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Translating "Agnostic" DER Hosting Capacity to Specific DER Types

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Each DER has its own characteristics

There are many types of DER being interconnected to the grid today

- Photovoltaics
- Energy Storage
- Microgrids
- Wind
- Cogeneration
- Etc…

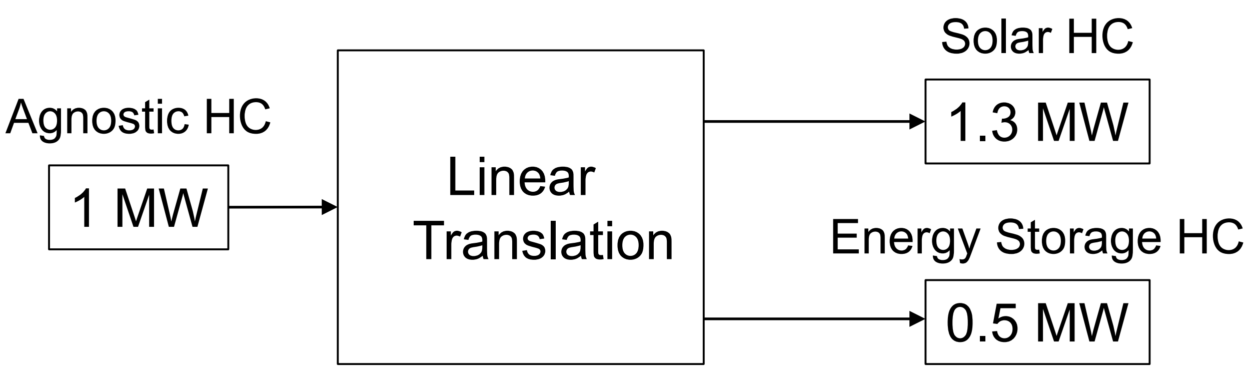
Each DER type has characteristics that can influence **hosting capacity**

- Power Output Variability
- Fault Current Contribution
- Power Factor

How do we calculate hosting capacity for multiple DER types?

- Method 1: Run Multiple Analyses
  – Run HC analysis for each DER type

- Method 2: Use Agnostic Hosting Capacity
  – Run HC analysis for a generic DER type once
  – Use linear multipliers to translate generic HC to HC for each specific DER type



