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The 27th INTERNATIONAL ELECTRIC VEHICLE SYMPOSIUM & EXHIBITION
BARCELONA
17th-20th November 2013

northumbria UNIVERSITY

A Modelling Tool to Investigate the Effect of Electric Vehicle Charging on Low Voltage Networks

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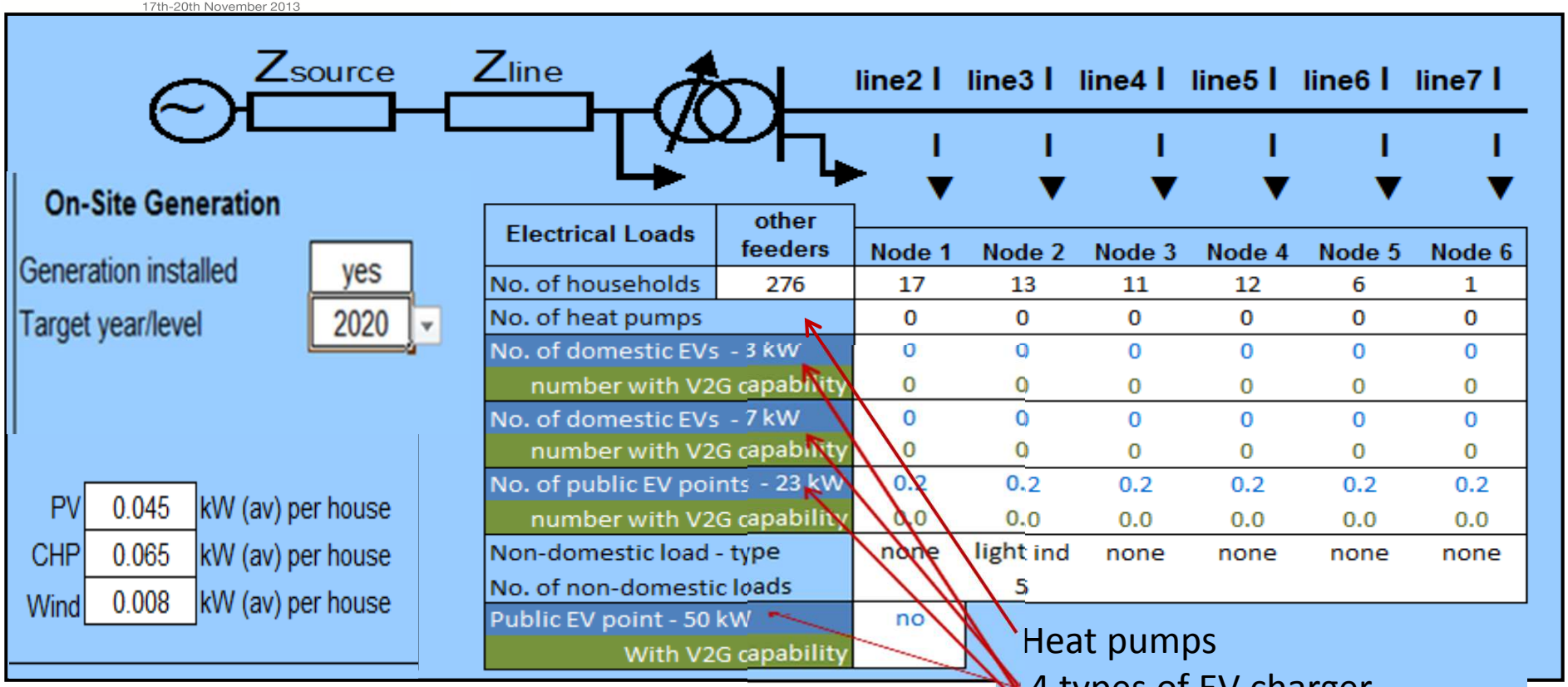
20% by 2020

- 20% of all homes will have
  - Microgeneration: PV panels or wind turbine
  - Low carbon heating: heat pumps

