Powerco CPP – Portfolio Overview Document

Portfolio Name	Palmerston North CBD Reinforcement
Expenditure Class	Capex
Expenditure Category	Growth & Security
As at Date	12 June 2017

Expenditure Forecast[1,2]	Pre CPP	FY19	FY20	FY21	FY22	FY23	Post CPP	CPP Period Total	Project Total
Pre-Internal Cost Capitalisation and Efficiency Adjustments[3] *(2016 Constant NZ$(M))*	$12.0	$1.3	$0.0	$0.0	$3.7	$9.6	$0.0	$14.6	$26.6
Post-Internal Cost Capitalisation and Efficiency Adjustments *(2016 Constant NZ$(M))*	$12.9	$1.4	$0.0	$0.0	$3.9	$9.5	$0.0	$14.8	$27.7

Description	
Project Need Overview	The sub-transmission network supplying the Palmerston North CBD has a number of constraints. A combination of load growth and the de-rating of unreliable oil-filled cables mean that the majority of the CBD cannot be backed up in the event of a subtransmission fault. Transformer capacity at a number of the substations is below the level needed to provide adequate backup also. Firm capacity at the Bunnythorpe GXP is exceeded at peak load times.

Preferred Solution	
Project Solution Overview	This project involves the reinforcement of the sub-transmission network into the Palmerston North CBD via the installation of 33kV underground cable interties to enhance existing cable links and the construction of a new zone substation (Ferguson) to reduce load on the existing subsbtations. New sub-transmission circuits will be installed to transfer some of the CBD load onto Linton GXP. Replacement of faulty oil-filled cables is not included in this project as it is covered under the renewal portfolio.

[1] Forecast expenditure is based on Powerco's financial year (i.e. FY18 is for the period April 2017 through March 2018). Expenditures do not consider general price level changes over time (i.e. are in real or constant terms).
[2] Only includes Growth & Security Expenditure. Some projects discuss and rely on the replacement of assets that are at "end of life". However, the replacement cost for these assets is accounted for in the Replacement Expenditure category.
[3] All other forecast expenditure / cost estimates in this POD are pre-internal cost capitalisation and efficiency adjustments, consistent with this forecast.

Need Identification	
Background ***Underlying Drivers and Investment Triggers***	The Palmerston North CBD is principally supplied by three zone substations (Pascal St, Main St and Keith St) as illustrated in Figure 1 and Figure 5. The existing meshed sub-transmission network supplying the CBD is experiencing a number of constraints/issues as follows: • During 2015 the Main St, Keith St and Kelvin Grove substation load was ≈55MVA (ADMD) and is supplied via a meshed set of three overhead circuits (BPE-KEG, KST_WEST, KST_EAST) from the Transpower Bunnythorpe substation. The meshed supply network has breached (N-1) capacity and the supply of the peak consumer load during network contingencies is reliant on the intermittent generation injected from the northern arm of the Tararua Wind Farm (34MW capacity). The present supply network does not meet the requirements of Powerco's Security-of-Supply Standard, which recommends that the combined load of the three substations should be afforded a (N-1), no break supply network with a security class of AAA[4]. • During 2015 the Main St substation experienced a peak load of 26.1MVA. During normal operating conditions the substation is supplied via a dual under-ground cable network (KST-MAIN1 and KST-MAIN2) that has well exceeded a (N-1), no break capacity. The present Main St supply network does not meet the requirements of Powerco's Security-of-Supply Standard, which recommends a (N-1), no break supply network, security class AAA for the substation. • Three 33kV, oil insulated, underground cables connect to the Main St substation (KST-MAIN1, KST-MAIN2 and PAS-MAIN). The condition of the cables is difficult to assess, the incidence of cable leaks is increasing and they have been de-rated to reduce the thermal cycling stress on the cable joints. In addition, during 2016 two of the oil filled 33kV failed and as a result Powerco has had to build a temporary overhead 33kV line between Keith St and Main St substations. • During 2015 the peak loads on the Main St and Pascal substations well exceeded their respective (N-1) firm transformer capacities of 20.0MVA and 19.2MVA. Main St and Pascal substations do not meet the requirements of Powerco's Security-of-Supply Standard, which recommends a (N-1), no break supply network, security class AAA[4] for both substations. • During 2015 the peak load on the Pascal and Kairanga substations was ≈40MVA (ADMD) and has exceeded the (N-1), firm, 33kV network supply capacity. This results from the fact that during contingencies on LTN-KAI or LTN-PAS the FITZ 33kV circuit overloads. The present supply network does not meet the requirements of Powerco's Security-of-Supply Standard, which recommends that the combined load of the two substations should be afforded a (N-1), no break supply network with a security class of AAA[4].

[4] AAA – Supply is uninterrupted in the event of the outage of one major element of the sub-transmission network. Load can be transferred to other substations without interruption by switching on the network if necessary to avoid exceeding ratings (Powerco - Standard 310S001 – Security of Supply Classification – Zone Substations).

	• During 2015 the peak load on the Kairanga substation was ≈19MVA. The substation is supplied via two circuits. One of them being the existing KAI-GSP-PAS circuit which includes an oil filled cable that has been de-rated to 12.7MVA. The sub-transmission to the Kairanga substation does not meet the requirements of Powerco's Security-of-Supply Standard, which recommends that substation should be afforded a (N-1), no break supply network with a security class of AAA[4]. • During 2015 the Transpower Bunnythorpe substation experienced a peak load of 100.3MVA which marginally breaches the substation's 100MVA transformer firm capacity. The Bunnythorpe substation does not meet the requirements of Powerco's Security-of-Supply Standard, which recommends a (N-1), no break supply network, security class AAA[4] for the substation. The upgrade of Bunnythorpe will be difficult and expensive. In contrast the Transpower Linton substation/GXP is moderately loaded. The increased use of the Linton substation to supply the Palmerston North CBD will reduce the loading on the Bunnythorpe substation and provide benefits in terms of diversity of supply into the Palmerston North CBD.
Timing	The existing electrical supply network into the Palmerston CBD is constrained at a number of locations. Powerco's electrical demand forecast indicates that the CBD's electrical demand will continue to increase at ≈1% per annum. The following tables and graphs compare the substation maximum demands against their associated class[5] and transformer capacities. Given the above facts the scoping, planning and consenting of the proposed sub-transmission and substation reinforcement into Palmerston North is underway. A new substation site within the Palmerston North CBD has been purchased (Ferguson substation site) and Powerco has begun securing the consents/easements/land necessary to construct the sub-transmission assets. In addition, during 2016 Powerco has commissioned the detailed design of specific aspects of the project and is also progressing two 33kV cable replacement projects (Gillespies to Pascall and Keith St. to Main St.). These two projects are linked to the security of the Palmerston North CBD but the costs are not included in this PoD.

[5] Class capacity is similar to Firm Capacity and represents the capacity that can be delivered following the first outage of any major equipment. Unlike Firm Capacity it considers the long term deliverable capacity in the context of switching and network reconfiguration (11kV & 33kV) post-fault conditions.

