eleXsys®

Enabling Smart Grids

Hosting Capacity & Voltage Management

Version Nov 2021

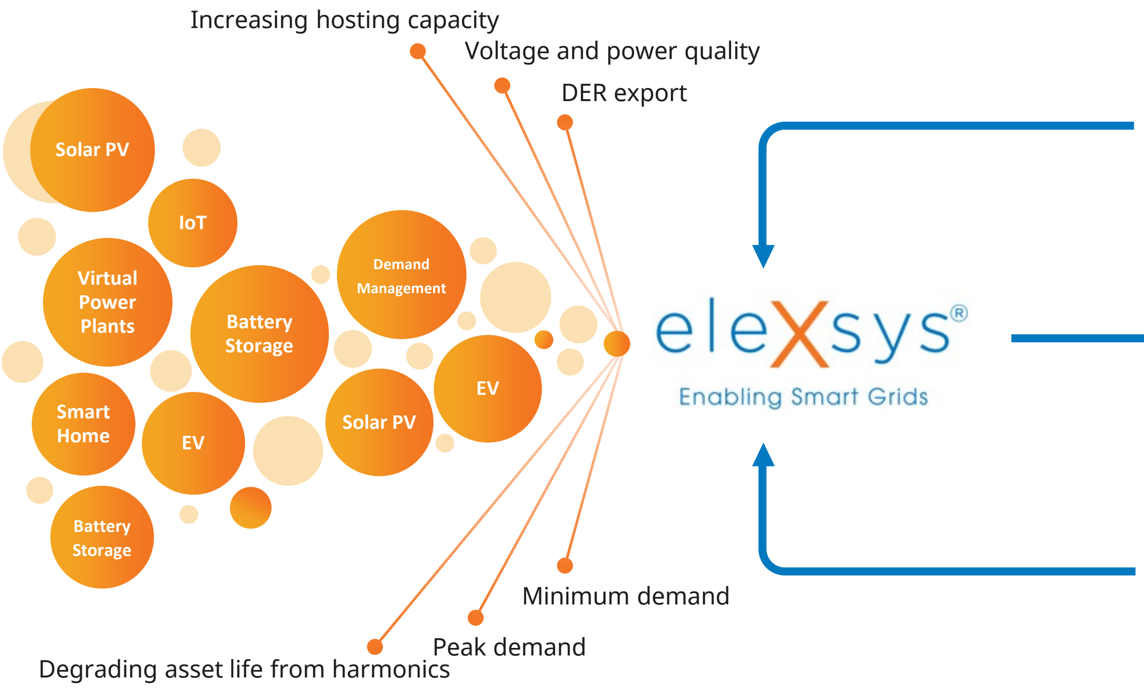
Enabling Distributed Energy on Electricity Grids Worldwide

Proven, Industry-Leading Technology with Cornerstone Customer Signed

Established Business

Problems eleXsys solves

Customers are changing the way they use energy at the grid edge



Customer Outcome

- Reduced barriers
- Reduced utility interactions
- Increased DER return
- Equitable outcome
- Greater trust

Grid Outcome

- Increased power quality
- Increased reliability
- Increased asset utilisation
- Increase hosting capacity
- Lower carbon footprint
- Visibility and control

How is eleXsys used?

Utility

Grid-Scale Voltage Management

- Grow hosting capabilities
- Improve power quality
- Voltage management and pacification along a feeder, circuit
- Dynamic var support
- Conservation voltage reduction

Commercial & Industrial

DER Maximiser Voltage Management-as-a-Service

- Increase solar capacity
- Overcome connection agreement limitations
- AI Logic to use, store, shift or trade solar energy
- Maximise revenue from DER investment
- Solar and micro wind

EV Demand Management

- Remove grid-side Disturbances from EV fast charging
- Reduce demand charges
- Overcome connection agreement limits

Battery-as-a-Service

- Shares capacity across several uses
- Improve battery asset life
- Peak lopping
- UPS backup
- Trade excess capacity

Microgrid-as-a-Service

- Grid forming
- Islanding
- Maximise solar capacity
- Coordination of battery storage
- Peak lopping
- Trade excess energy
- 10 x bigger and NET Zero

Off Grid

Off-Grid Clean Energy Microgrids

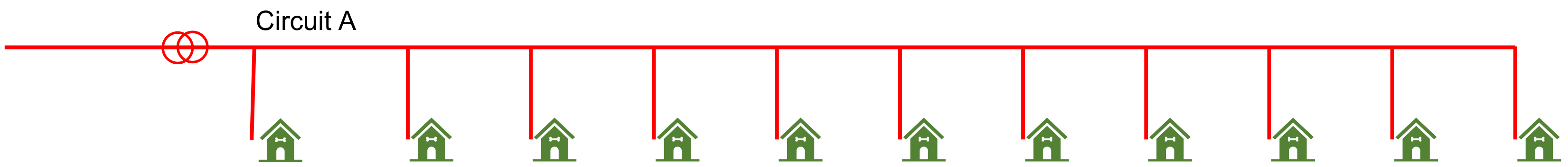
- Reliance on expensive energy generated by diesel
- Off grid Microgrid cheaper & more reliable
- Applicable to 1st world and developing world
- Removes reliance on obsolete and aging infrastructure

powered by eleXsys® AI technology platform

Hosting Capacity

Load Only | Dist Gen | eleXsys Volt Mgmt | eleXsys Dist Gen

Voltage Rise from Distributed Generation

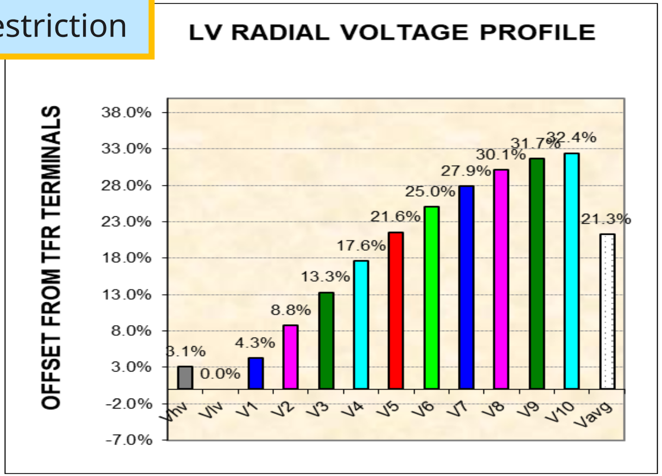


- For solar / battery inverters to connect to the grid, they raise the voltage to inject energy.
- Customers further away from the transformer have to continually increase the voltage
- Utilities have traditionally limited customer connections and sizes of distributed generation to the 15% rule

Example

- If all customers on a LV circuit had 30KW of solar and were unrestricted on voltage the voltage would increase by 32% as shown on graph
- 100% of the total transformer thermal limit.

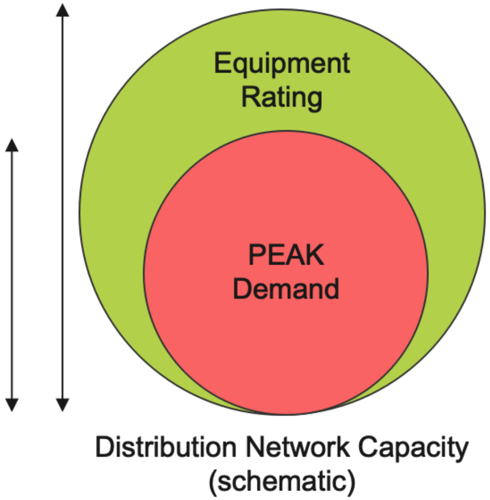
No Restriction



Hosting Capacity Definitions

100% Hosting Capacity Rating Based

100% Hosting Capacity NREL Definition



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Techniques to Improve Hosting Capacity

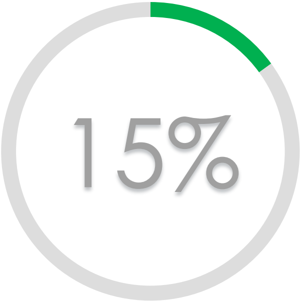
Utilities are pursuing multiple paths to increase hosting capacity with the common methods being:

1. Oversized smart inverters
2. OLTP Transformers
3. Dynamic Limitations
4. Zone substation voltage feedback from smart meter
5. Storage

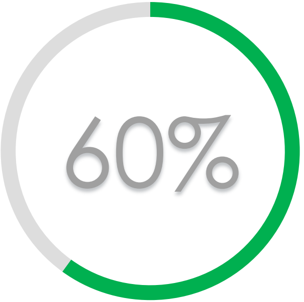
Here are some of the examples in the Australian market captured by Energeia Consulting.