  What is the effect of these technologies on the low voltage network?
  - What is the effect of 20% EV ownership?
    - Domestic chargers used at 3kW or 7kW
    - Fast (23kW) and super-fast (50kW) chargers available

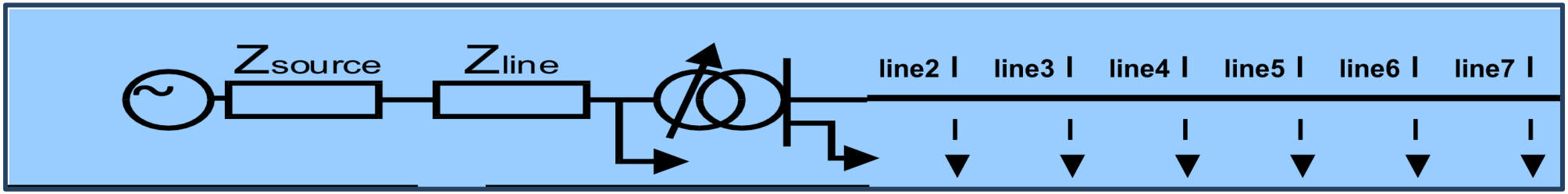
LV distribution network



Electrical Loads	other feeders	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
No. of households	276	17	13	11	12	6	1
No. of heat pumps		0	0	0	0	0	0
No. of domestic EVs - 3 kW		0	0	0	0	0	0
number with V2G capability		0	0	0	0	0	0
No. of domestic EVs - 7 kW		0	0	0	0	0	0
number with V2G capability		0	0	0	0	0	0
No. of public EV points - 23 kW		0.2	0.2	0.2	0.2	0.2	0.2
number with V2G capability		0.0	0.0	0.0	0.0	0.0	0.0
Non-domestic load - type		none	light ind	none	none	none	none
No. of non-domestic loads			5				
Public EV point - 50 kW		no					
With V2G capability							

Position of 23kW fast charger is possible at any or all nodes

Position of fast charger	Power quality issues		
node	Transformer power flow	Thermal cable current	Voltage limit violated
0	0.959	0.866	0.945
1	1.201	1.077	0.940
2	1.201	1.071	0.937
3	1.201	1.068	0.934
4	1.201	1.066	0.933
5	1.201	1.064	0.930
6	1.201	1.062	0.924
all	1.254	1.109	0.931