Demand Forecast[6] | Manawatu Area

MANAWATU AREA SUBSTATIONS			FORECAST MAXIMUM DEMAND [MVA]						
SUBSTATION	CLASS CAPACITY	GROWTH	2016	2017	2018	2019	2020	2025	2030
Feilding	23.7	1.0%	22.0	22.2	22.4	22.6	22.8	23.9	24.9
Kairanga	19.1	0.5%	19.6	19.7	19.8	19.9	20.0	20.5	21.0
Keith St	21.9	0.5%	19.1	19.2	19.3	19.4	19.5	19.9	20.3
Kelvin Grove	17.2	2.2%	18.9	19.4	19.8	20.2	20.6	22.7	24.8
Kimbolton	0.6	0.2%	3.1	3.1	3.1	3.1	3.1	3.1	3.2
Main St	17.0	0.5%	29.4	29.5	29.7	29.8	30.0	30.7	31.4
Milson	18.1	1.5%	18.9	19.2	19.5	19.8	20.1	21.4	22.8
Pascal St	17.0	0.3%	23.4	23.5	23.6	23.6	23.7	24.0	24.4
Sanson	0.0	1.0%	8.9	9.0	9.1	9.2	9.2	9.7	10.2
Turitea	0.0	1.4%	16.0	16.2	16.5	16.7	16.9	18.0	19.1

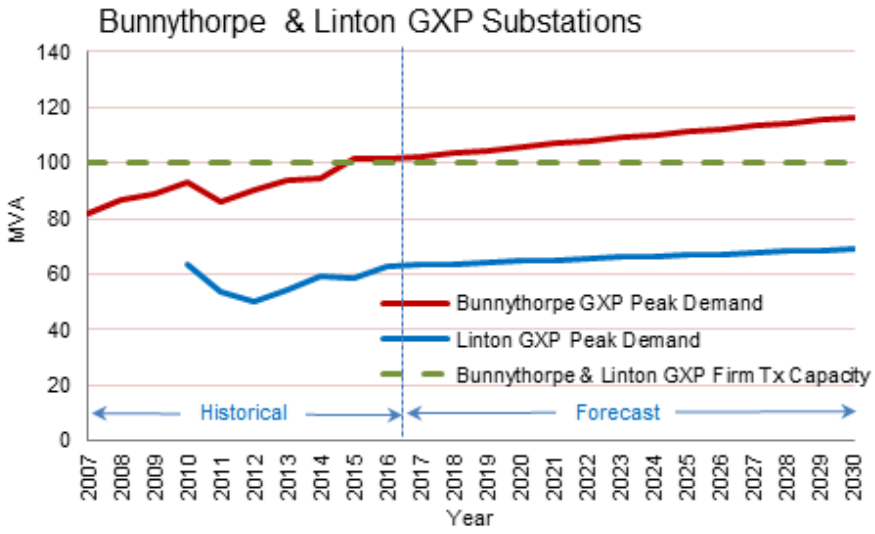
MANAWATU AREA SUBSTATIONS			FORECAST MAXIMUM DEMAND [MVA]						
SUBSTATION	TX CAPACITY	GROWTH	2016	2017	2018	2019	2020	2025	2030
Bunnythorpe GXP	100.0	1.1%	101.4	102.5	103.6	104.6	105.7	111.2	116.6
Linton GXP	100.0	0.7%	62.9	63.3	63.8	64.2	64.6	66.8	69.0

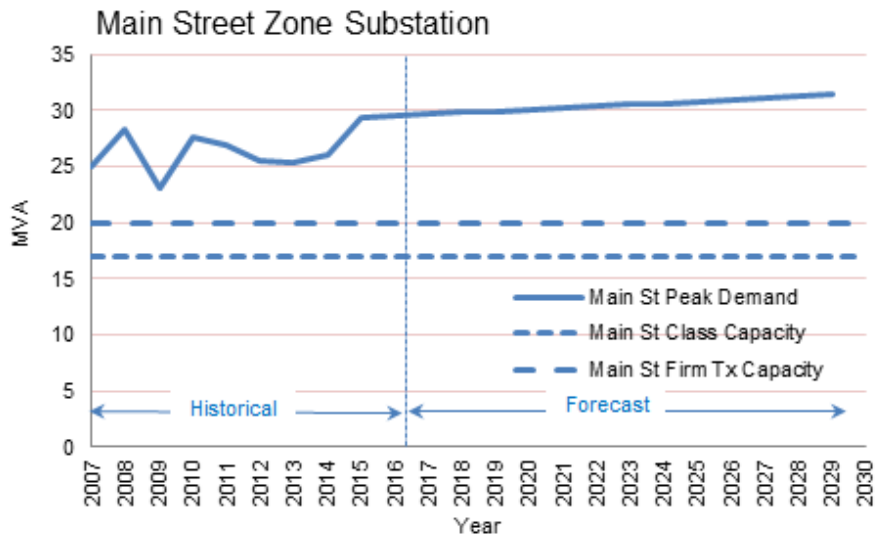
Notes:

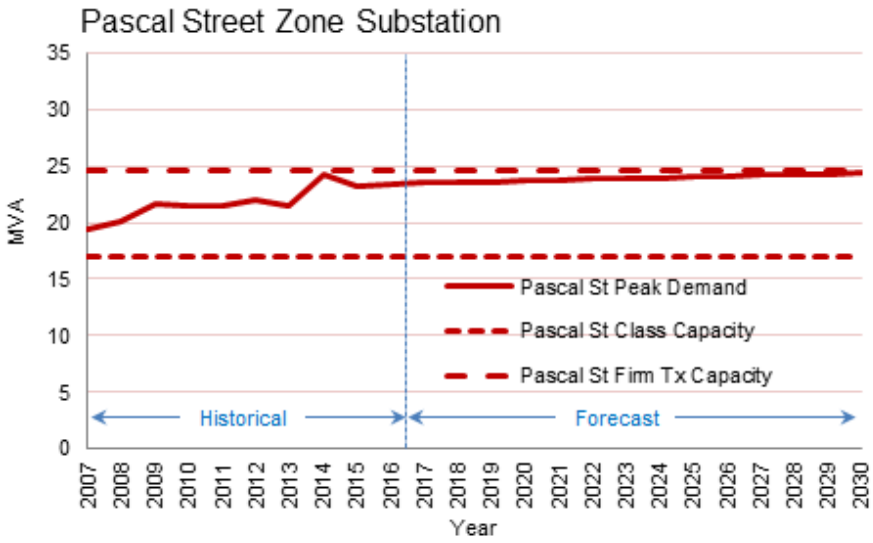
a. All maximum demand values are in MVA.

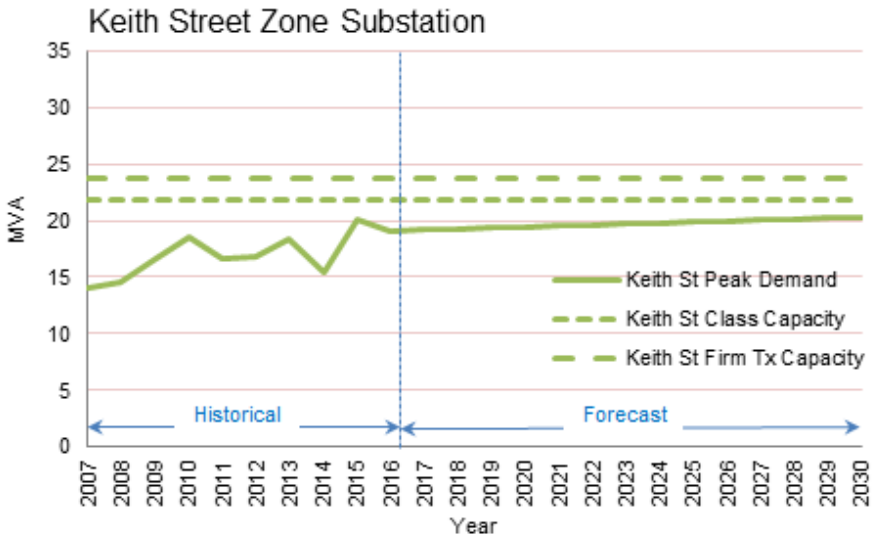
b. Purple shaded cells indicate that the substation's Class Capacity[5] has been exceeded and network enhancements should be considered.

[6] Powerco's Asset Management Framework outlines the input information and basis of its Demand Forecast.


