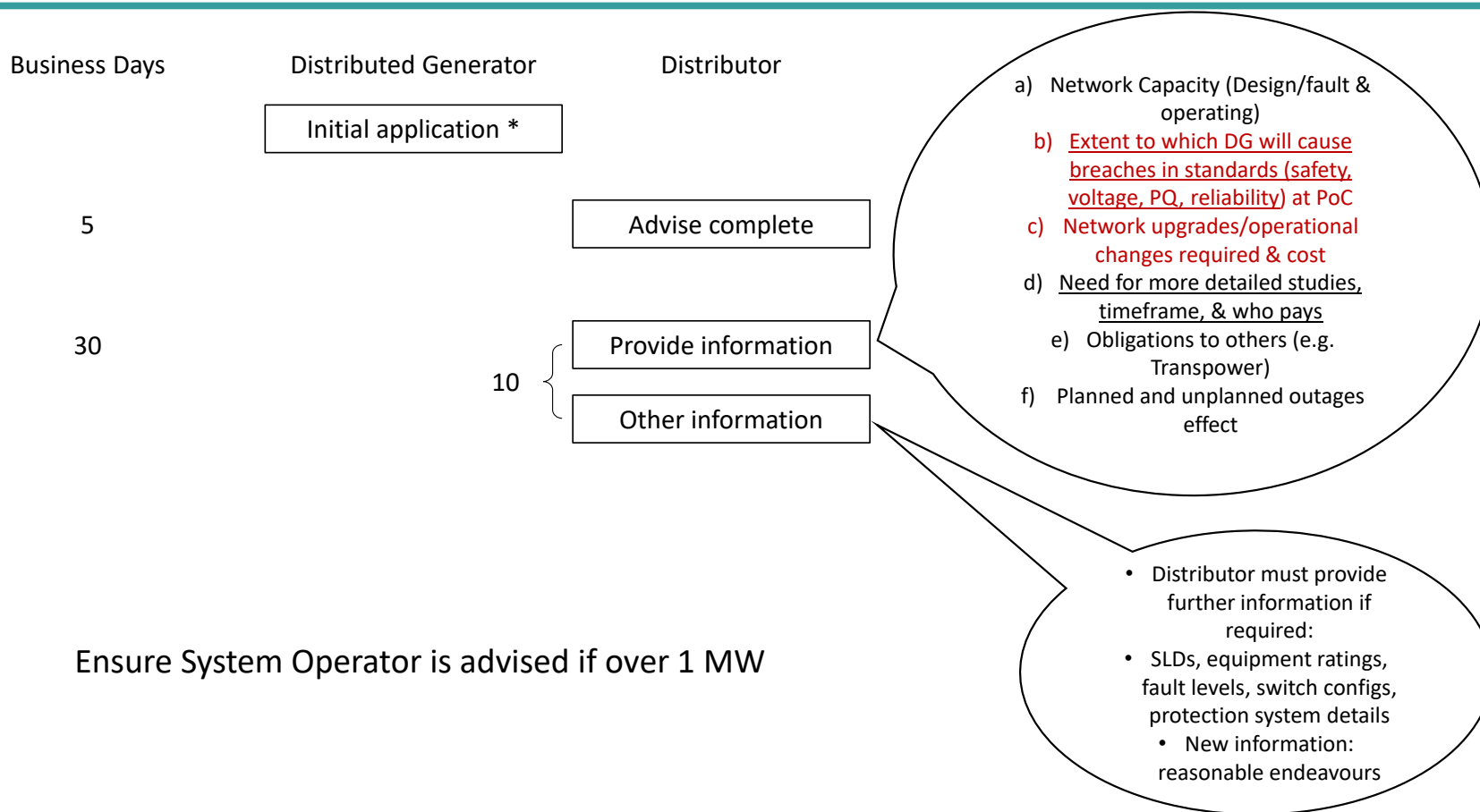Known locations subject to export congestion

Fees (prescribed)

List of makes and models of inverters approved

Contact information

Code Part 6 Process
What should an EDB do when it receives an application?