Hosting Capacity Criteria

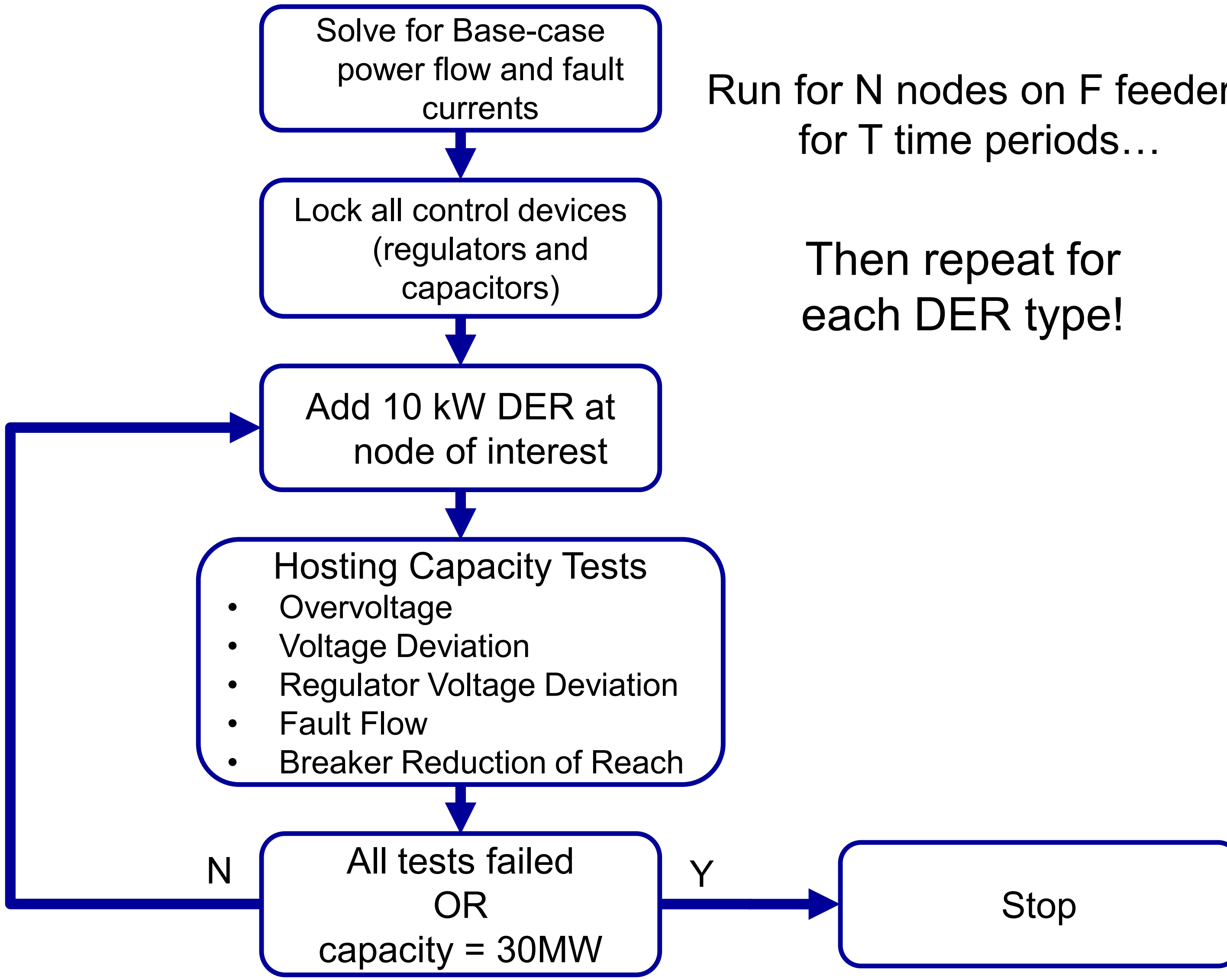
Voltage issues

- Overvoltage
- Voltage Deviation
- Regulator Voltage Deviation

Protection Issues

- Fault Flow
- Breaker Reduction of Reach

Detailed Hosting Capacity Method



Run for N nodes on F feeders for T time periods…

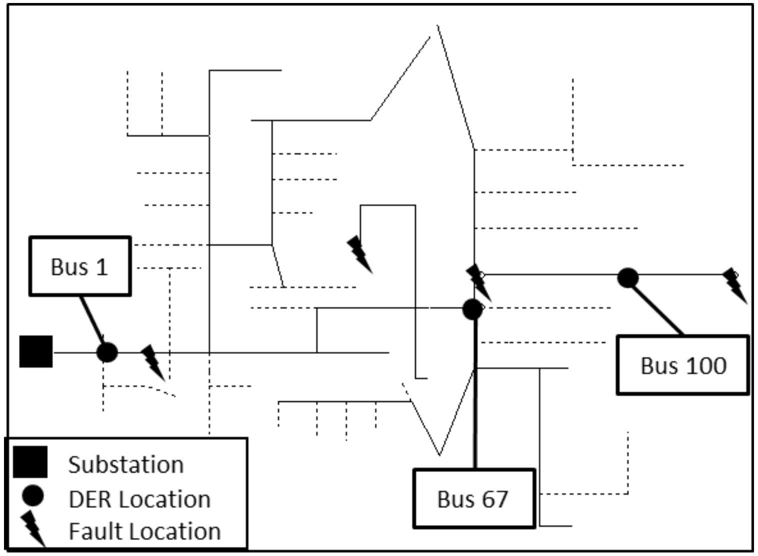
Then repeat for each DER type!