Bunnythorpe & Linton GXP Substations
MVA
Year
Bunnythorpe GXP Peak Demand
Linton GXP Peak Demand
Bunnythorpe & Linton GXP Firm Tx Capacity
Historical
Forecast


Main Street Zone Substation
MVA
Year
Main St Peak Demand
Main St Class Capacity
Main St Firm Tx Capacity
Historical
Forecast


Pascal Street Zone Substation
MVA
Year
Pascal St Peak Demand
Pascal St Class Capacity
Pascal St Firm Tx Capacity
Historical
Forecast


Keith Street Zone Substation
MVA
Year
Keith St Peak Demand
Keith St Class Capacity
Keith St Firm Tx Capacity
Historical
Forecast

Options Analysis | Long List of Project Options | High Level Assessment	
Assessment Process	A wide range of potential options are available for the resolution of electrical network constraints. However, depending on local conditions many of the options can have fatal flaws. On this basis a two tier Options Analysis is followed. In the first instance all potential options are considered against a set of high level criteria. Those options that are identified as having significant challenges and not favourable are not considered further. As a result of the process a short list of viable options is identified for further analysis. Note that the costs outlined in the Options Analysis do not include Powerco's internal costs[9]. The final, more detailed, costs outlined for the preferred option also do not include internal costs[9].
Long List of Options	The following table contains a list of the high level project options that are potentially available to resolve the electrical supply issues into the Palmerston North CBD. The three non-network options (Nos. 1, 2 and 3) are not shortlisted on the following basis: • The supply from the existing Tararua wind farm is intermittent and is not firm. Single source renewable generation sources are generally not considered to be a reliable supply alternative due to their intermittent nature. Viable renewable generation options are also limited by the fact that the CBD load is winter peaking[7]. Fossil fuelled generation is technically viable but not shortlisted due to cost, environmental, consenting and land acquisition issues. • Fuel switching and demand side response (DSR) are considered to be deferment strategies and their viability is not certain given the fact that security levels are already well exceeded and electrical demand is projected to increase. In addition the CBD consumer loads are not considered to be good candidates for fuel switching and DSR. The network expansion options all involve the construction of sub-transmission lines/cables from either the Bunnythorpe or the Linton GXP substations into the Palmerston North CBD. Both of the GXPs are a similar distance from the Palmerston North CBD across similar terrain. The Transpower Bunnythorpe substation is highly loaded and its upgrade is considered to be difficult and expensive. In contrast the Transpower Linton substation has spare capacity, is closer to future emerging load and thus supply from this substation is considered to be the most cost effective solution. Furthermore, the additional sub-transmission network would improve the diversity of supply into the Palmerston North CBD. As a result of this fact, three sub-transmission reinforcement options (Nos. 4, 5 & 6), from the Linton substation, are shortlisted. The upgrade of the sub-transmission from the Bunnythorpe substation (No. 7) is not short listed.

[7] For example, photovoltaic plant would need battery storage and incur more cost.

Long List of Options | High Level Assessment

Palmerston CBD		*Long list of projects and high level assessment*	*Assessment Criteria*						
PROJECT FOCUS	**No.**	**PROJECT**	Safety	Fit	Feasible Practical	GEIP	Security	Cost	**Short-list**
Non-network:	1	Distributed Generation (DG) including peak lopping generation	✓	✗	✓	✗	✓	✓	✗	✗
	2	Fuel switching to reduce electrical demand	✓	✓	✗	✗	✓	✓	✗	✗
	3	Demand Side Response (DSR)	✓	✓	✗	✗	✓	✓	✗	✗
Network Reinforcement	4	Upgrade of existing subtransmission network from Linton GXP (Feeder fed transformers)	✓	✓	✓	✗	✓	✓	✗	✓
	5	Upgrade of existing subtransmission network from Linton GXP (Meshed network)	✓	✓	✓	✓	✓	✓	✓	✓
	6	Upgrade of existing subtransmission network from Linton GXP (Cascaded meshed network)	✓	✓	✓	✓	✓	✓	✓	✓
	7	Upgrade of existing network from Bunnythorpe GXP	✓	✓	✗	✗	✓	✗	✗	✗

Key:

Safety	Health and Safety: Any significant implications in terms of Safety or Health - new products or compounds or practices, or requires difficult live line access etc.
Fit	Fit for Purpose: Does the option address the need appropriately and does it fit with other developments in the vicinity.
Feasible	Technically Feasible: Consider the complexity, future adaptability, and whether it aligns with company standards, strategies and policies.
Practicality	Practical to Implement: Are there potential environmental or property issues which may be insurmountable. Can it be achieved in the required time frame.
GEIP	Good Electricity Industry Practice (GEIP): Good practice (technically and environmentally) and in terms of AM practice (capacity, age, technological)
Security	Security and Reliability: Does the option provide adequate levels of security and appropriate reliability considering the demand, load type and future growth.
Cost	Some options will intuitively be known to be far more expensive than other options, and this may preclude them.

Options Analysis | Short List of Options		
Option	**Capital Cost**[8,9,10]	**Description**
Option 4: ***Feeder Fed Transformers (from Linton) Refer to Figure 2 & Figure 6***	**$34.0M**	**Linton GXP**: Install an additional 4 x 33kV feeder breakers (Transpower cost). **33kV Sub-transmission**: The following network enhancements: • Upgrade 2.7km of the existing Fitzherbert 33kV feeder (FITZ) that runs between the Linton and Pascal Substations. A section of the existing cable, from the south of the Manawatu River to the Pascal substation, consists of 240mm^2, copper, PILC cable with a continuous rating of 17.4MVA. This would be replaced with a 630mm^2, copper, XLPE cable with a rating of 35MVA. • Two new dedicated 25MVA, 33kV, underground cable circuits from Linton to the proposed Ferguson substation. Ferguson would not be equipped with a 33kV switchboard and have unit protection across the transformers/cables. However, the substation would be designed with sufficient space to install a 33kV switchboard should there be a need to integrate the sub-transmission supply into the rest of the Palmerston North city network at a later date. • A new substation (Ferguson) equipped with 2 x 16/24MVA, 33/11kV, feeder fed transformers and an 11kV switchboard. • Two new dedicated 25MVA, 33kV, underground cable, circuits from Linton to the Main St substation. These cables would be terminated on the two existing 33kV feeder CBs at Main St.
Option 5: ***Upgrade of existing sub-transmission network from Linton GXP (Meshed network) Refer Figure 7***	**$25.7M**	**Linton GXP**: Install an additional 2 x 33kV feeder breakers (Transpower cost). **33kV Sub-transmission**: The on-going development of a meshed 33kV network involving the installation of two additional 33kV cables emanating from Linton as follows: • Upgrade 3.3km of the central & northern sections of the existing Linton-Pascal 33kV cable (known as Fitzgerald feeder) and diversion through (in & out) the proposed Ferguson substation. • Two new 8.9km, 35MVA, 33kV cable circuits from Linton to Ferguson. One to terminate at the proposed Ferguson substation and the second to continue on to Main St (an additional 2.0km length). The cable to Main St would terminate on one of the existing 33kV feeder CBs. • A new 2.0km, 35MVA, 33kV cable link between the Main St and the proposed Ferguson substation. This cable would be terminated on one of the existing 33kV feeder CBs at Main St. • A new substation (Ferguson) equipped with 2 x 16/24MVA, 33/11kV, a 33kV switchboard (7 x CBs) and an 11kV switchboard.

[8] The total capital cost of each project. The costs do not consider the time value of money and do not include the economic value of other factors (i.e. network losses and consumer outage costs).

[9] Excluding Powerco's internal costs (AMG) or interest during construction (IDC).

[10] Excludes Main to Keith 33kV cable replacement and Pascal to Gillespies 33kV cable replacement. The costs associated with these replacement projects are accounted for in the replacement capital costs.

Option 6: ***Upgrade of existing sub-transmission network from Linton GXP (Cascaded mesh network) Refer to Figure 8***	**$26.6M**	**Linton GXP**: Install an additional 2 x 33kV feeder breakers (Transpower cost). **33kV Sub-transmission**: This option is effectively a hybrid of Options 1 & 2 that delivers a simplified network architecture (and associated protection system) with an improved network reliability. The following is proposed: • Upgrade 2.7km of the central/northern section of the existing Linton-Pascal 33kV cable (Fitzgerald feeder) to continue supplying Pascal. • Two new dedicated 8.9km, 40MVA (each), 33kV underground/overhead cable circuits from Linton to the proposed Ferguson substation (equipped with a 33kV switchboard). • Two new dedicated 2.0km, 30MVA, 33kV circuits from Ferguson to Main St (equipped with 33kV switchboard). These cables would be terminated on the two existing 33kV feeder CBs at Main St. • A new substation (Ferguson) equipped with 2 x 16/24MVA, 33/11kV, a 33kV switchboard (8 x CBs) and an 11kV switchboard. • A 1.5km, 33kV, single circuit, cable link between the Pascal substation and the proposed Ferguson substation. This enhancement is included to manage the risks associated with the 8.9km, 33kV underground cable circuits from Linton to Ferguson (cables installed in common trench). The link makes use of the existing 17.4MVA, 33kV cable that presently forms part of the Fitzgerald feeder. The new section of cable having a significant rating in the event that the existing cable requires upgrade.
Other Projects Linked to Palmerston CBD & this PoD		The following 2016 initiatives/projects (not costed above) are shared by all of the above options: • The existing Keith to Main St 33kV, oil insulated cable circuits are retired and replaced by a single 30MVA, 33kV underground cable. • The existing Pascal to Main St 33kV, oil insulated cable would be retired. • The Gillespies-Pascal 33kV, 12.7MVA underground cable is replaced with a new 30MVA, 33kV cable.