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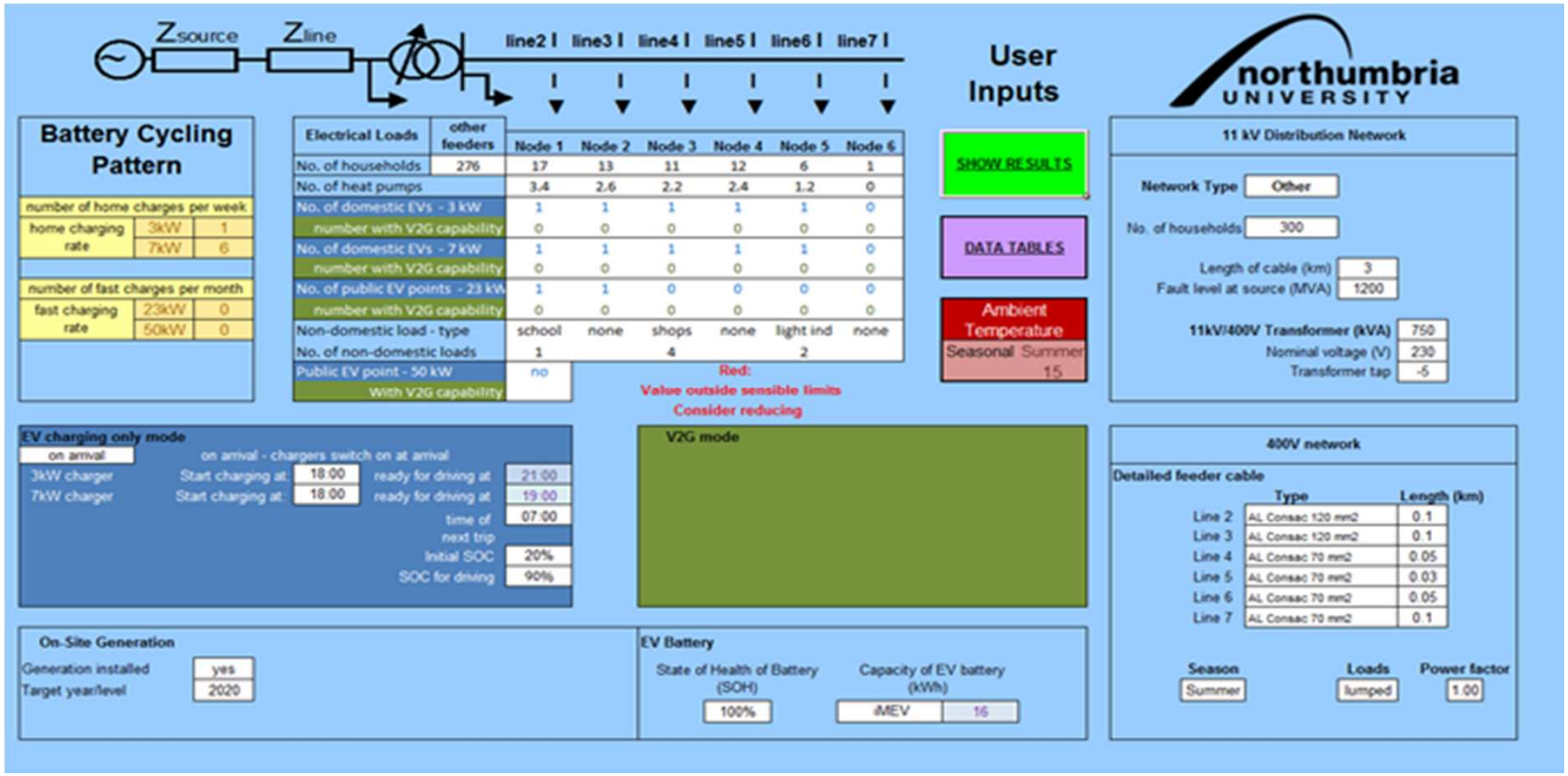
20% Evs and 20% heatpumps