Hosting Capacity Translation Factors

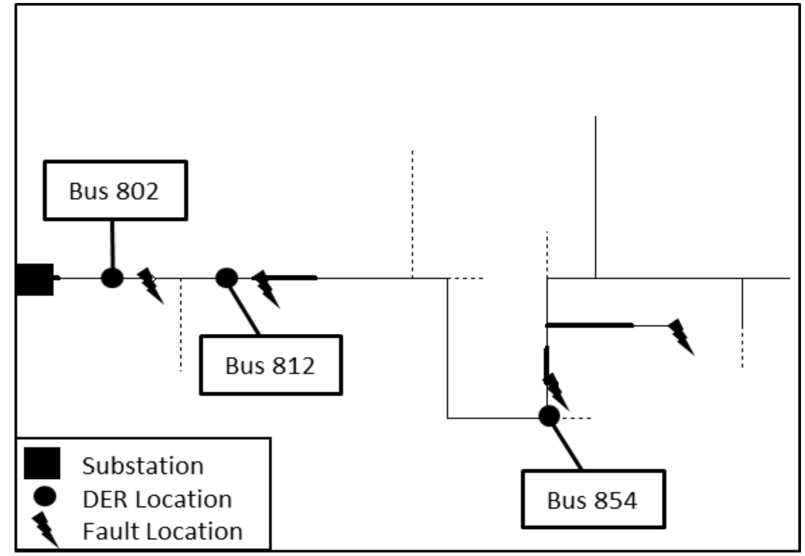
Voltage Deviation	Protection
$k_{\Delta P} = \frac{\Delta P_{agnostic}}{\Delta P_{specific}}$	$k_{If} = \frac{I_{f,agnostic}}{I_{f,specific}}$
$HC_{specific} = k \times HC_{agnostic}$	

Test cases

IEEE 123-bus



IEEE 34-bus



DER type	Power Fluctuation, ΔP	Fault Current, I_f	Power Factor
Agnostic	100%	2 pu	Unity
PV	60%	1.2 pu	Unity
Storage	200%	2 pu	Unity
Synchronous	20%	6.13 pu*	Unity
Wind	40%	4.36 pu*	.91

*Fault current varies. Maximum fault current is used here.