Option Analysis | Advantages vs Disadvantages

The following sections summarise the advantages/disadvantages associated with the short listed options. The intention being to also capture project risks and inter-dependencies.

Option	Advantages	Disadvantages
Option 4: ***Feeder Fed Transformers (from Linton)*** ***Refer to Figure 2 & Figure 6***	• Practical and achievable in terms of consenting and routes. • Utilises known technology and proven designs. • Highly reliable design with simple protection system. • Provides flexibility in final configuration of future substations. • Delivers higher level of cable capacity into the CBD. • Avoids the installation of 33kV switchboards.	• The feeder fed transformer design tends to have less flexibility to change and does not lend itself to staged development. • Common mode failure involving 4 x 33kV cables that are proposed to be in a single trough/trench across Massey University. • The four cable requirement means that a wider cable corridor (or multiple cable corridors) is required that is expected to delay consenting and easement acquisition.
Option 5: ***Meshed network (from Linton)*** ***Refer to Figure 3 & Figure 7***	• Least capital cost of all options. • Only 2 x 33kV additional Linton feeders required. • Reduced amount of new 33kV cable required. • Lower levels of 33kV cable congestion around Linton.	• Meshed/Ring networks tend to have a lower network reliability due, in part, to the more complex protection system involved. • Common mode failure involving 2 x 33kV cables (single trench across Massey University) supplying the proposed Ferguson and Main substations. This is mitigated to some extent by the 33kV link into Pascal. • Common mode failure involving 3 x 33kV cables (single trench along Church & Ferguson streets).
Option 6: ***Cascaded mesh network (from Linton)*** ***Refer to Figure 4 & Figure 8***	• Cascaded network configuration simplifies protection systems with improved reliability (in comparison to Option 2). • Increases load transfer capability between Bunnythorpe and Linton (i.e. improves diversity of supply). • Lower levels of 33kV cable congestion around Linton.	• Common mode failure involving 2 x 33kV cables supplying the proposed Ferguson substation. This risk is mitigated via the installation of the Pascal to Ferguson and Main to Ferguson 33kV cables. • Common mode failure involving 3 x 33kV cables (single trench along Church & Ferguson streets).
Shared Features	• All circuits are of underground construction, which should improve reliability to Palmerston CBD. • All options increase the 33kV load transfer capability between Bunnythorpe and Linton (i.e. improves diversity of supply).	• All options need to cross the Manawatu River which does present consenting and construction challenges/risks. The proposal is to thrust ducts under the river to accommodate the cables. • All options require an easement to traverse land owned by Massey University.

Recommendation	
Preferred Option	The preference is to proceed with Option 6 : Cascaded Mesh network (from Linton)
Reasons for choosing Option	The capital costs associated with Option 6 are expected to be higher than the least capital cost Option 5. However, Option 6 is expected to deliver higher levels of network reliability that will result in less network outages. The lower number of network outages will be of economic benefit to the consumers within the Palmerston North CBD and over time Option 6 is expected to deliver the most cost effective option. Option 6 can be staged and enables the network development to be deferred or brought forward as load growth evolves. The network architecture associated with Option 6 is flexible and adaptable to change (in the event that the Palmerston North CBD supply requirements change).

Option 6 | Detailed Costs[11]

Item	Description	Actual Cost	Projected Cost
A	Costs to secure project		
A.1	Expenditure to date	$2,204	-
A.2	Land, Easements, Consents & Investigations - Future	-	$1,935
A.3	Drilled Manawatu River Crossing (single crossing to secure one cable route) - Future	-	$1,760
A.4	He Ara Kotahi Bridge Crossing (to secure the four cable routes) - Future	-	$760
B	Distribution Network Enhancements		
B.1	11kV distribution cable & switchgear to integrate new substation - Future	-	$1,200
C	Subtransmission Network Enhancements		
C.1	Construct Ferguson substation - Future	-	$5,900
C.2	33kV cable from Linton to Ferguson - Future	-	$10,306
C.3	33kV cable from Pascal Substation to Main Substation - Future	-	$2,230
D	Grid Exit Substations		
D.1	Works at Linton GXP (to enable the installation of a new Transpower owned 33kV switchboard)	-	$300
E	Commited/Historical Costs (A+B+C+D)	$2,204	
F	Future Projected Costs (A+B+C+D)		
G	Anticipated Final Cost (E+F)		$26,595

[11] Excludes Powerco's internal/overhead costs.

Option 6 | Implementation Plan				
Project or Action	Start Year[1]	End Year[1]	NZ $'000	Details / Comments
Project costs to date	-	FY14	$2,204	Costs that have already occurred.
Easements/land/Investigations	FY15	FY23	$1,935	Purchase easements/land/Investigations. A large portion of land/easement purchas is across Massey University.
Drilled River Crossing (single crossing)	FY22	FY23	$1,760	Drill a single duct/pipe under Manawatu River (for one 33kV cable)
He Ara Kotahi Bridge River Crossing	FY17	FY22	$760	Costs to secure passage for 4 x 33kV cables across the proposed new bridge
Construct Ferguson substation	FY17	FY19	$5,900	2 x 15/24MVA substation, 33kV switchboard and 11kV switchboard.
Connect Ferguson to 11kV network	FY17	FY19	$1,200	11kV cable & switchgear to integrate Ferguson into the existing 11kV distribution network.
Construct Linton to Ferguson 2 x 33kV cable/line link	FY22	FY23	$10,306	8.9km double cct 33kV cable from Linton to Ferguson.
Linton GXP Enabling Works	FY23	FY23	$300	Minor works to facilitate Transpower installing a new 33kV indoor switchboard at Linton
Construct Pascal-Ferguson-Main 33kV cable	FY17	FY18	$2,230	2.8km 33kV cable link from Pascal to Ferguson to Main
Total Project Costs	FY14	FY23	$26,595	Includes only Growth & Security Expenditure.

Supporting Documents and Models	
Planning documents ***Standards | Policies*** ***Reviews and Consultant reports*** ***Concept Designs | Estimates***	1. Network Development Plan, January 2017. 2. Manawatu Southern Sub-transmission Development, Powerco Area Study, 21/10/2014. 3. Manawatu Strategy Plan, Powerco Document. 4. Peer review of Palmerston Supply Options, SKM (now Jacobs) review letter, dated 24/07/2013. 5. Board Memo : Palmerston North CBD Reinforcement – Land and Easement Acquisition, 2013. 6. Ferguson Street Zone Substation Concept Design Report, Jacobs report, August 2014. 7. Palmerston North Sub-transmission Property Compensation & Cost Estimates, The Property Group, dated 17/04/2015. 8. Palmerston North CBD Reinforcement Investigations, 33kV Cable Route Concept Cost Estimate, Jacobs report, April 2015. 9. Palmerston North CBD Reinforcement Investigations, Linton 33kV Switchroom Conceptual Cost Estimate, Jacobs report, April 2015. 10. Powerco's Demand Forecast. 11. Powerco's 2016 Asset Management Plan (AMP). 12. Powerco's Annual Planning Report (APR). 13. "*310S001 Security-of-Supply Classifications – Zone Substations*", Powerco Standard. 14. "*393S041 Zone Substation Transformer Ratings*", Powerco Standard. 15. "*393S035 Electrical network Conductor Rating Standard*", Powerco Standard. 16. "*Palmerston North CBD Reinforcement Investigations – Ferguson St Zone Substation Concept Design Report*", Jacobs Report ZP01546-2, dated August 2014. 17. Board memo : Palmerston North Capacity Upgrade Programme – Enabling Works. 1st September 2016.