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20% Evs and 20% heatpumps

RESULTS

RETURN TO INPUT FORM

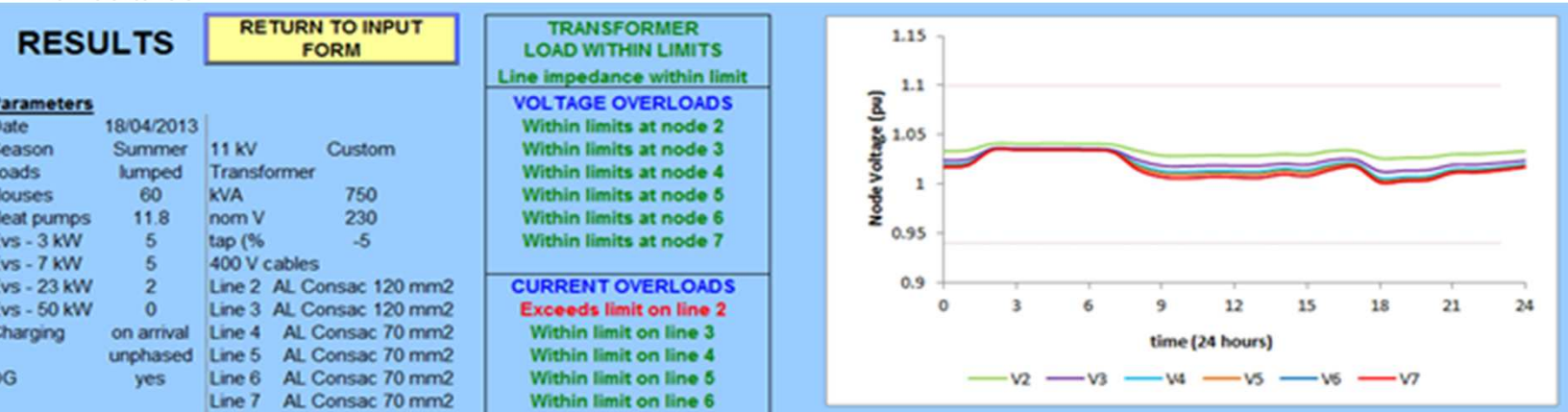
Parameters

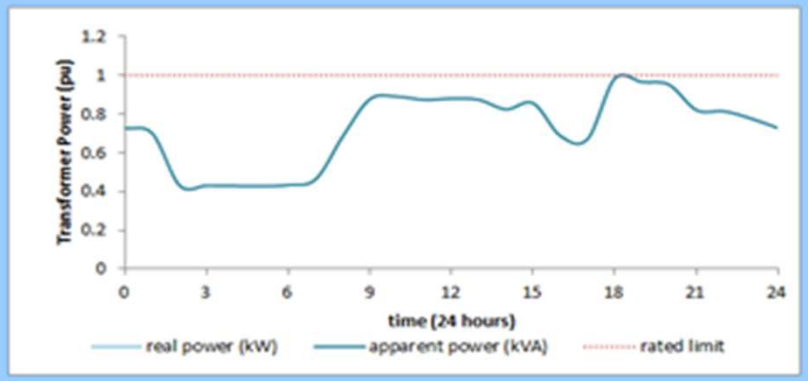
Date	18/04/2013		
Season	Summer	11 kV	Custom
Loads	lumped	Transformer	
Houses	60	kVA	750
Heat pumps	11.8	nom V	230
Evs - 3 kW	5	tap (%	-5
Evs - 7 kW	5	400 V cables	
Evs - 23 kW	2	Line 2	AL Consac 120 mm2
Evs - 50 kW	0	Line 3	AL Consac 120 mm2
Charging	on arrival	Line 4	AL Consac 70 mm2
	unphased	Line 5	AL Consac 70 mm2
DG	yes	Line 6	AL Consac 70 mm2
		Line 7	AL Consac 70 mm2

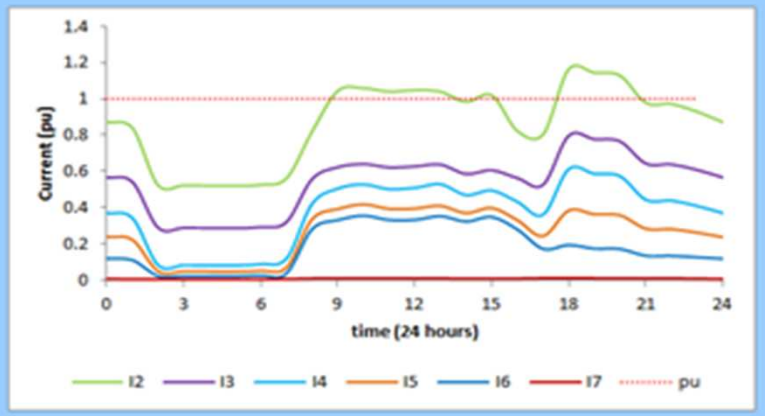
TRANSFORMER LOAD WITHIN LIMITS
Line impedance within limit

VOLTAGE OVERLOADS
Within limits at node 2
Within limits at node 3
Within limits at node 4
Within limits at node 5
Within limits at node 6
Within limits at node 7

CURRENT OVERLOADS
Exceeds limit on line 2
Within limit on line 3
Within limit on line 4
Within limit on line 5
Within limit on line 6
Within limit on line 7