Category	Solution		Capex	Opex	Units
Consumer	Water Heater Management – Controlling Existing		$150	$15	kW
	Pool Pump Management - Controlling Existing		$50	$15	kW
	Storage Management - Controlling Existing		$50	$15	kW
Pricing	Coarse (e.g. ToU pricing), excl. smart meter		Negligible	$0	Customer
Signals	Granular (e.g. real-time pricing), excl. smart meter		$12m	$250k	DNSP
Technical Standards	Inverter Standards		Negligible	$0	DNSP
	Remote Inverter Configuration		Negligible	$0	Country
	Static Limitations		Negligible	$0	DSNP
	Dynamic Limitations		$6m	$250k	DNSP
Reconfiguration	Change Taps		Negligible	$1-2k	Trip
	Change Topology		$200k-$660k	$0	Feeder
	Change UFLS		$100k-$150k	$0	Feeder
	Change Protection		$1,000	$0	Feeder
	Balance Phases		Negligible	$1.5-$2k	Trip
New Methods	Third Party Data	New Install	$500	$5	Customer
		Previous Install	Negligible	$5	Customer
	Better Long – Term Forecasts		$8m	$250k	DSNP
New Assets	LV Metering		$3,500	$30	Transformer
	Voltage Regulators		$300,000	2.5% of capex	Regulator
	Larger Assets		$100k-$400k	2.5% of capex	Asset
	On-Load Tap Changer	Vault	$120k	$7k	Transformer
		Pole-Mounted	$60k	$7k	Transformer
	Harmonic Filters		$500k	$0	Substation
	Statcom (Single-Phase)		$5-8k	2.5% of capex	LV Phase
	Network Storage		$550	2.5% of capex	kWh

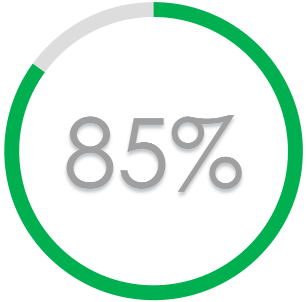
Hosting Capacity – Limits in the USA (Hawaii)



Initial limit of distributed generation capacity on the network to ensure MV voltages and protection are not disturbed

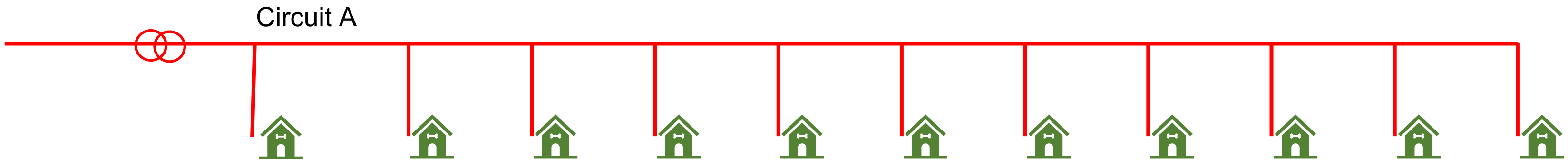


Network limit achieved with smart inverters using
volt-var and volt-watt controls.
At the expense of the customer



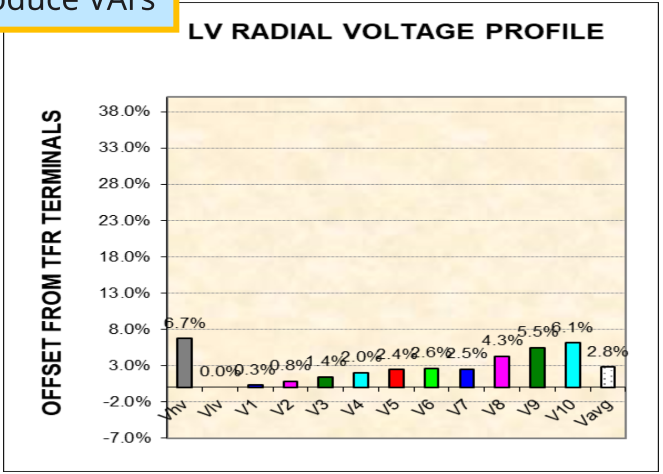
Limits obtained using switched capacitors and smart inverters.

Smart Inverter Approach



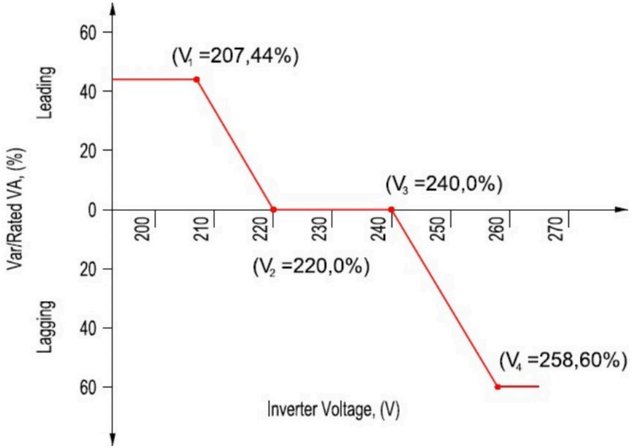
- Example all 10 customers have 30KW of solar PV
- 100% distribution transformer rating
- Smart inverters at every premise enable the voltage profile to remain within standards
- However, each premise would be creating 18kVAR meaning that all 10 premises have created 180kVAR. There is also a 60kW energy loss.

All inverters produce VArs

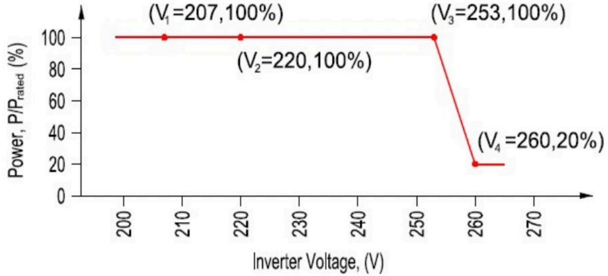


DER Voltage Regulation via Smart Inverter Settings to further harm DER

Updated SMART Inverter Settings for Volt/Var



Updated SMART Inverter Settings for Volt/Watt Output

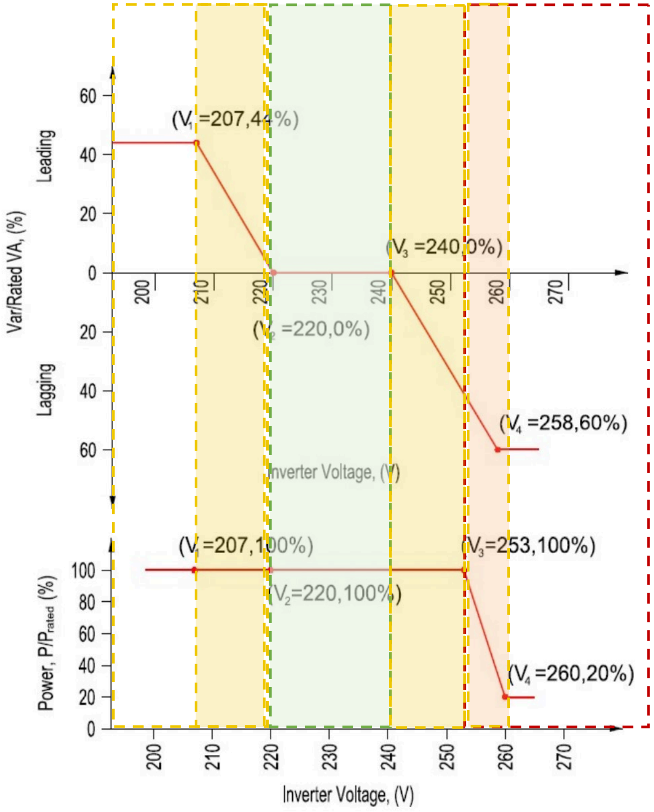


- Updated Smart Inverter framework to respond to increasing DER rollouts
- New Smart Inverter settings to trigger volt-watt, volt-var operations
- Maximum non-loss Voltage level set at 240 Volts only
- Beyond 240 volts, VARs start being produced; and
- Beyond 253 Volts, the inverters are derated (volt-watt)
- USA standards are tighter with a very small real power element.