Notes/Assumptions	
Generic Assumptions in relation to Options Costs	• Costs are expressed in 2016 (real) dollars. • The costs quoted are to construct the network and do not include economic factors (i.e. costs of non-supply). Powerco has considered economic factors in order to choose the preferred option. • The capital costs fall within the Growth and Security expenditure categories only. • The capital costs only include Powerco's capital expenditure (not Transpower or other parties). • All the costs associated with the proposed projects (or alternate options) are reported regardless of whether they fall within the CPP period or not.
Specific Assumptions in Relation to Options Costs	• The costs associated with the chosen option have been further refined. In particular this has involved investigating the costs associated with traversing the Manawatu River. • Property and consenting costs are usually a high risk area involving considerable uncertainty. Due to the urban nature of the project the 33kV circuits are mostly installed underground and where possible installed in road reserve. The exception to this is the route across Massey University where an easement is being negotiated and some sections of overhead 33kV line have been accepted by the land owner. • All options include the installation of the Pascal-Gillespies 33kV cable and the Keith-Main 33kV cable. These two projects are replacement projects, are not demand driven and are not included in the capital costs of the options outlined in this document.

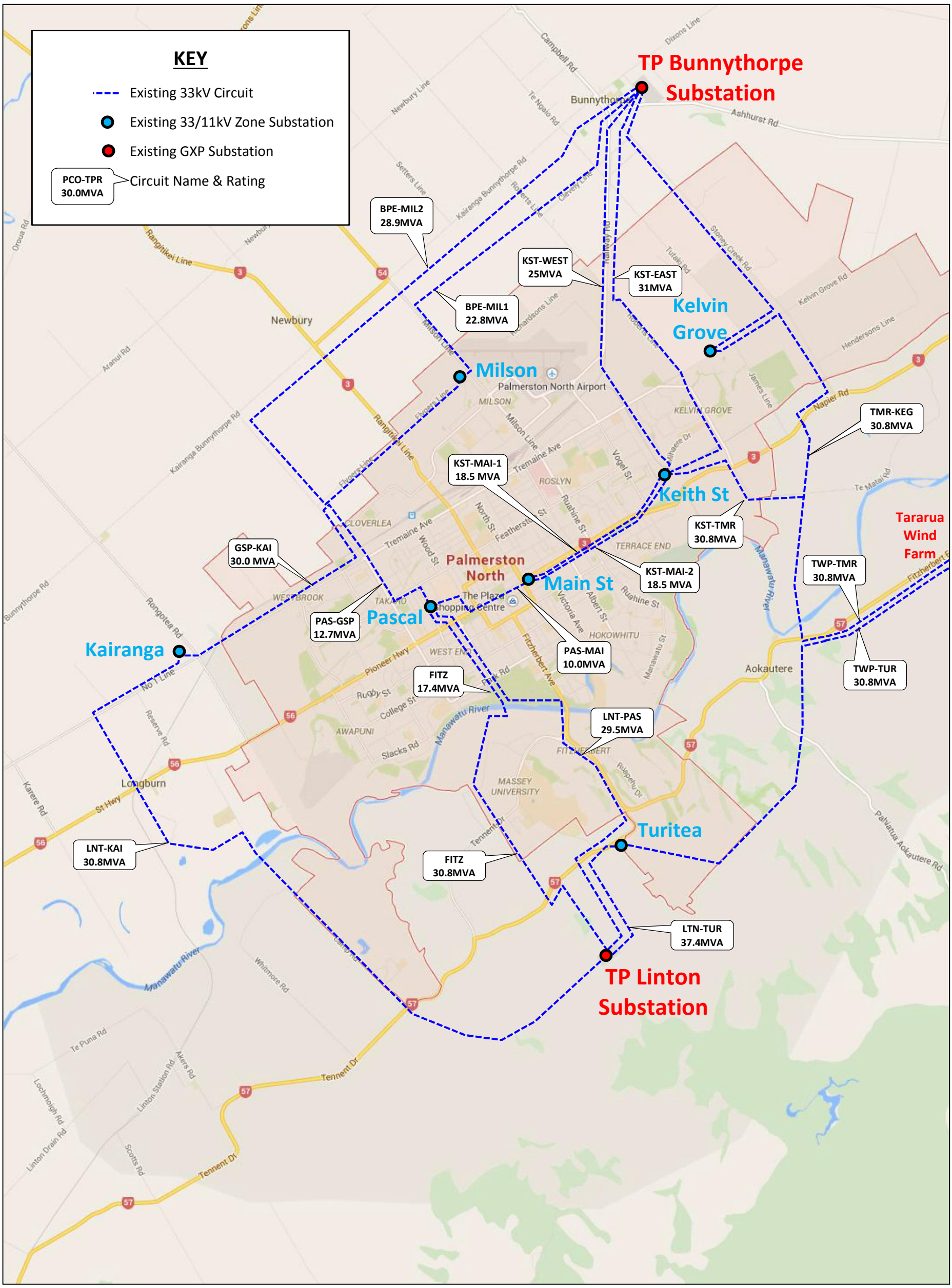


Figure 1 Existing Palmerston North CBD Sub-transmission Network: Geographic Diagram