Business Days	Distributed Generator	Distributor
	Initial application *	
5		Advise complete
30		Provide information
10		Other information

a) Network Capacity (Design/fault & operating)
b) Extent to which DG will cause breaches in standards (safety, voltage, PQ, reliability) at PoC
c) Network upgrades/operational changes required & cost
d) Need for more detailed studies, timeframe, & who pays
e) Obligations to others (e.g. Transpower)
f) Planned and unplanned outages effect

- Distributor must provide further information if required:
- SLDs, equipment ratings, fault levels, switch configs, protection system details
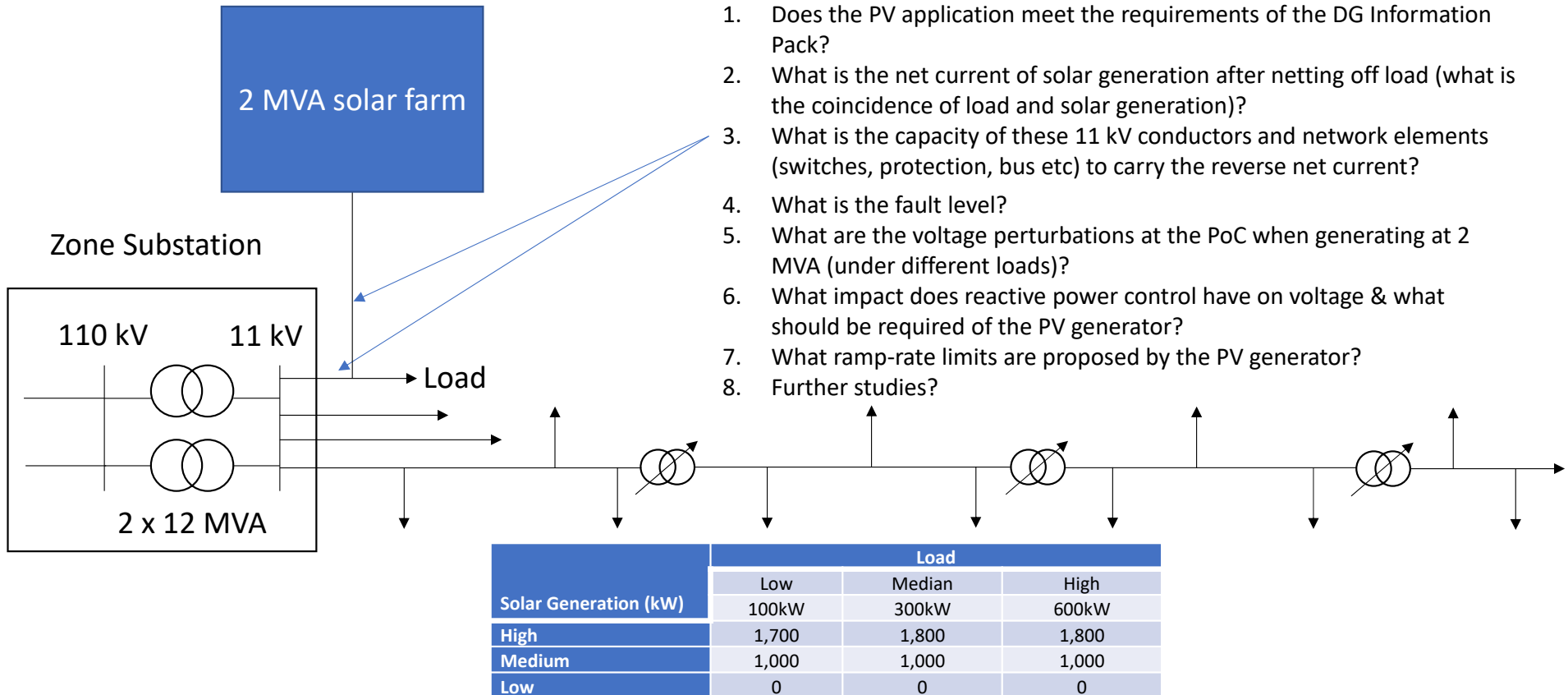- New information: reasonable endeavours