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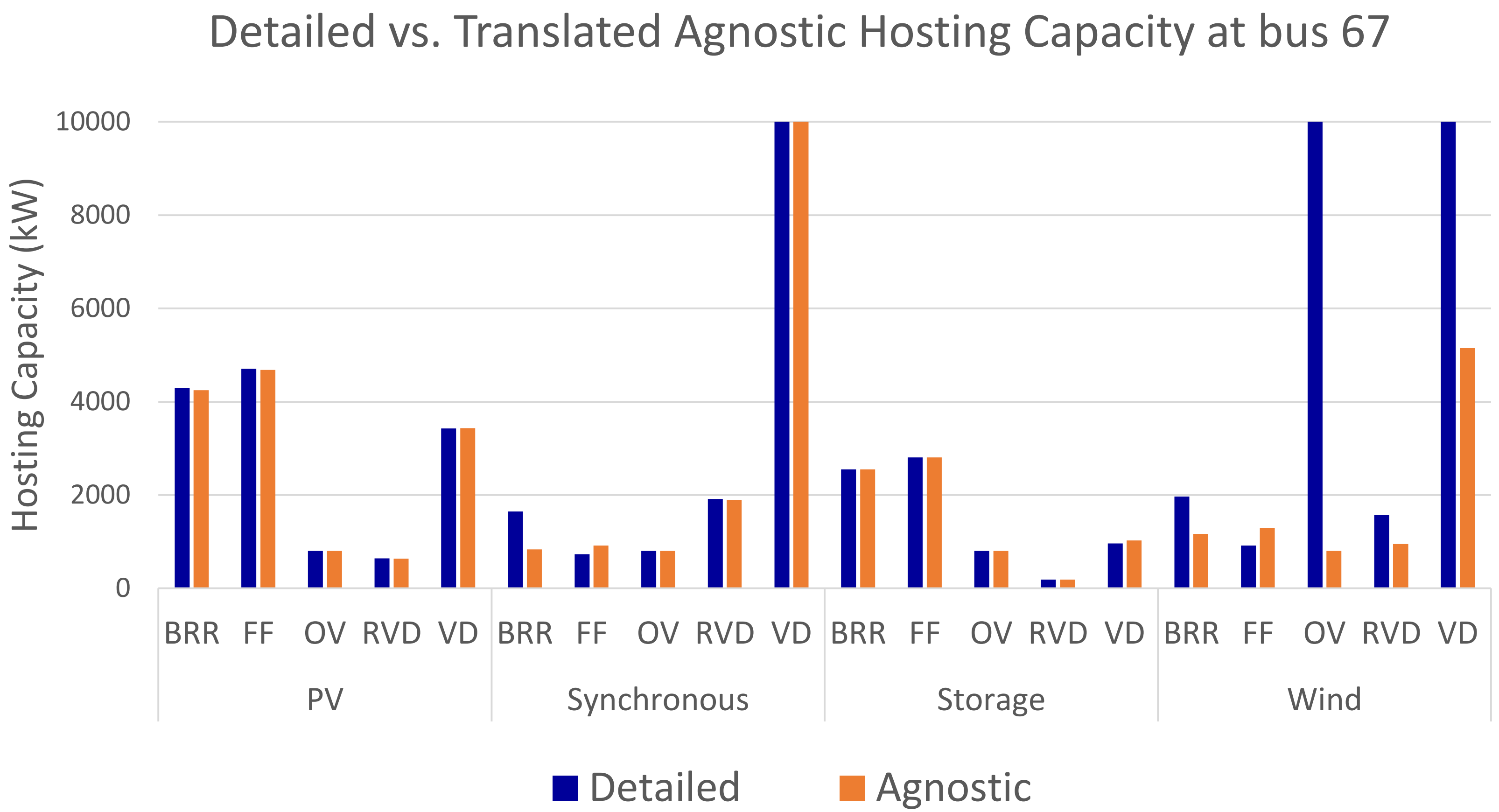