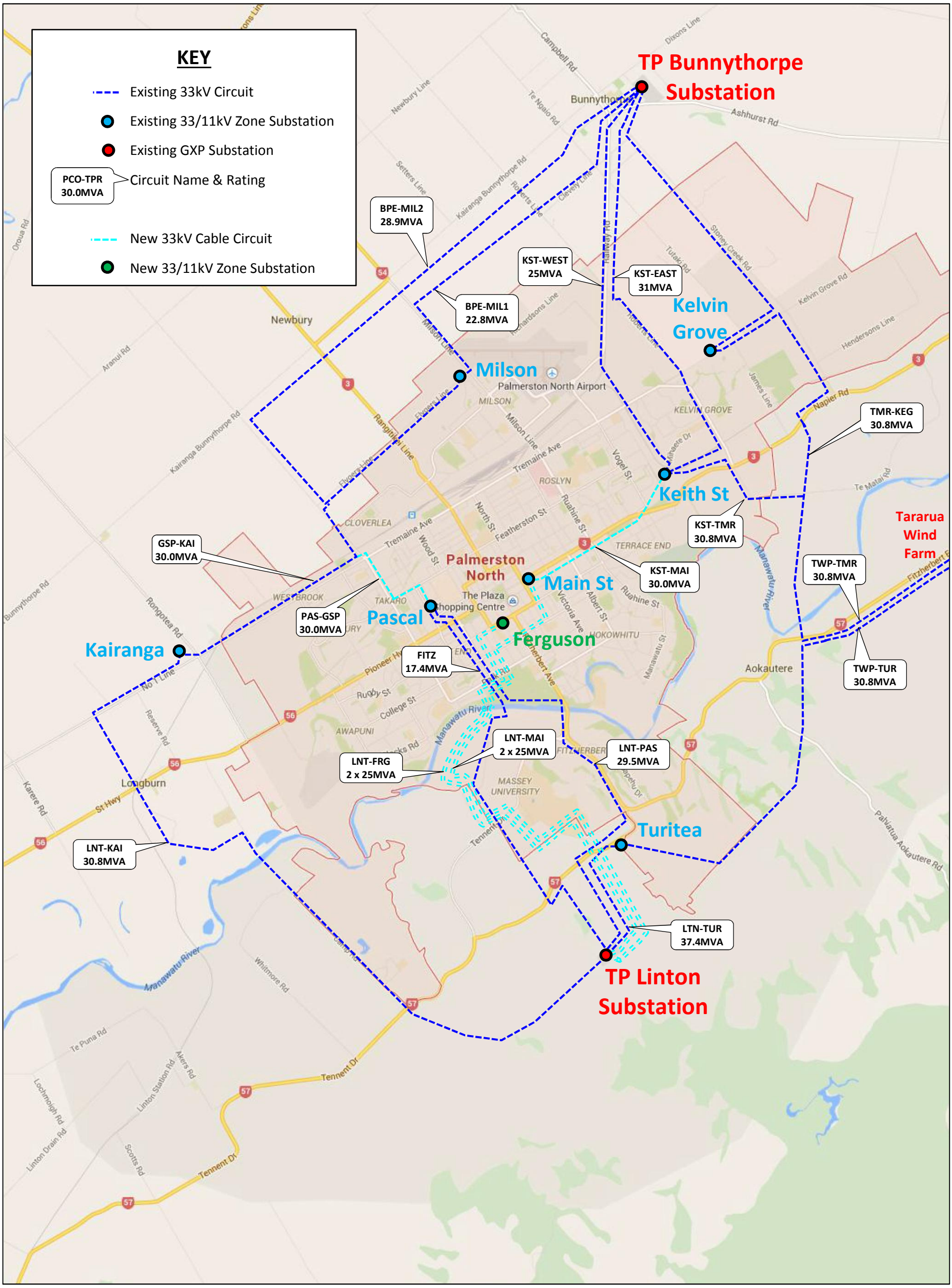


Figure 2 Option 4: Feeder Fed Transformers (from Linton): Geographic Diagram

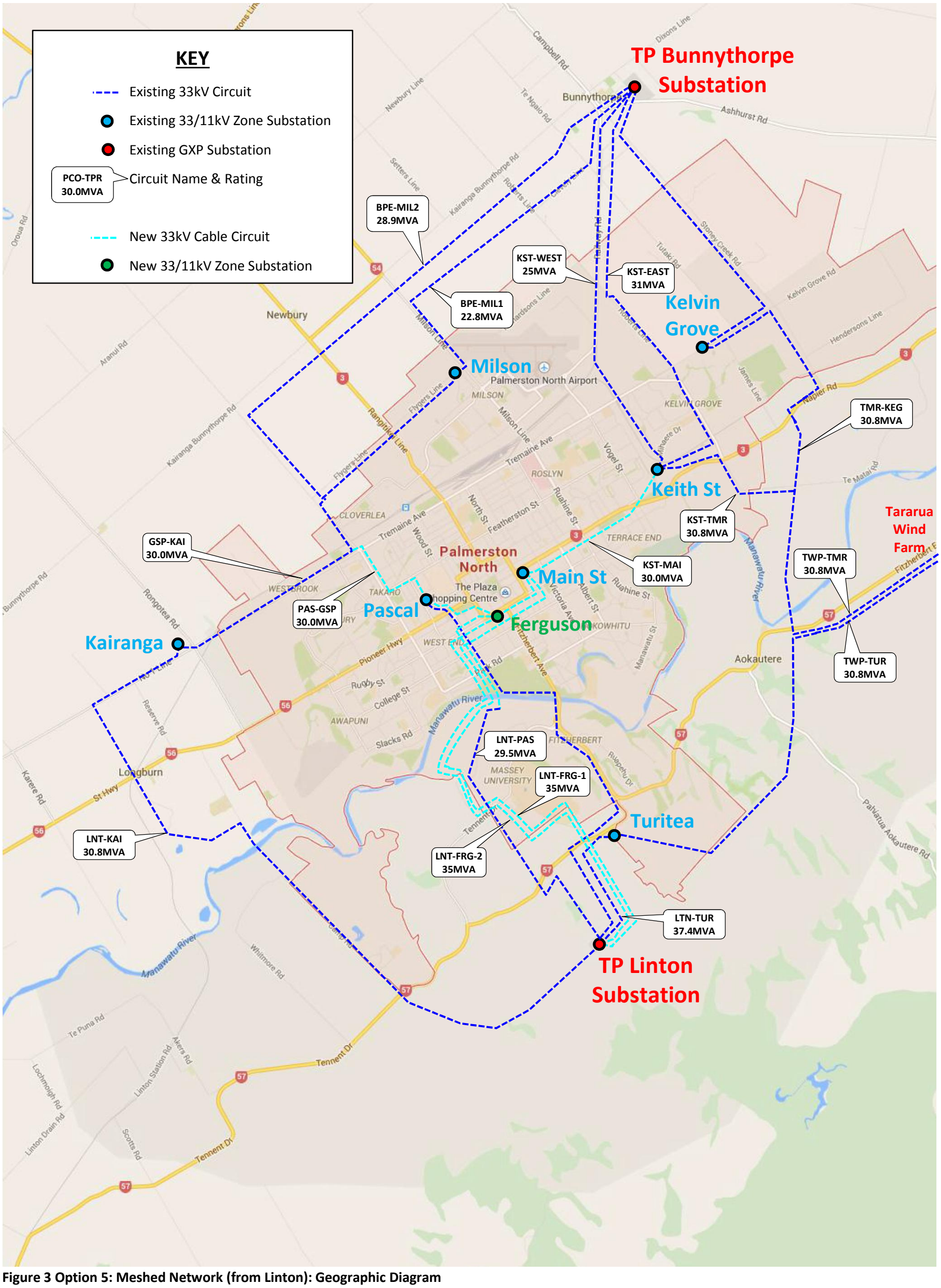


Figure 3 Option 5: Meshed Network (from Linton): Geographic Diagram