DER Voltage Regulation via Smart Inverter Settings to further harm DER

Updated SMART Inverter Settings for Volt/Var

Updated SMART Inverter Settings for Volt/Watt Output



- Allowed Inverter Voltage for 100% Real Power
- Anything > 240 V to be curtailed via VAR generation requirements.

- VAR creating mandate to start already at 240 Volts causing significant reduction in real power
- Smart Inverters typically require 2-Watt real power for every 3-VAR in reactive power to get created
- Based on actual Voltage levels real power losses of up to 60% possible

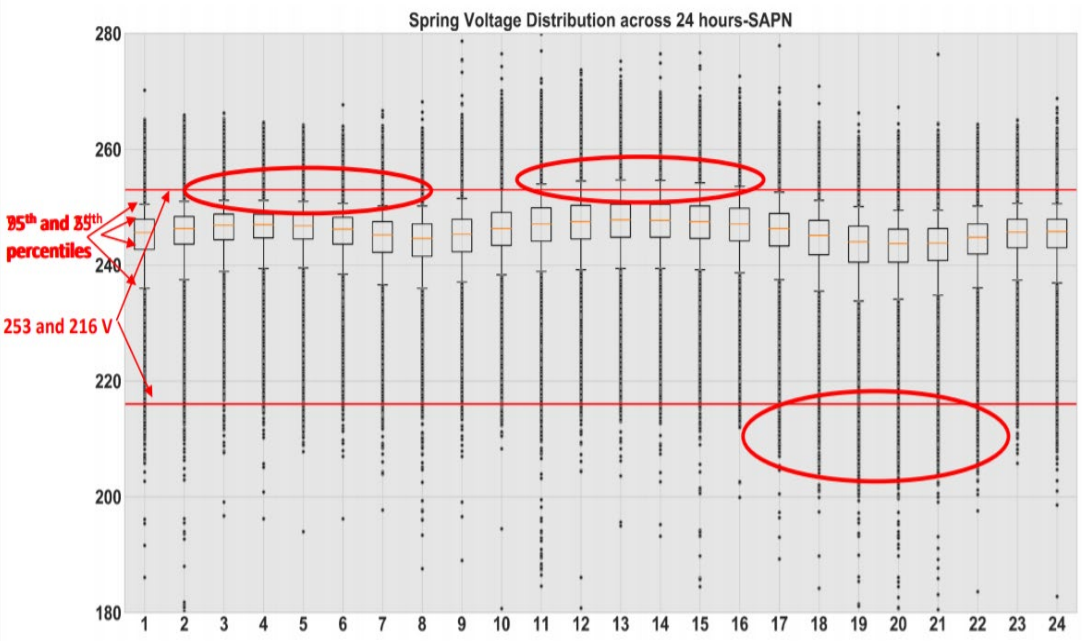
- Further Watt limitations beyond 253 Volts to lead to nearly full curtailment

Voltage issues in Australia

The key finding of the UNSW report is that, even in the absence of solar PV, there is a significant level of high voltage across all DNSPs in all NEM states as highlighted in the following chart.

The nominal voltage standard in the NEM is 230V - more than 95% of readings were found to be higher than this.

In South Australia, average maximum voltages frequently sit near the upper bound of 253V over the entire year, although they are generally highest in Autumn and Spring, when State demand is typically lower and PV performance is relatively good.



Load Only | Dist Gen | eleXsys Volt Mgmt | eleXsys Dist Gen

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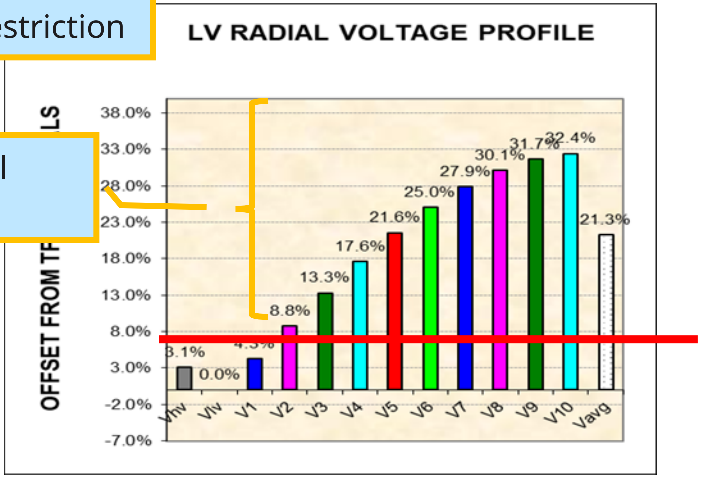
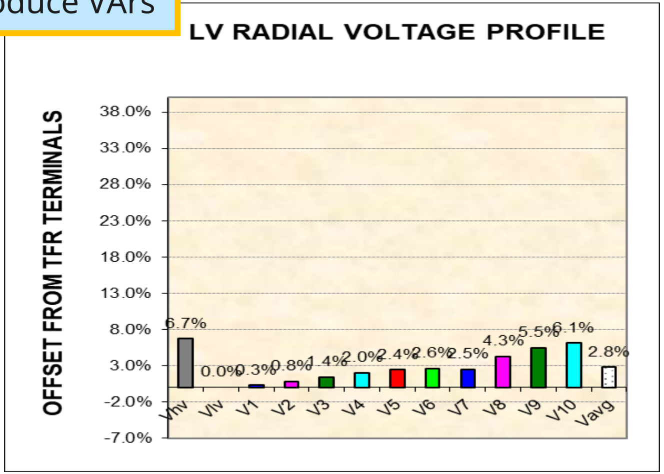
Smart Inverter Approach

No Restriction

Curtailed Real Energy



All inverters produce VArs



- The creation of the VARs means that the customer are losing the Real Power benefits on their tariff.
- These 10 inverters would lose a total of 60kW of their generation capacity, which is 20% of inverter capacity.
- The lost real energy is also lost to the market operator

- VAR production happens at every premise and is not in the optimal location
- Customers further away from the transformer are affected more than customers closer to the transformer which is not an equitable outcome

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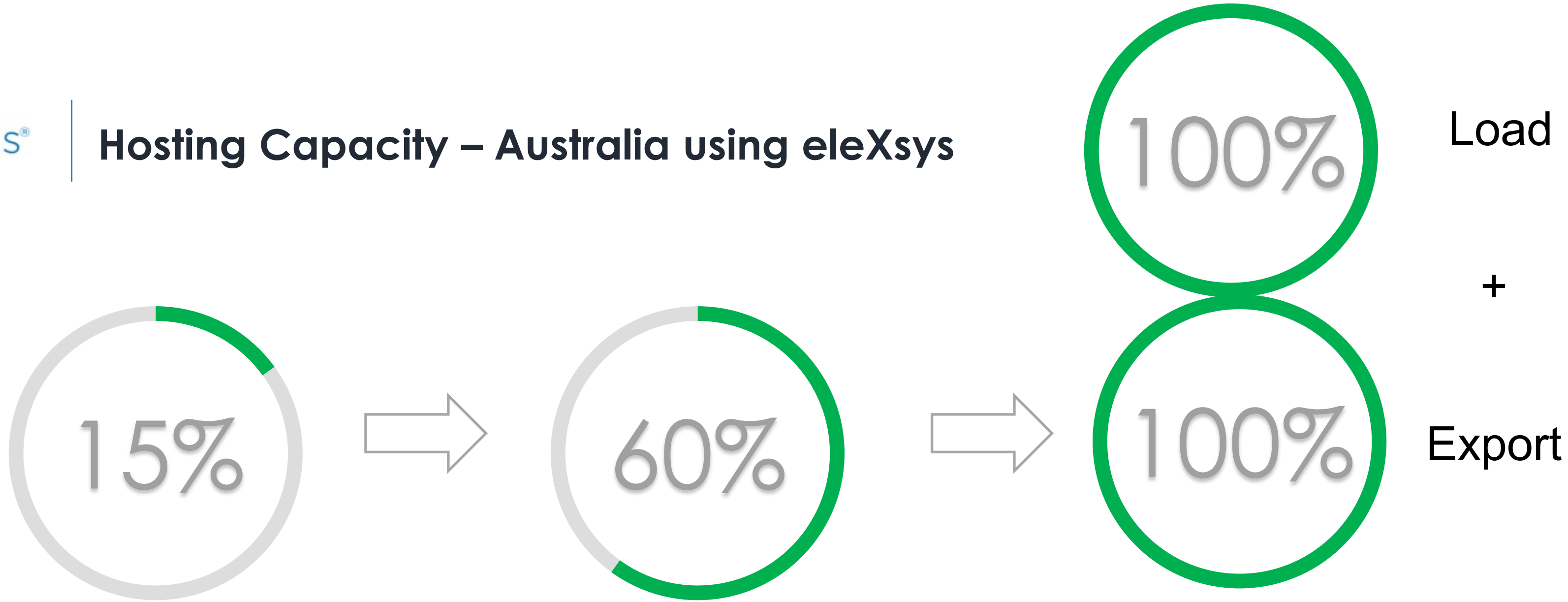
Hosting Capacity – Australia using eleXsys