Ensure System Operator is advised if over 1 MW

Determining Capacity – some scenarios
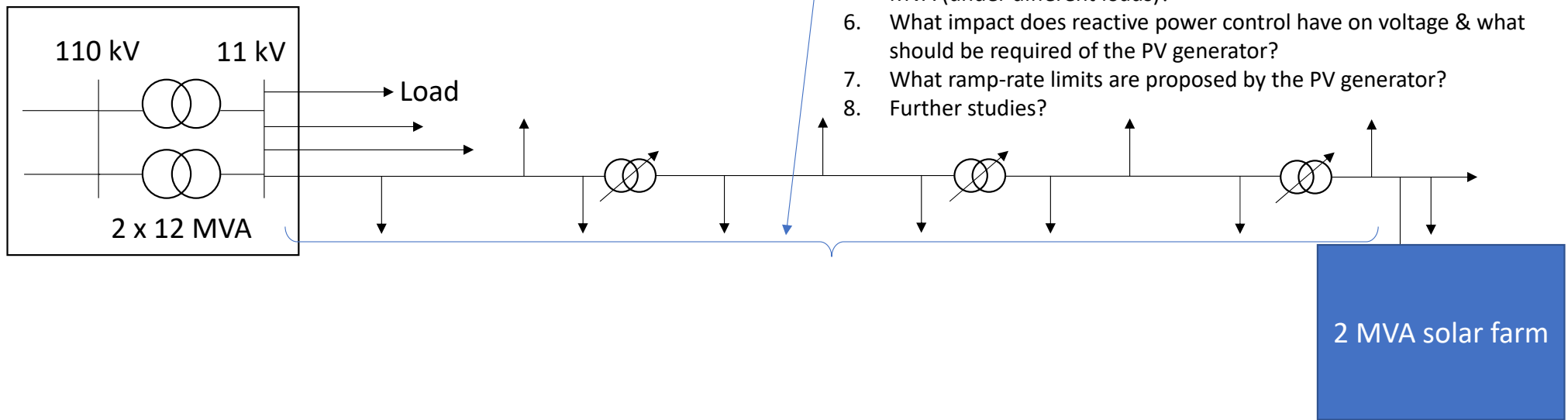
- To date

- Possible in the future

Case 1

1. Does the PV application meet the requirements of the DG Information Pack?
2. What is the net current of solar generation after netting off load (what is the coincidence of load and solar generation)?
3. What is the capacity of these 11 kV conductors and network elements (switches, protection, bus etc) to carry the reverse net current?
4. What is the fault level?
5. What are the voltage perturbations at the PoC when generating at 2 MVA (under different loads)?
6. What impact does reactive power control have on voltage & what should be required of the PV generator?
7. What ramp-rate limits are proposed by the PV generator?
8. Further studies?

Solar Generation (kW)	Load		
	Low	Median	High
	100kW	300kW	600kW
High	1,700	1,800	1,800
Medium	1,000	1,000	1,000
Low	0	0	0