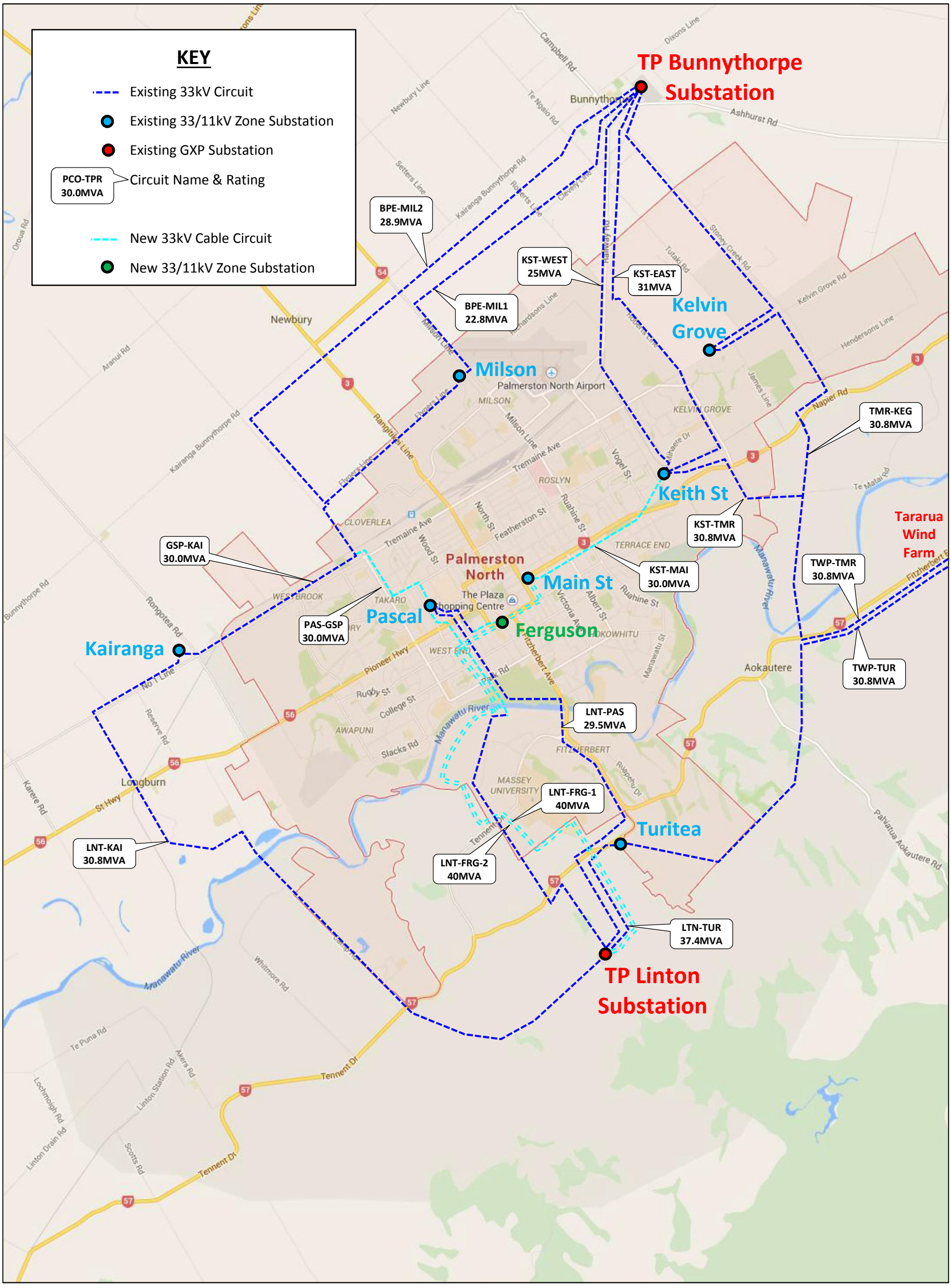


Figure 4 Option 6: Cascade Meshed Network (from Linton): Geographic Diagram

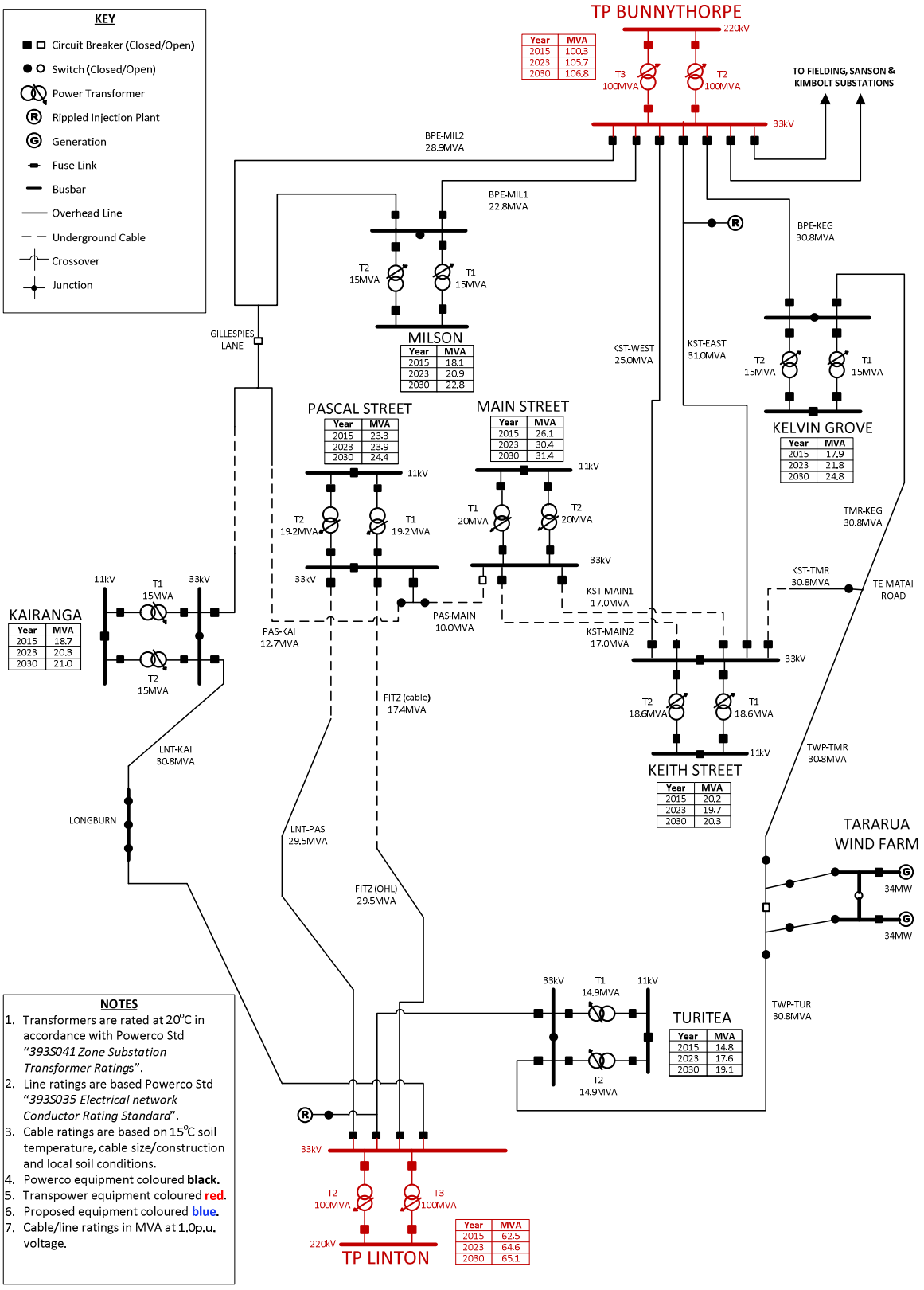


Figure 5 Existing Palmerston North CBD Sub-transmission Network: One-Line Diagram