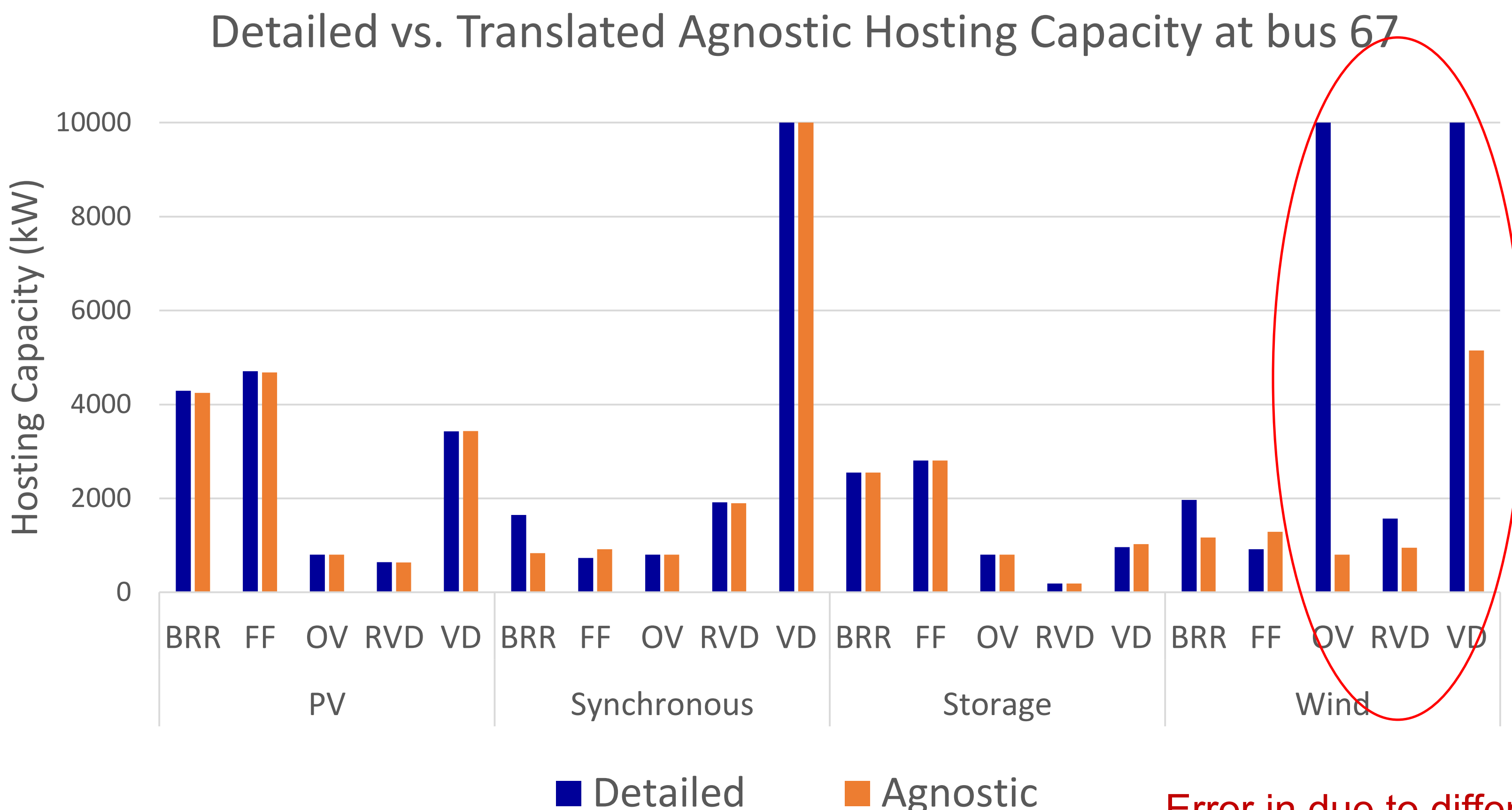
How does agnostic translation compare to the detailed method?