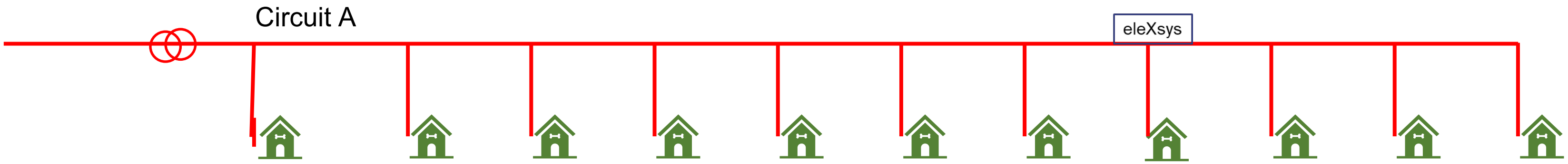


Initial limit of distributed generation capacity on the network to ensure MV voltages are not disturbed

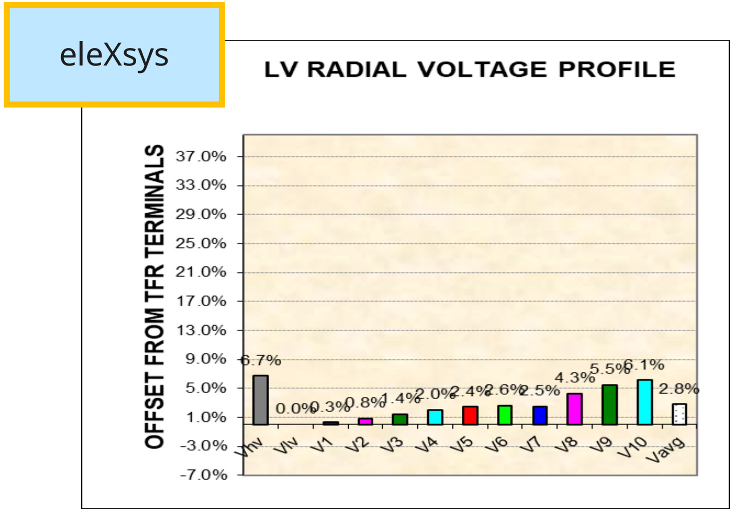
Network limit achieved with smart inverters using volt-var and volt-watt controls.

Limits obtained using eleXsys enable that the network to accommodate (100% Load + 100% Export)

eleXsys Approach



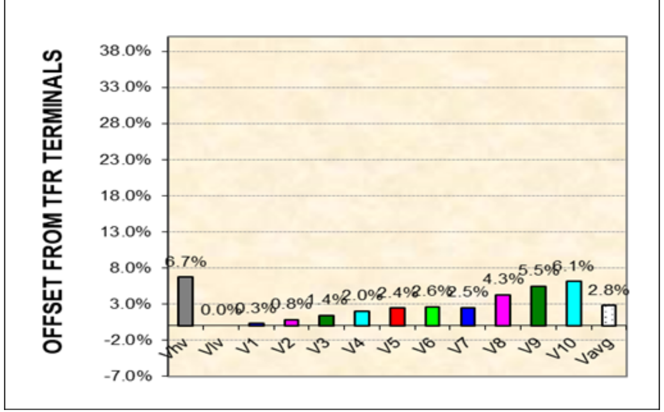
- eleXsys operates in the dead band
- Voltages are all maintained within standards
- Smart inverters at every premise remain in unity power factor
- 90 kVAR of eleXsys capacity at a single location
- Transformer thermal limits maintained with 100% load and 100% export



ELEXSYS HOLDINGS LTD
Commercial in Confidence

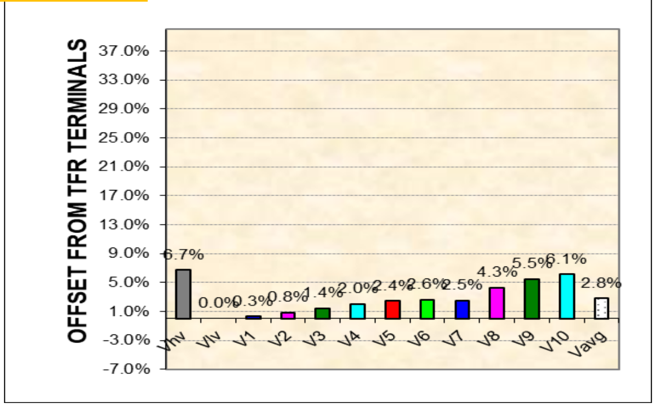
Smart Inverter – eleXsys Comparison

All inverters produce VARs



- Great voltage outcome
- For the 30KW example each premise would create 18kVAR for a total of 180kVAR and 60kW loss.
- Customer equity and lost real power issues
- Insufficient VAR capacity to move beyond 60% hosting capacity

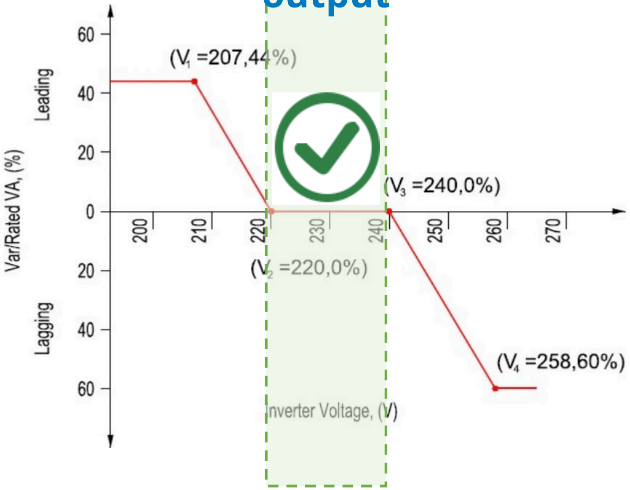
eleXsys



- Great voltage outcome
- eleXsys installed in the optimal location, in front or behind the meter
- Total 90kVAR produced and 6kW loss
- All customer inverters remained in unity pf with no real energy lost and provides equitable access.

eleXsys can guarantee to keep Voltages in the 100% Output Range → SECURE your Investments with eleXsys RETROFIT

100% within any set Voltage band to guarantee output



Never exceed set Smart Inverter Voltage bands

- eleXsys to guarantee keeping voltages within any band set
- Flexible adjustments once regulations change
- Smart Inverters in an eleXsys supported network don't enter any curtailment band (direct and indirect)

Operate at Unity Power Factor for DER

- eleXsys to handle any required reactive power / VAR creation and allows inverter to operate at unity power factor
- eleXsys creates required VARs before any Smart Inverter reaches set trigger values
- No loss from volt-var on smart inverters

Customer additional costs to oversize equipment verses eleXsys

Customer intention was to purchase a 30KW solar system for their home, however it was derated by 20% as their system was required to produce VARs which meant a 6kW loss.