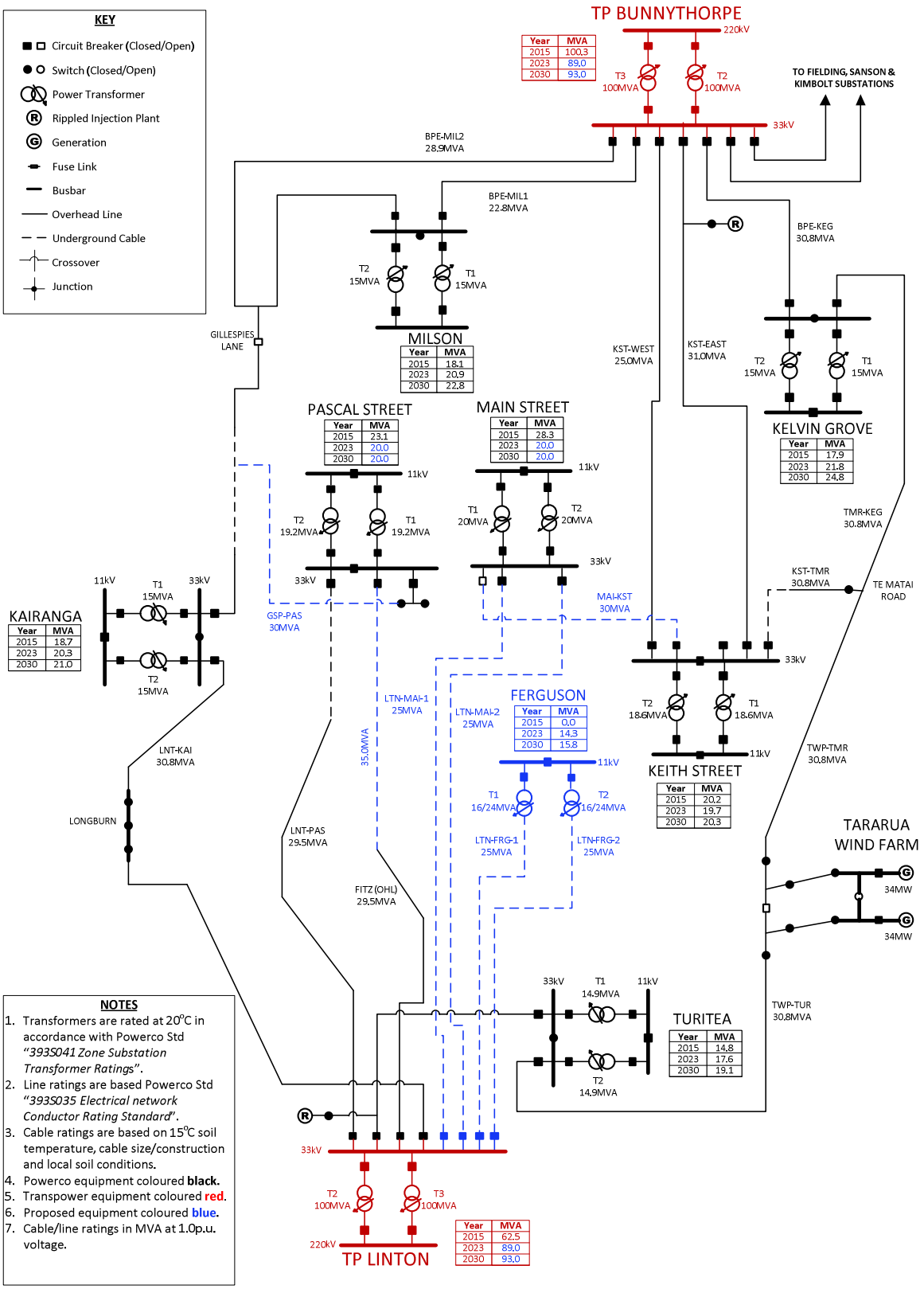


Figure 6 Option 4: Feeder Fed Transformers (from Linton): One-Line Diagram

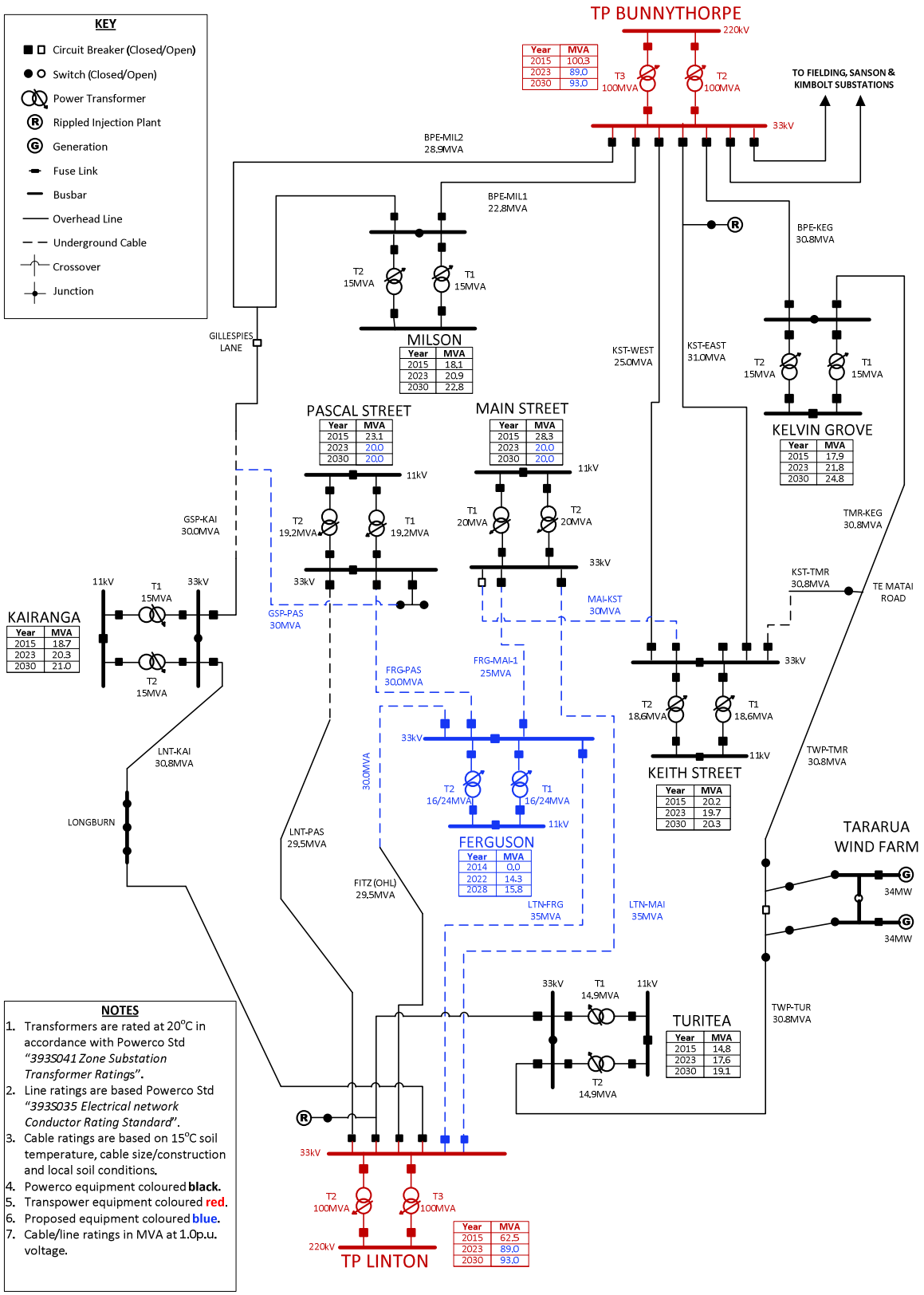


Figure 7 Option 5: Meshed Network (from Linton): One-Line Diagram

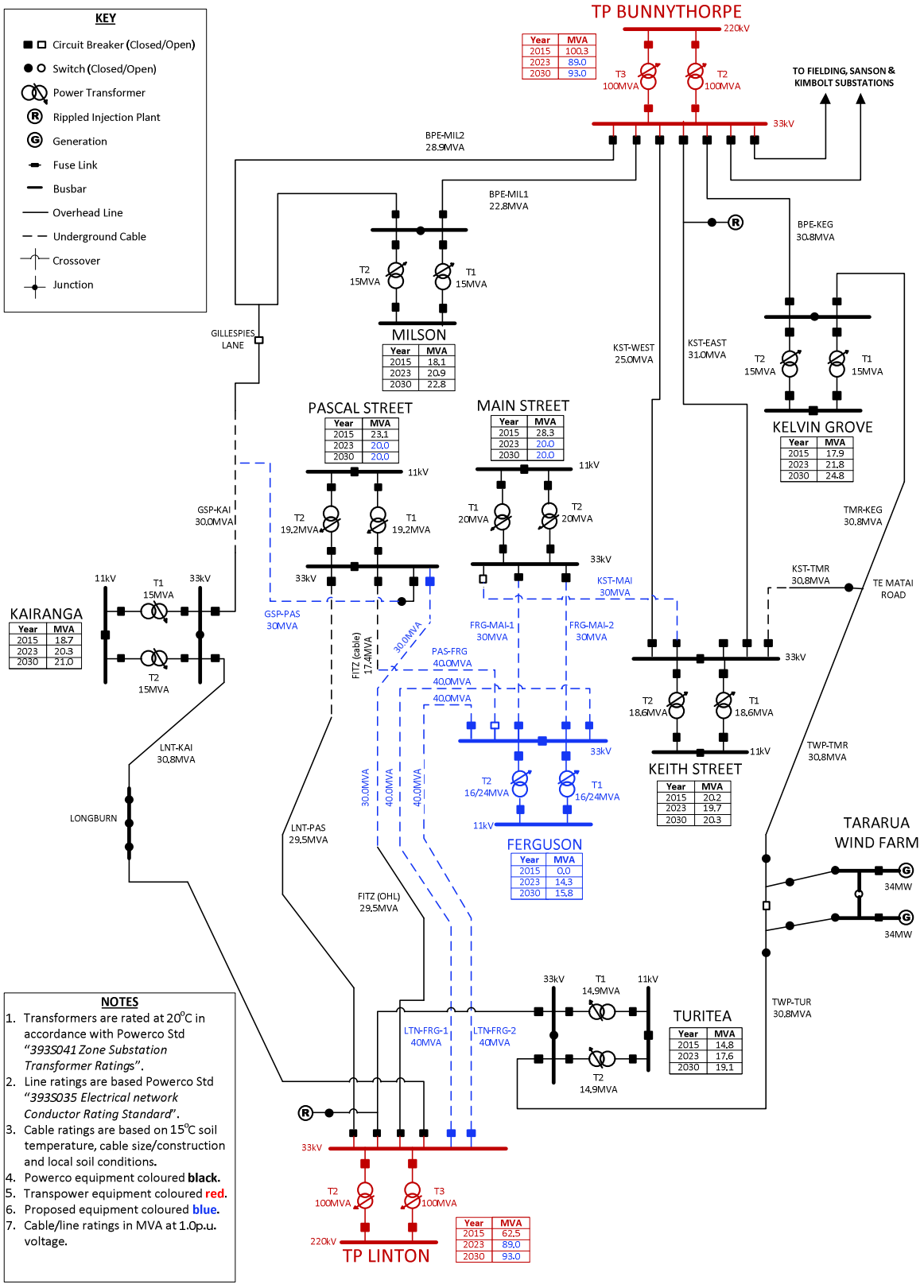


Figure 8 Option 6: Cascade Meshed Network (from Linton): One-Line Diagram