BRR – Breaker Reduction of Reach
FF – Fault Flow
OV – Overvoltage
RVD – Regulator Voltage Deviation
VD – Voltage Deviation

How does agnostic translation compare to the detailed method?



Error in due to difference in power factor

BRR – Breaker Reduction of Reach
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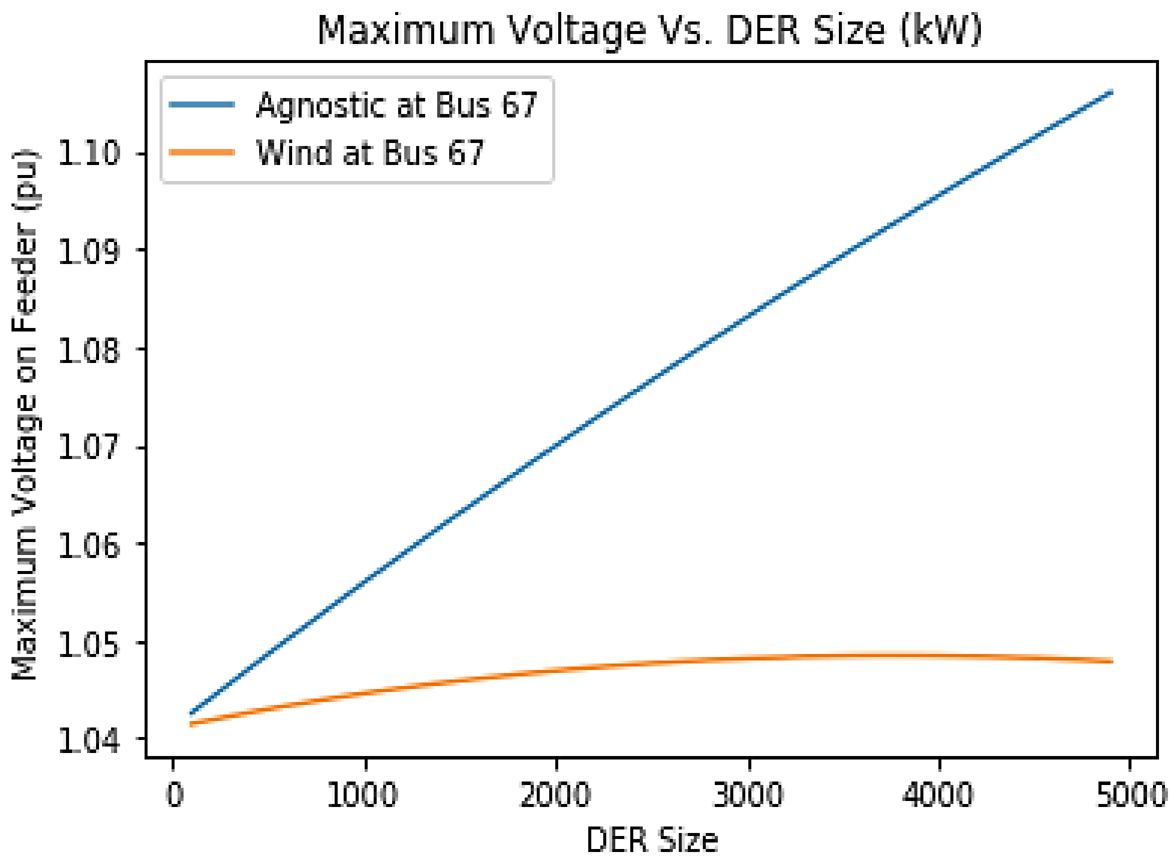
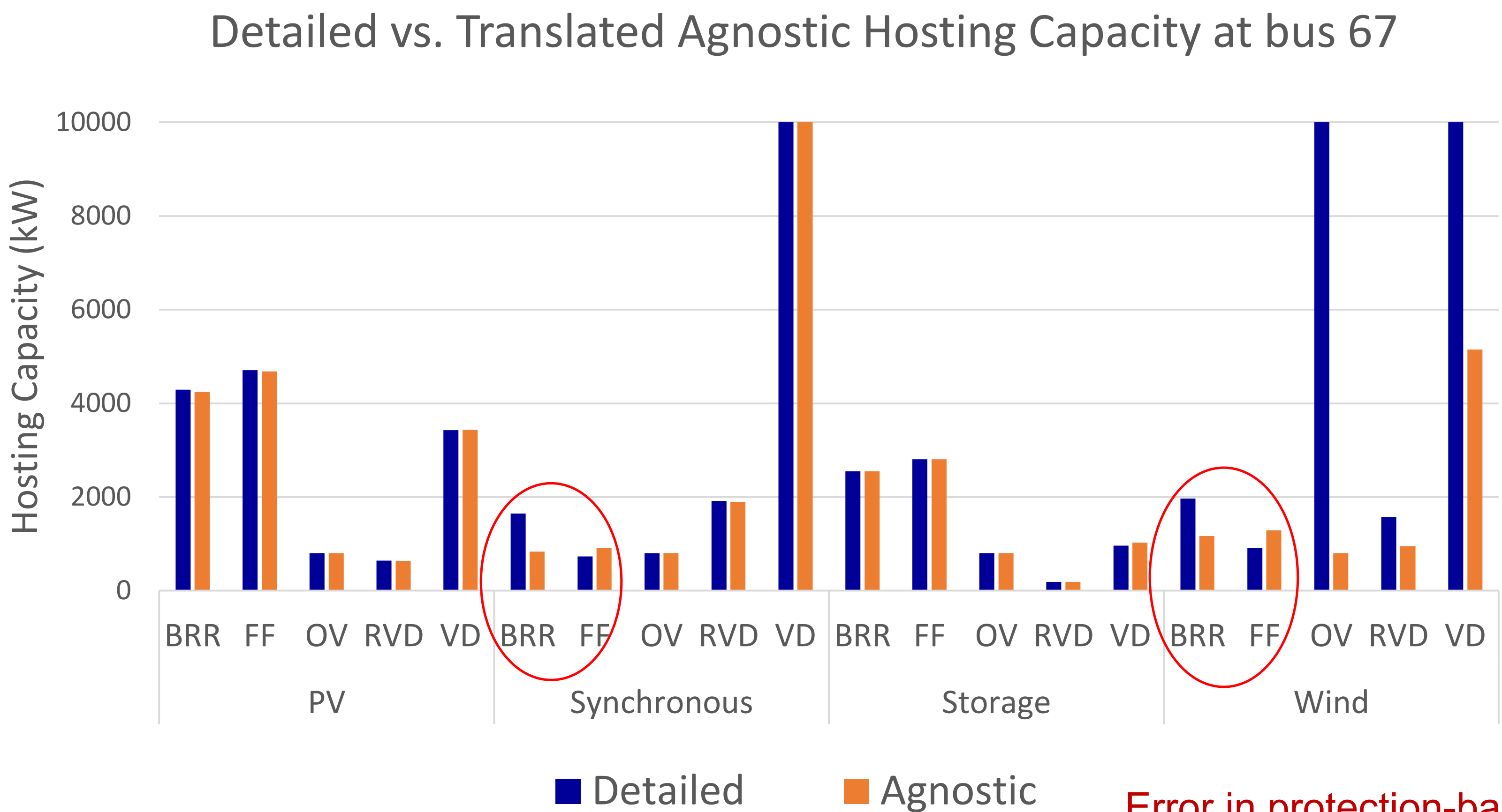
Power Factor Affects All Voltage Issues