- Purchase price for 1 x 30kW system is $31k
- For all 10 customers this is a price of $310k

Due to a 6kW loss for each customer totaling 60kW, this is a total loss of $62k of solar investment. This also means the customers 10c FiT adds up to a $9700 pa lost value.

The cost to implement the 3 eleXsys units is $21k

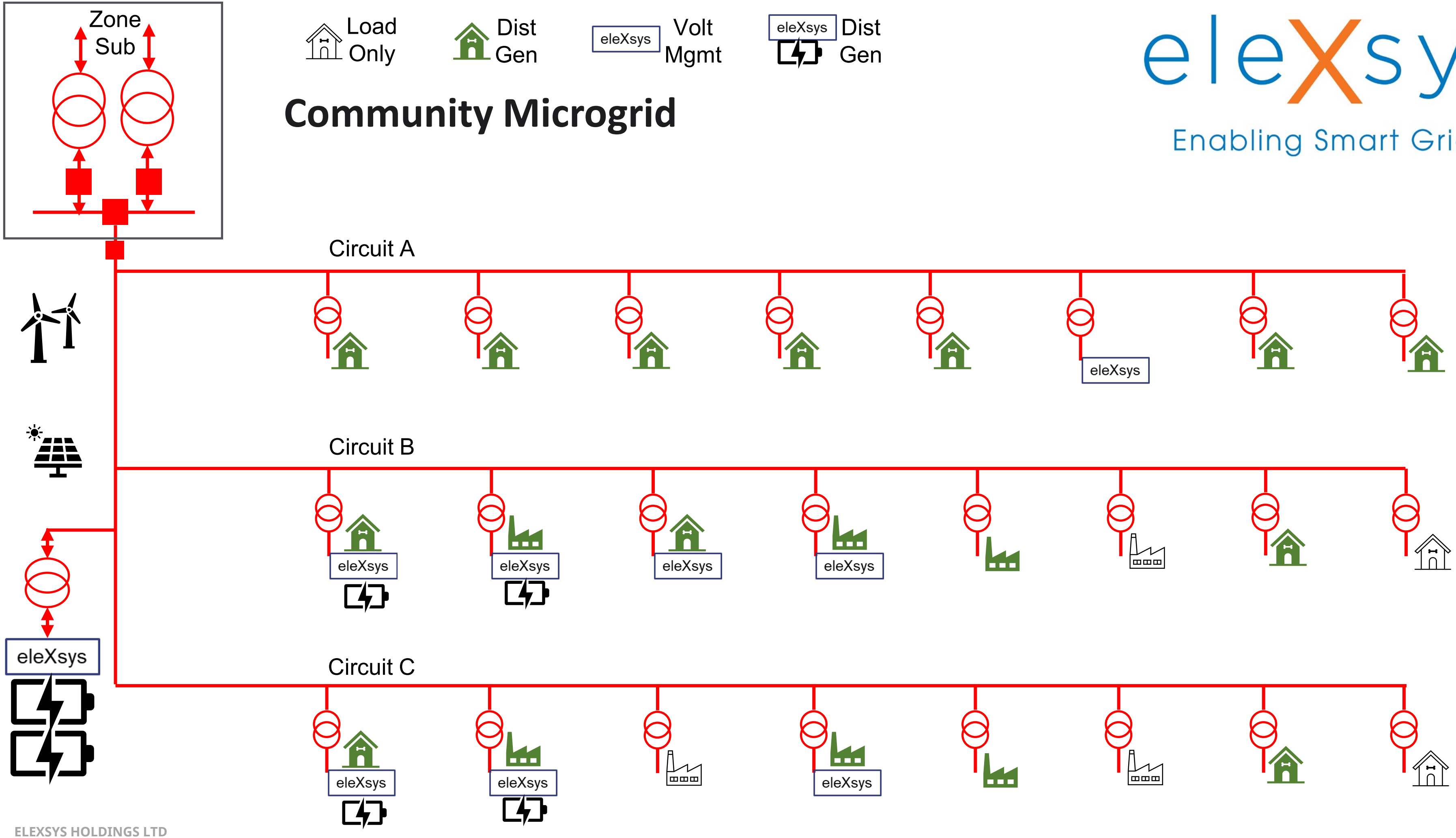
eleXsys benefits

- eleXsys operates in the dead band
- Voltages are all maintained within standards
- Transformer thermal limits maintained with 100% load and 100% export
- Customers all achieved equal access to the network
- Customers all achieved maximum benefit for their solar production either local use or FiT
- Maximum real energy was available to the market operator
- Overall cheaper cost
- Operates 24 hrs a day to also support VPP and storage assets
- Storage can be direct connected to also time shift energy