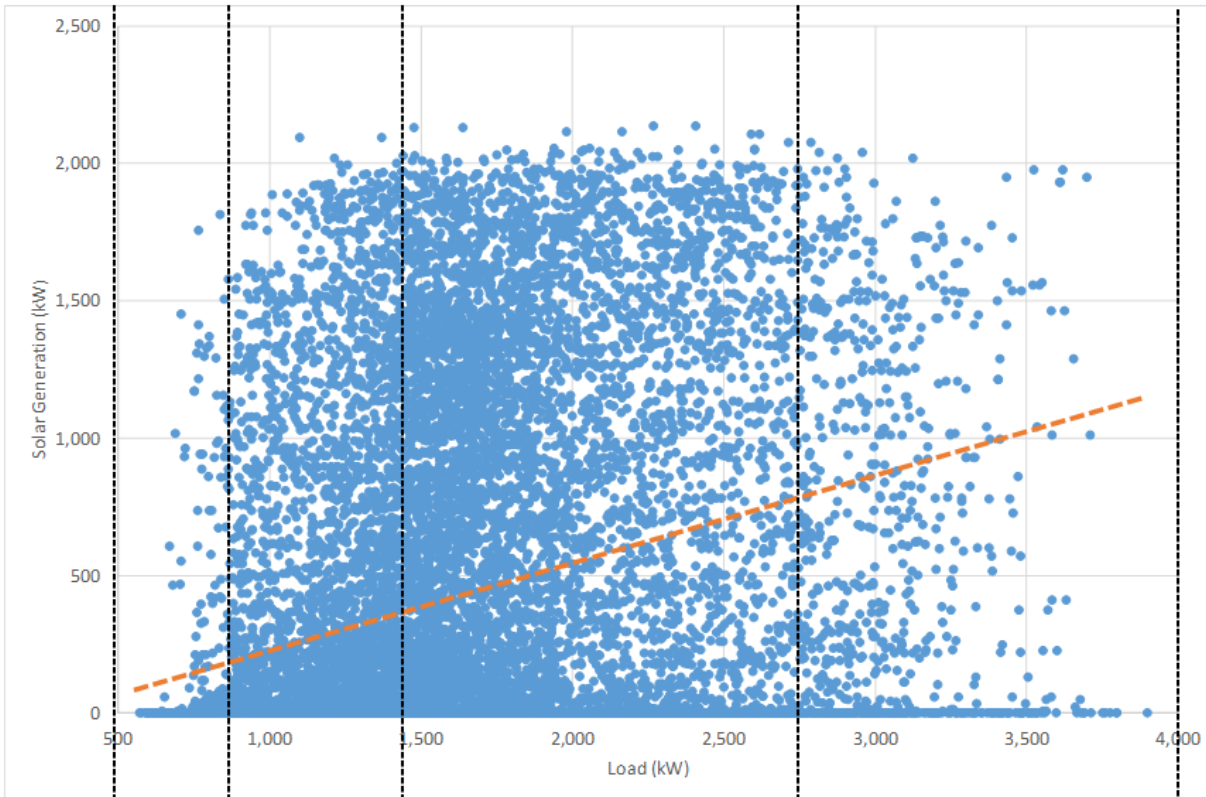# Case 2

Zone Substation

110 kV   11 kV

2 x 12 MVA

Load

2 MVA solar farm

1. Does the PV application meet the requirements of the DG Information Pack?
2. What is the net current of solar generation after netting off load (what is the coincidence of load and solar generation)?
3. What is the capacity of these 11 kV conductors and network elements (switches, protection, bus etc) to carry the reverse net current?
4. What is the fault level?
5. What are the voltage perturbations at the PoC when generating at 2 MVA (under different loads)?
6. What impact does reactive power control have on voltage & what should be required of the PV generator?
7. What ramp-rate limits are proposed by the PV generator?
8. Further studies?

Solar Generation (kW)	Load		
	Low	Median	High
	800kW	1,500kW	2,700kW
High	1,700	1,800	1,800
Medium	1,000	1,000	1,000
Low	0	0	0

Load

| Generation	Low	Median	High
High	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$
Medium	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$
Low	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$	$V_1 =$ $P_1, Q_1 =$ $V_2 =$ $P_2, Q_2 =$ $V_n =$ $P_n, Q_n =$

-Add scenarios (reactive generation, regulators)
-Rapidly becomes complex – where to draw the line between EDB studies and final application studies?

Case 2...

Case 2 further investigations and requirements

- Loading of devices along the feeder
  - Main feeder load is close to the zone substation
  - What is the load from solar powerflow in conductor sections, including spur losses
  - Regulator loading
  - How does loading change over time with solar generation and load

- Regulators
  - Ability to handle reverse power flow and regulate
  - Increased regulator action and wear
  - Solar farm ramp-rate limiting to deal with intermittent fast-moving cloud (Ramp up from 0 to 2 MW over 5 minutes / ramp down ?)