The induction wind generator absorbs reactive power, which counteracts voltage rise.

How does agnostic translation compare to the detailed method?



Error in protection-based hosting capacity

BRR – Breaker Reduction of Reach
FF – Fault Flow
OV – Overvoltage
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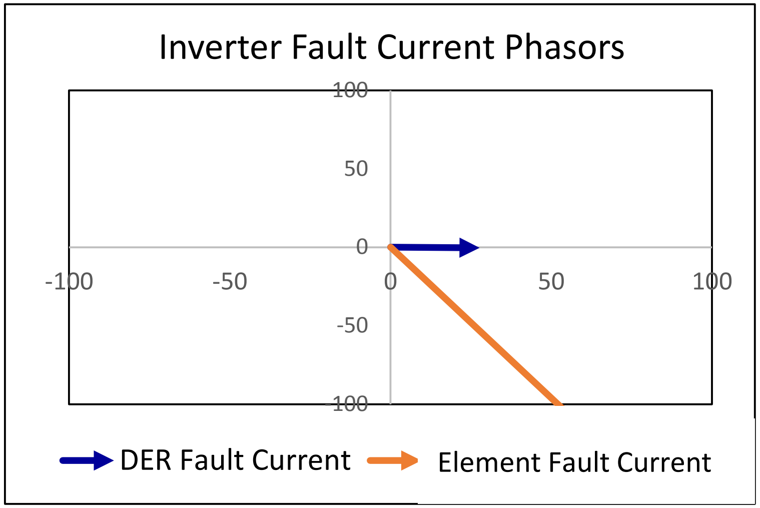
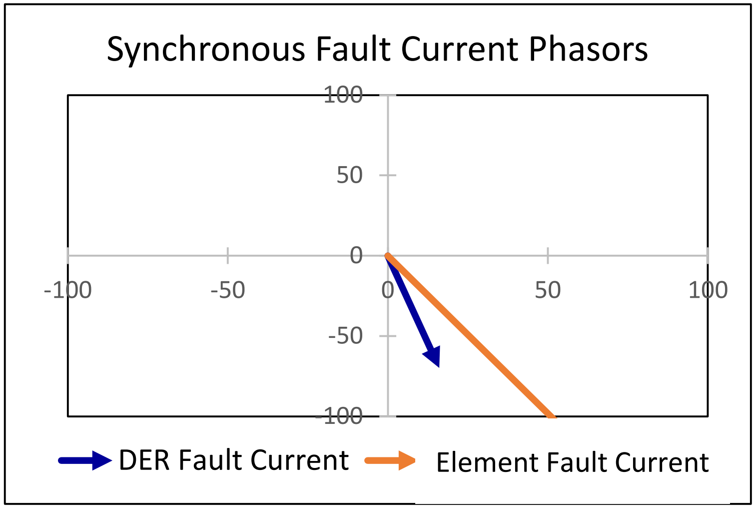
Protection Error

Inverter-based generators produce fault current that is more out-of-phase with system fault current





These don’t affect total fault current in the same way;

We need an additional factor to account for this phase difference

Conclusions

	Inverter-Based	Non-Inverter-Based	Non-Unity Power Factor
Overvoltage	✓	✓	✗
Voltage Deviation	✓	✓	✗
Regulator Voltage Deviation	✓	✓	✗
Fault Flow	✓	✗	✗
Breaker Reduction of Reach	✓	✗	✗

- Translation factors are effective for inverter-based DERs.
- More work is needed to address the difference in fault current phase angle to improve performance for non-inverter-based DERs
- More work is needed to address differences in DER power factor.