eleXsys Community Microgrid Capabilities

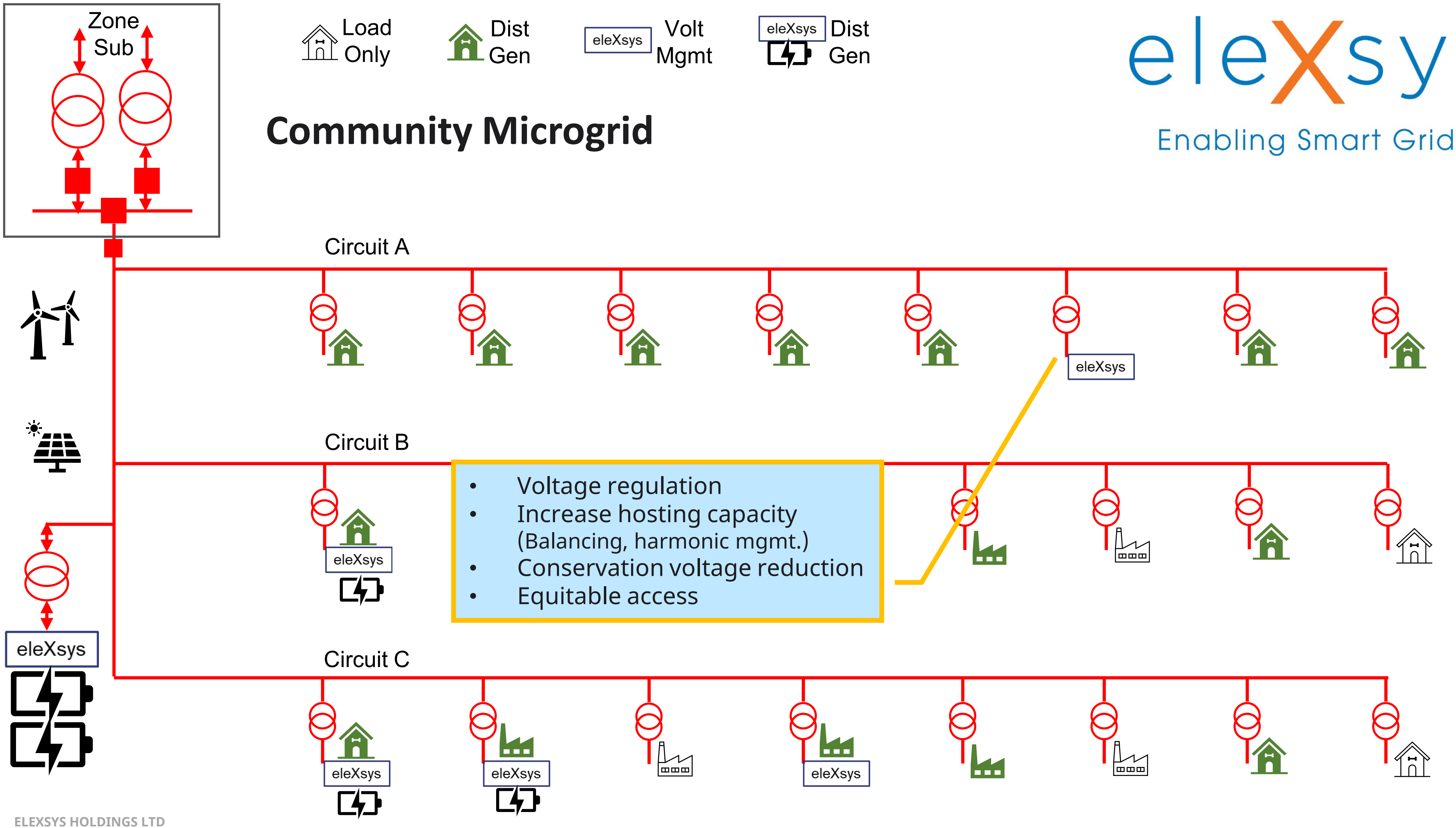
Community Microgrid

Enabling Smart Grids



Community Microgrid

eleXsys®
Enabling Smart Grids



Community Microgrid

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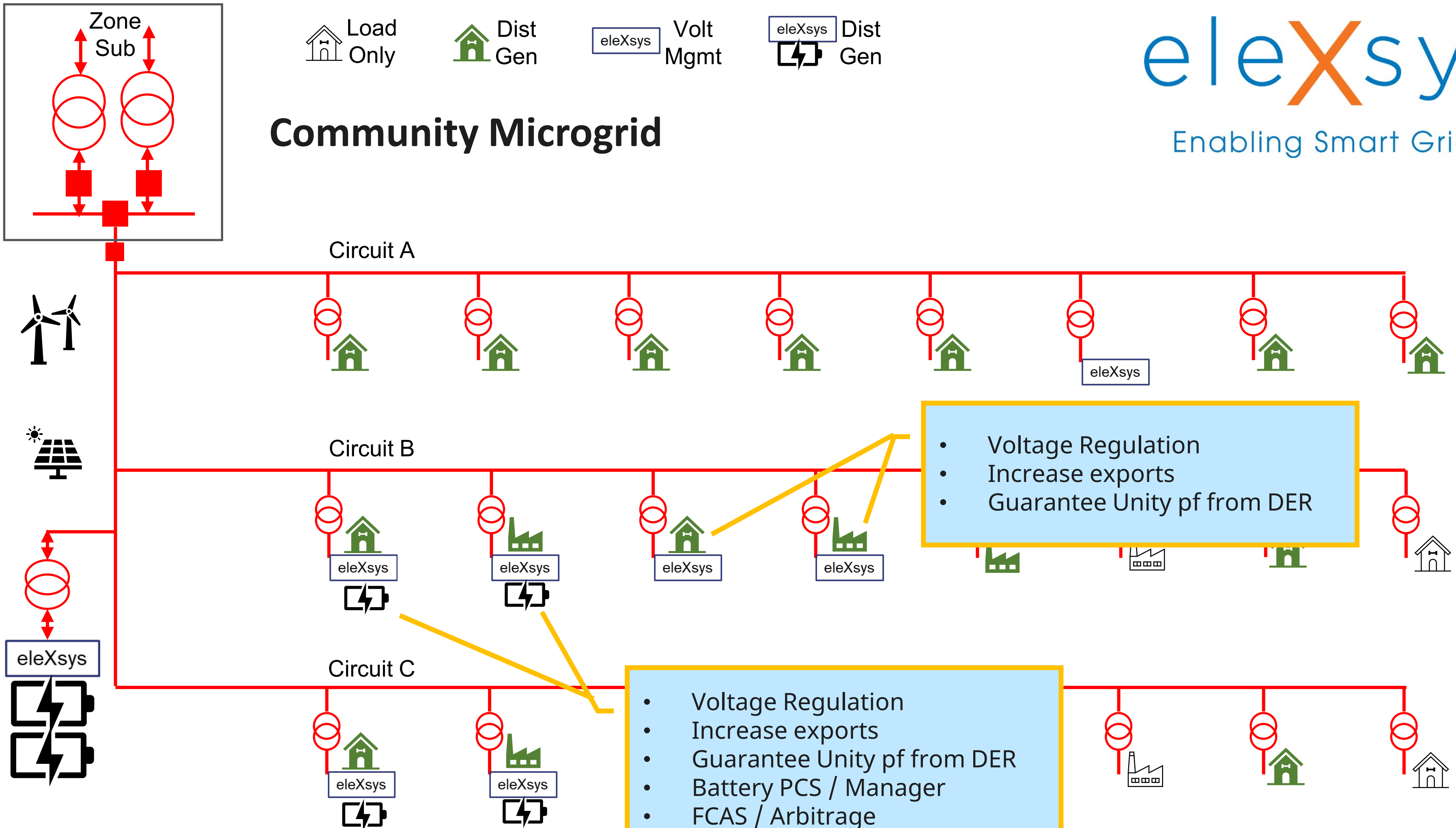
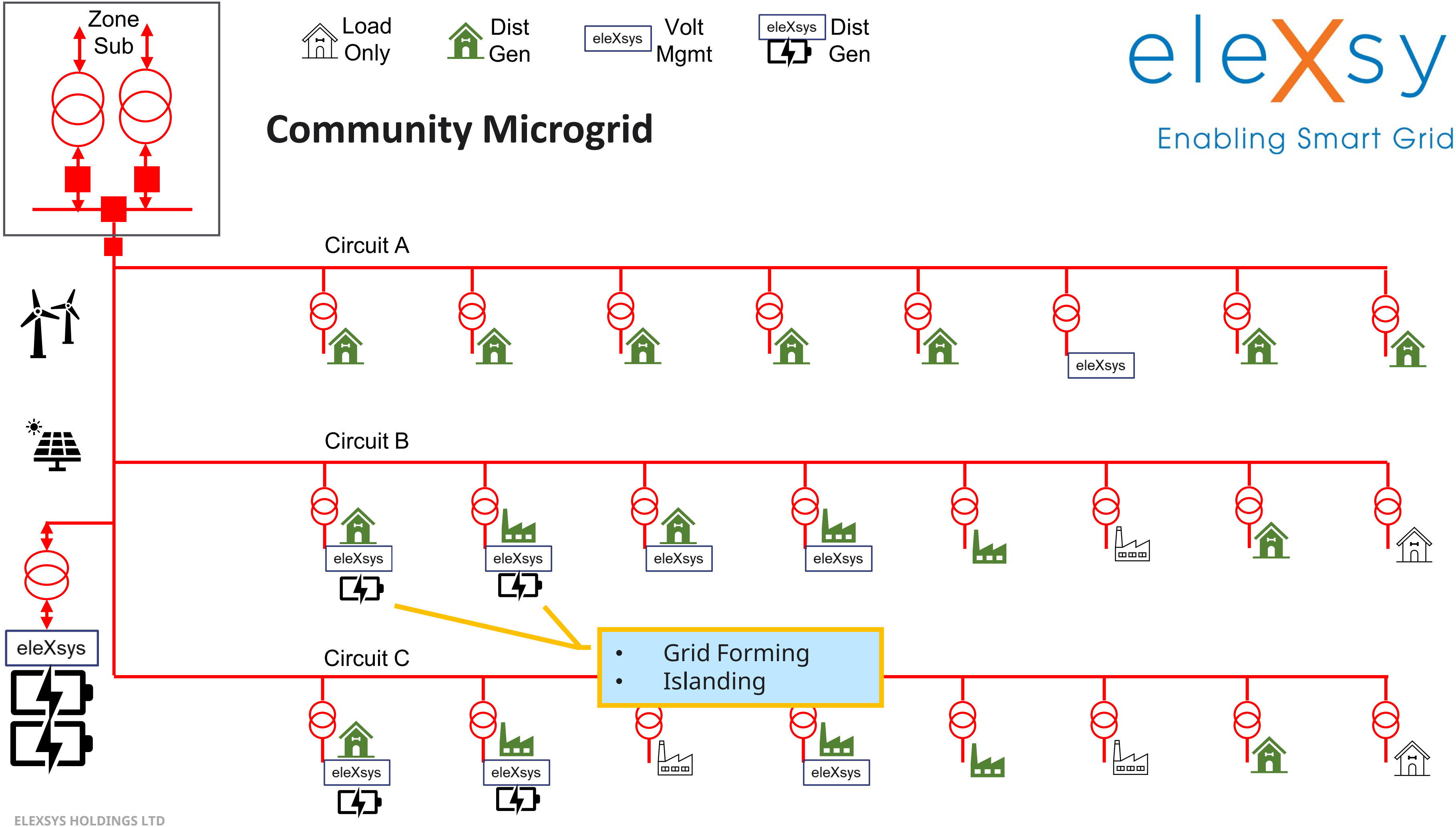
Enabling Smart Grids