- Dynamic stability and voltage stability

- Inverter voltage control

Future
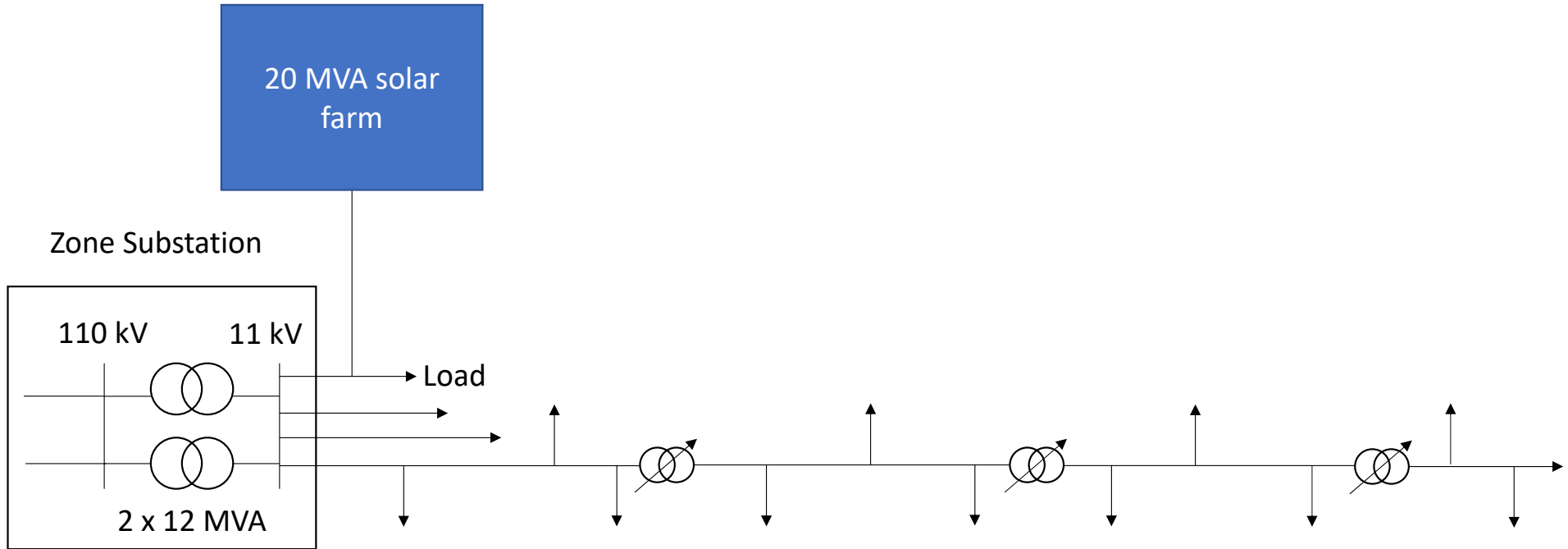
Future
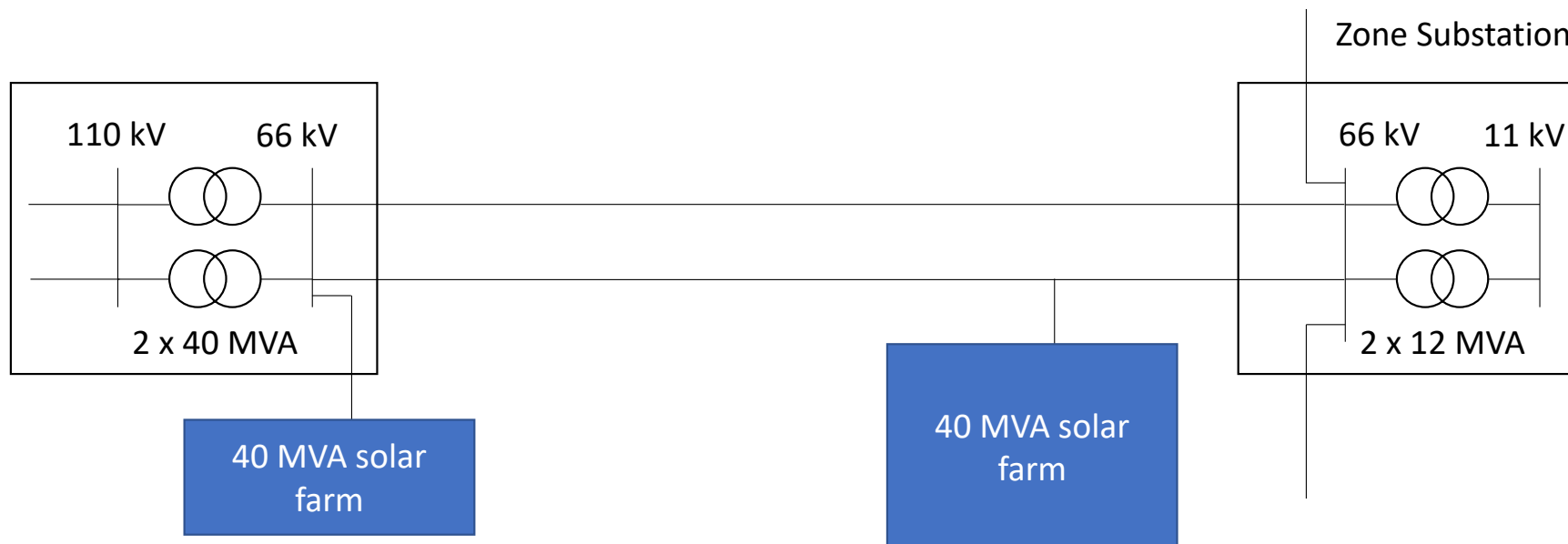
Summary