Backup Slides

Translation Derivation

DER type	Power Fluctuation, ΔP	Fault Current, I_f	Power Factor
Agnostic	100%	2 pu	Unity
PV	60%	1.2 pu	Unity

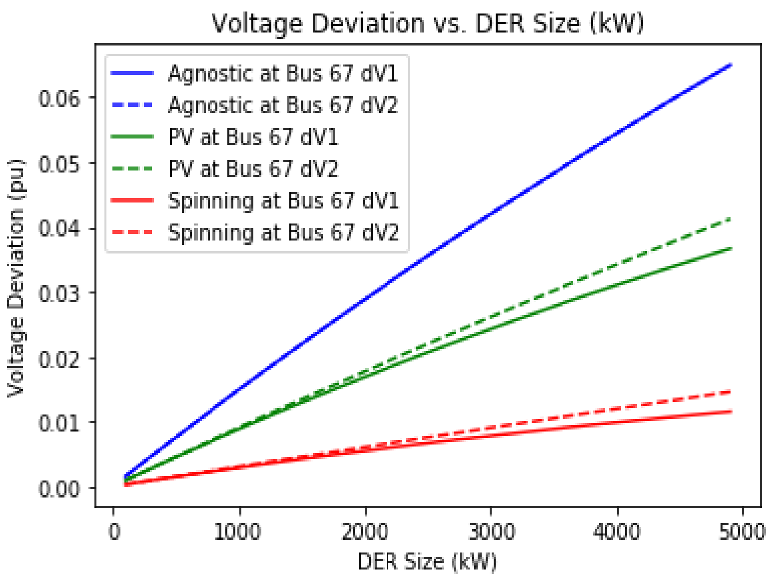
From the detailed analysis, we know that agnostic DER has a voltage deviation hosting capacity of 1 MW.

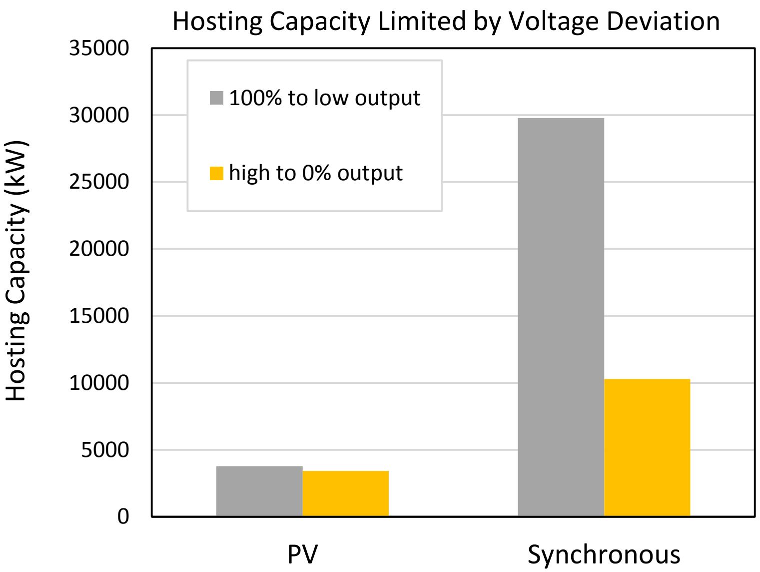
This means that $1\text{ MW} \times 100\% = 1\text{ MW}$ of power fluctuation results in a 3% voltage deviation.

PV power output is expected to fluctuate by only 60%. So, it takes $\frac{1\text{ MW}}{60\%} = 1.67\text{ MW}$ of PV to cause 1 MW of power fluctuation.

Thus, the ratio of agnostic to PV hosting capacity is $\frac{100\%}{60\%} = \frac{\Delta P_{agnostic}}{\Delta P_{PV}} = k_{\Delta P}$

Voltage Deviation Considerations





- Voltage deviation depends on DER active power variability
- Losses affect voltage deviation from large DERs
- Testing for voltage deviation at multiple operating points improves accuracy

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