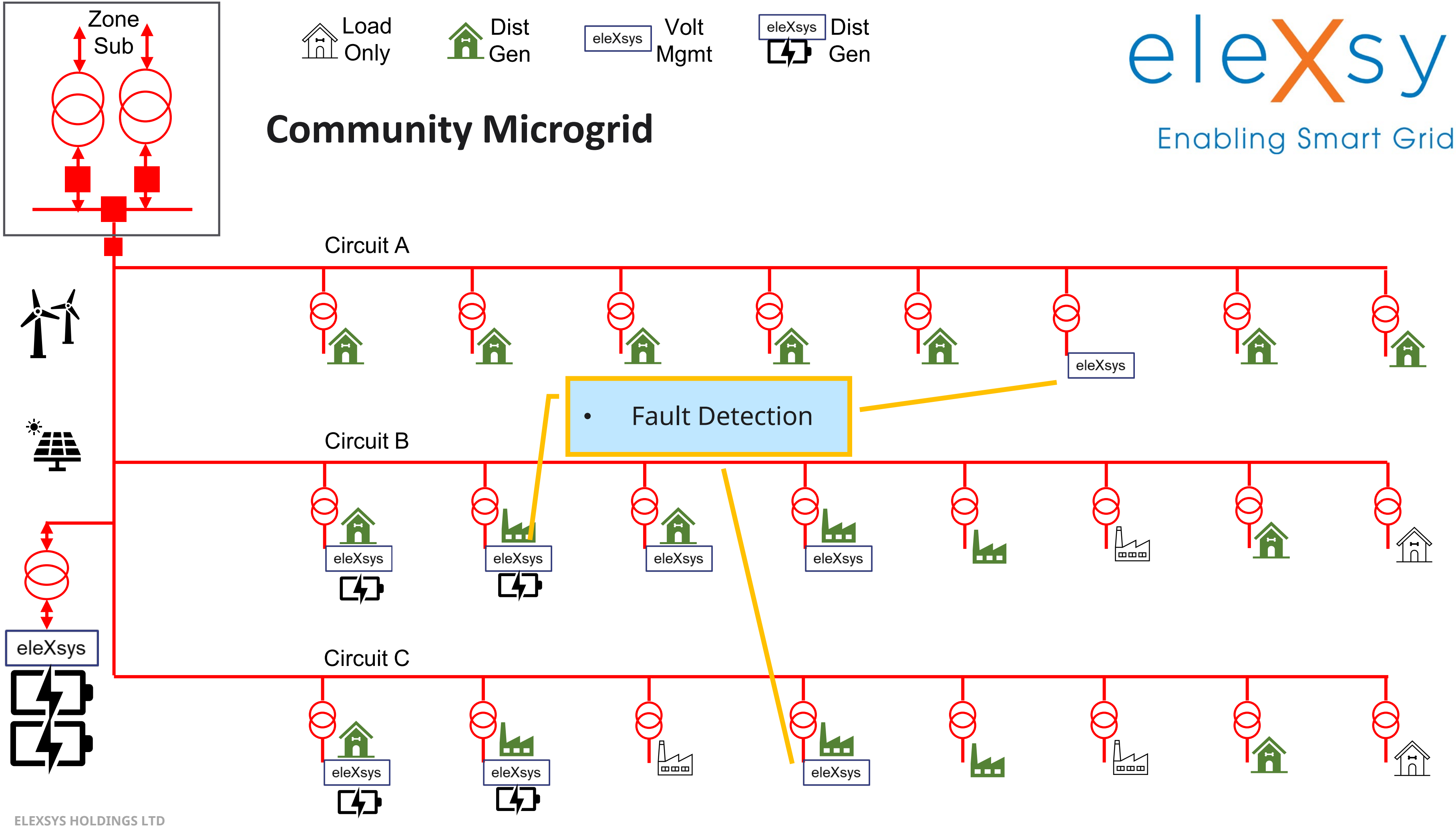
Community Microgrid



Enabling Smart Grids

Community Microgrid

Enabling Smart Grids



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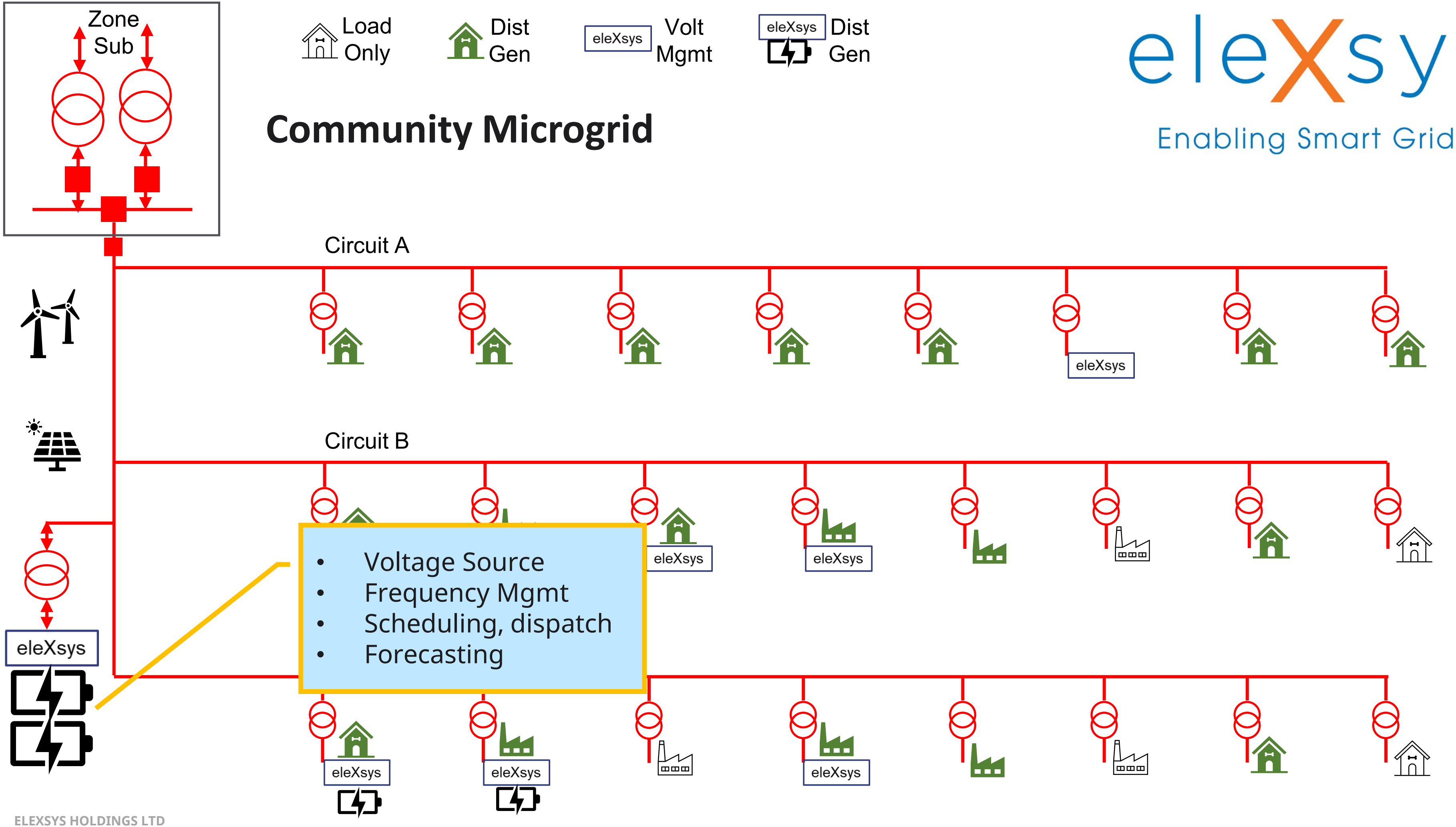