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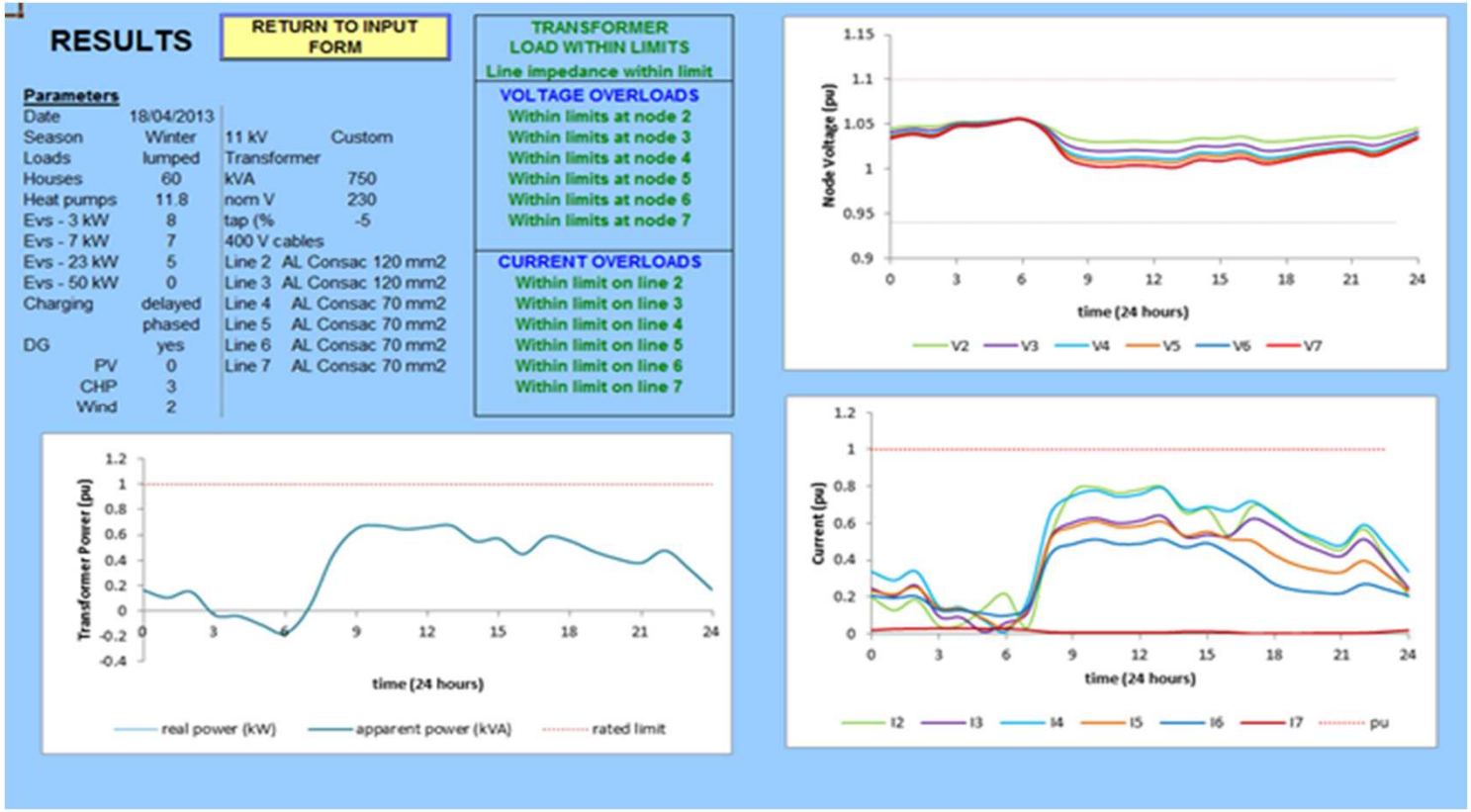
Add delayed charging



Add V2G

RESULTS

RETURN TO INPUT FORM

Parameters

Date	18/04/2013
Season	Winter
Loads	lumped
Houses	60
Heat pumps	11.8
Evs - 3 kW	8
Evs - 7 kW	7
Evs - 23 kW	5
Evs - 50 kW	0
Charging	delayed
	phased
DG	yes
PV	0
CHP	3
Wind	2

11 kV	Custom
Transformer	
kVA	750
nom V	230
tap (%	-5
400 V cables	
Line 2	AL Consac 120 mm2
Line 3	AL Consac 120 mm2
Line 4	AL Consac 70 mm2
Line 5	AL Consac 70 mm2
Line 6	AL Consac 70 mm2
Line 7	AL Consac 70 mm2