- The connection voltage and location of a proposed solar farm affects the depth and extent of investigation required

- Requires experience, practice is developing

Loss Factor

- Often assumed that DG will lower losses
- This depends on its location, operation, feeder load, and feeder characteristics
- May be a U-shaped curve

Case 2

Losses (y-axis), Solar Generation (x-axis)

High feeder load
Median feeder load
Low feeder load
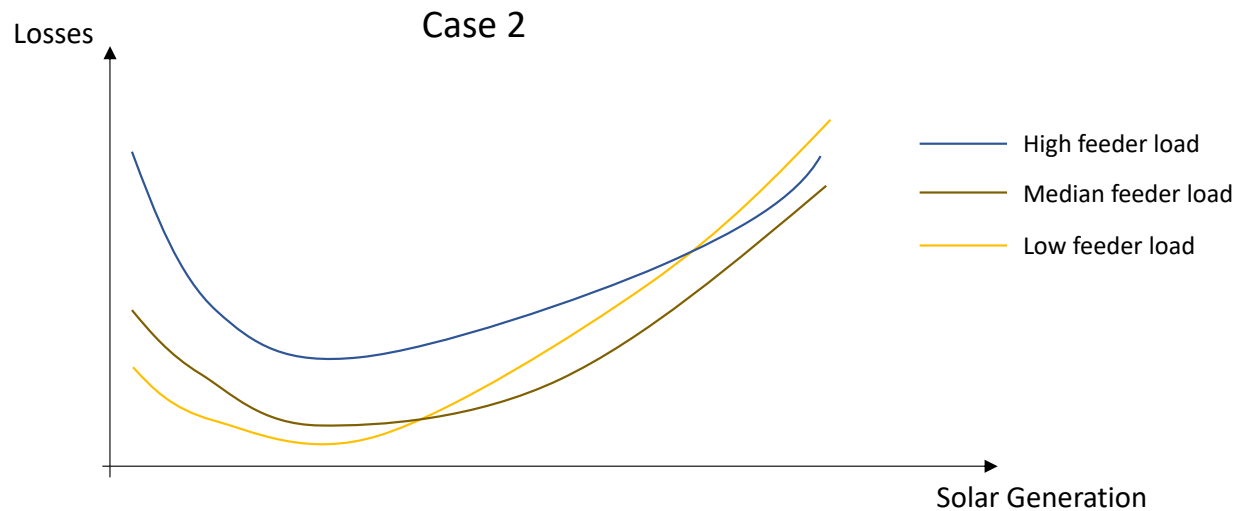
- The code sets out the loss factor calculation methodology –solar generation vs load matrix (Case 2) is needed for this
- Depending on the EDB's loss factor policy they may wish to update the loss factor / apply to the DG

Beyond the Initial Application

ANSA

Business Days | Distributed Generator | Distributor

Initial application *

5 — **Advise complete**

Part 6, Part 2, 12, 13 & 14

Outline information a distributor must provide

30 — **Provide information**

10 — **Other information**

In-depth investigations if required:
- Steady state power flow
  - Protection
  - Dynamic stability
  - Voltage stability
  - Harmonic studies
  - Flicker studies
- Agree who carries these out and funds them

Brad & Noel

Doesn't mean that the distributor must approve final application though (18). If declining, must give detailed reasons.

DG can report breaches to the Electricity Authority

Within 12 months — **Final Application**

10 — **Notice to third parties**

45 (< 1MW) — **Give approval or decline notice (with conditions and reasons, charges)**

Intention to proceed

- NB: Distributor must be satisfied that DG will comply with Health and Safety at Work Act 2015 and Electricity Industry Act 2010
  - Meets Connection and Operation Standards