Phasor Model

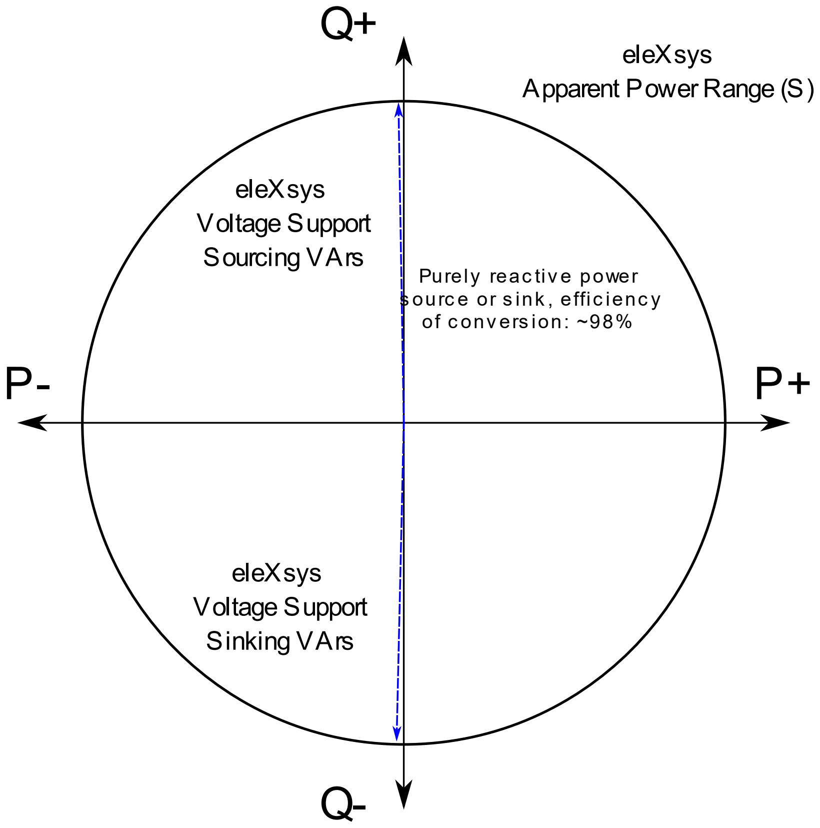
How does the eleXsys work?

Real energy is consumed as part of the switching cycle (phase shifting) which amounts 2% losses.

The device introduces a phases shifted current waveform to the network through a 50 kHz switching process powered

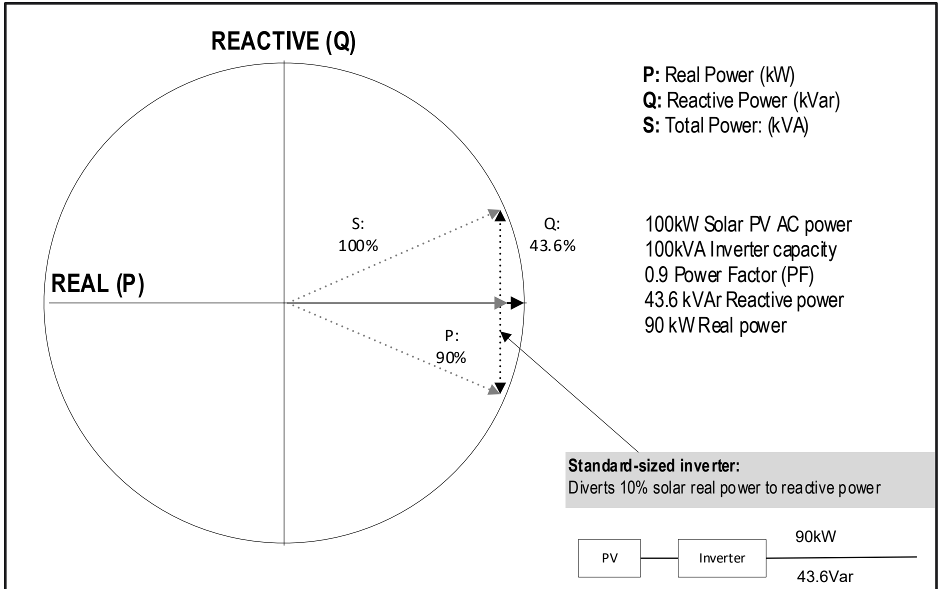
This is achieved through power electronics via switching a polypropylene capacitor bank at high frequency, specifically designed for the eleXsys.

The is very similar to a plain old capacitor or inductor bank.



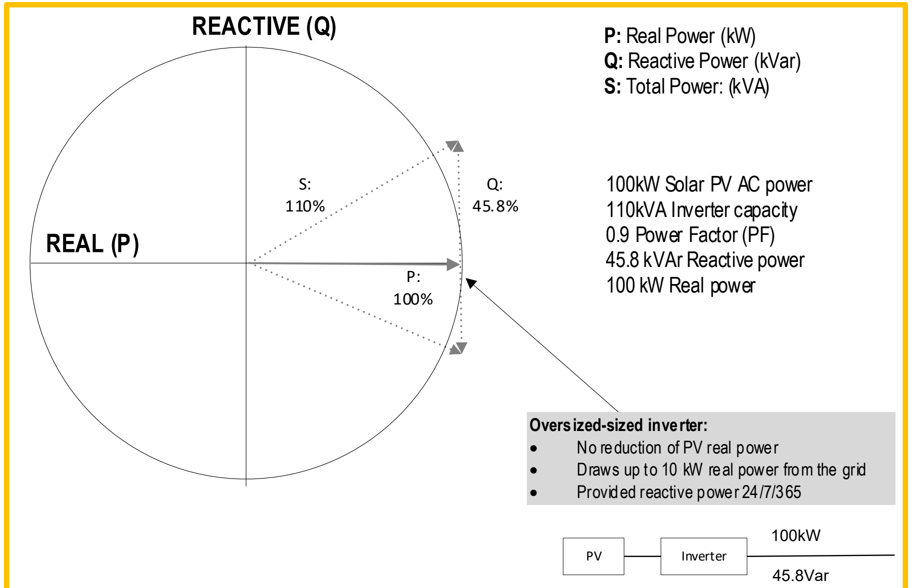
Phasor Approach:
Advanced Inverters – Recovering & Compensating Benefits

Advanced Inverters – Reactive Power



Source: Clean Coalition: Advanced Inverters – Recovering and Compensating Benefits

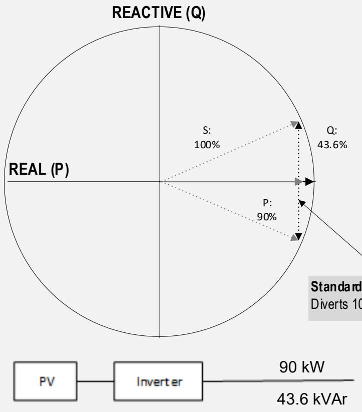
Advanced Inverters - Reactive Power (over sized)



Source: Clean Coalition: Advanced Inverters – Recovering and Compensating Benefits

Phasor Approach: An Alternative Approach

Advanced Inverters – Reactive Power



P: Real Power (kW)
Q: Reactive Power (kVar)
S: Total Power: (kVA)

100kW Solar PV AC power
100kVA Inverter capacity
0.9 Power Factor (PF)
43.6 kVAr Reactive power
90 kW Real power

Standard-sized inverter:
Diverts 10% solar real power to reactive power

Source:
Clean Coalition: Advanced Inverters – Recovering and Compensating Benefits

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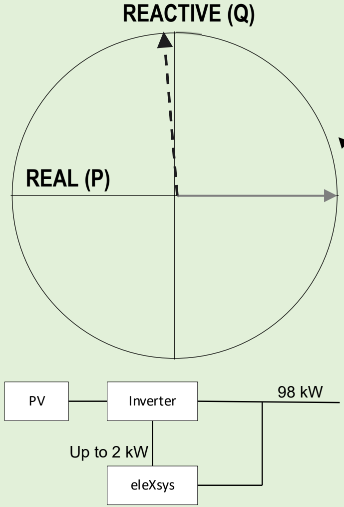

Q:
Unity

P: Real Power (kW)
Q: Reactive Power (kVAr)
S: Total Power: (kVA)

100kW Solar PV AC power
100kVA Inverter capacity
Unity Power Factor (PF)
-
eleXsys losses
=
98kW Real power

eleXsys:
- 2% losses (internal) when phase shifting

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Operate at Unity Power Factor for DER
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  eleXsys creates required VARs before any Smart Inverter reaches set trigger values
- eleXsys introduces a phase shifted current waveform to the network through a 50 kHz switching process powered

Source: eleXsys