TRANSFORMER LOAD WITHIN LIMITS

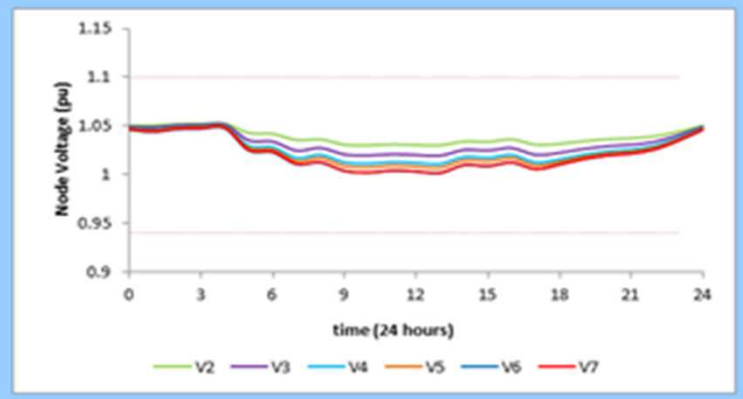
Line impedance within limit

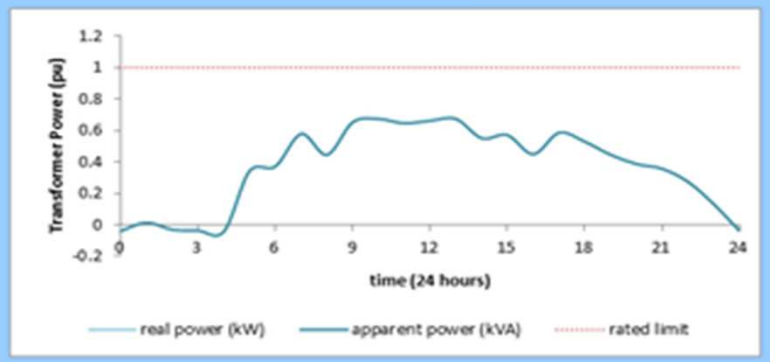
VOLTAGE OVERLOADS

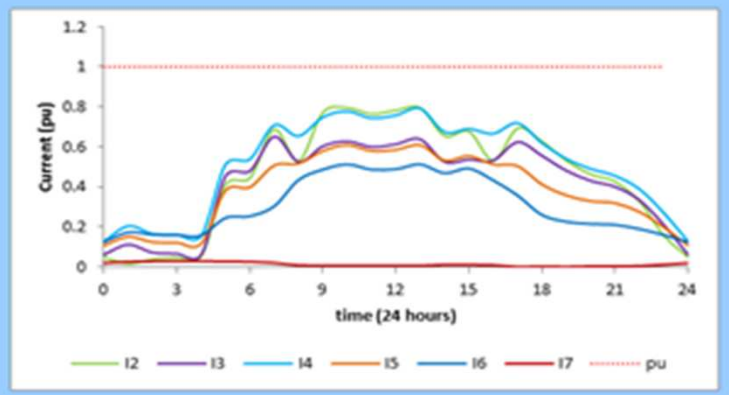
Within limits at node 2
Within limits at node 3
Within limits at node 4
Within limits at node 5
Within limits at node 6
Within limits at node 7

CURRENT OVERLOADS

Within limit on line 2
Within limit on line 3
Within limit on line 4
Within limit on line 5
Within limit on line 6
Within limit on line 7







Add fast chargers

RESULTS | RETURN TO INPUT FORM

Parameters

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Season	Winter
Loads	lumped
Houses	60
Heat pumps	11.8
Evs - 3 kW	8
Evs - 7 kW	7
Evs - 23 kW	5
Evs - 50 kW	1
Charging	delayed
	phased
DG	yes
PV	0
CHP	3
Wind	2

11 kV	Custom
Transformer	
kVA	750
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tap (%	-5
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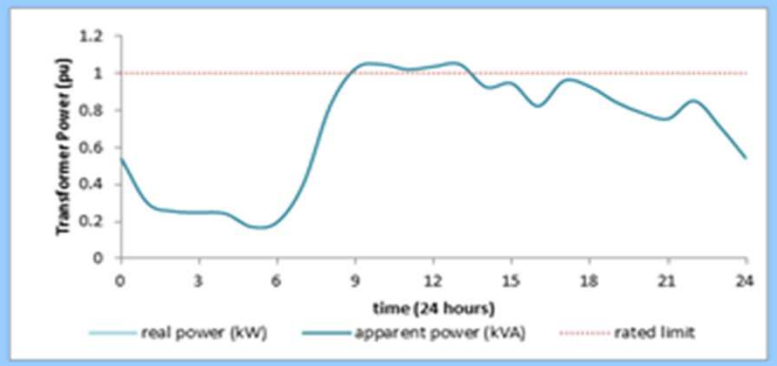

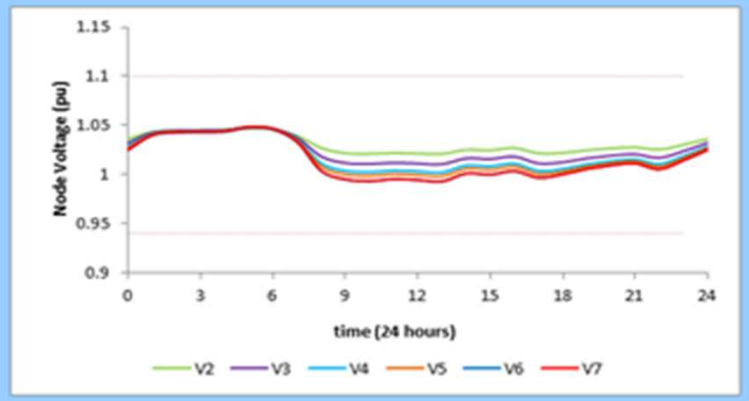

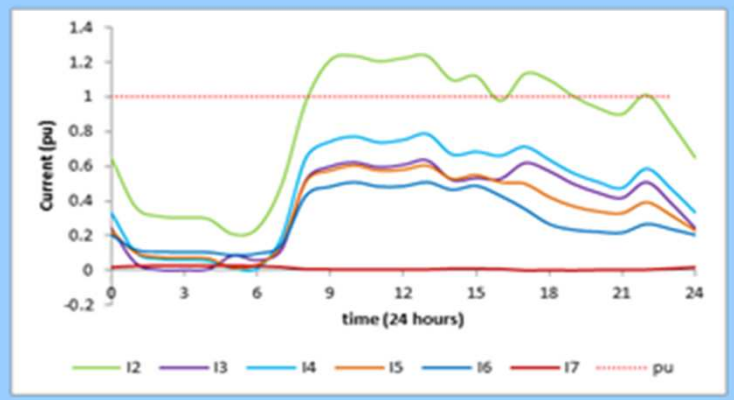

Adding EV charging posts on the low voltage network is shown to increase the likelihood of power quality issues occurring.

- These issues are identified as the power rating of transformers being exceeded, the thermal rating of LV feeders being exceeded, and violating regulatory statutory voltage limits
- Uncontrolled charging increases the likelihood of thermal limits and voltage limits being exceeded.
- Asset upgrade of transformers will be needed sooner as EV penetration increases.

Charging issues

- Timed charging for a fixed time of day is shown to cause problems for the network at that time, regardless of the domestic demand, if EV penetration is high.
- Fast charging is shown to exacerbate the network problems, indicating which cables will need to be upgraded to prevent thermal overload. It also causes excessive voltage drop, particularly if chargers are used at the end of the feeder.

Charging solutions

- Delaying daily slow EV charging until after the evening peak
- Connecting fast chargers only at nodes close to the transformer
- Staggering the charging start time gives the best results for network health.

Smart charging

This demonstrates that the concept of smart charging, which allows charging only if the network is not stressed will become essential if EVs become ubiquitous

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Thank you for your attention

Any questions?

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