Attachment 5 – Worked Examples Illustrating the Application of the Connection Charging Methodology

The following Examples are to illustrate the application of the Connection Charging Methodology and are not intended to provide an accurate estimate of the charges which a person would become liable in respect of the provision of a connection. The Examples do not necessarily represent the Minimum Scheme for a specific connection application or how we would classify a connection between what is a Demand Connection or Generation Connection. Where an example only applies to either Demand or Generation Connections, then this is identified in the Example title, otherwise the examples apply to both.

The figures quoted in the Examples are illustrative. Section [7] of this statement provides our charges and indicative costs to undertake various activities.

The Examples illustrate where we undertake both the Contestable and Non-Contestable Work. These costs will include the determination of the POC and assessment and design costs, though these are not explicitly identified in the Examples.

Where Contestable Work is undertaken by an ICP, we will apply CIC Charges for services associated with the Contestable Works which would cover activities including design approval, inspection and monitoring. The CIC Charges are not shown in the Examples. For the avoidance of doubt, in each Example, where an ICP undertakes the Contestable Work, our Connection Charge will include the cost of the Non-Contestable Work and the CIC Charges but exclude the cost of Contestable Work.

The Examples are generic and standard for all LDNOs, but they do not represent the network analysis and subsequent design solutions that would be completed for an actual connection scheme. The actual designs are subject to our design policies.

The Examples quantify capacity as either Volt-Amperes (VA) or Watts (W). VA values – Kilovolt-amperes (kVA) or Megavolt-amperes (MVA) – are provided throughout the examples to quantify Demand capacities and reinforcement works, while W values – Kilowatts (kW) or Megawatts (MW) – are provided to quantify Generation capacities, in line with industry practice. Where an example includes values in both VA and W, a unity power factor is assumed (I.e., 1W = 1VA).n the Examples, where it is a Demand Connection, the capacities are stated in kilo or mega Volt-Amperes (kVA or MVA) and Generation Connections in kilo or mega Watts (kW or MW). Where an example includes values in both VA and W, a unity power factor is assumed (I.e., 1W = 1VA).

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Example	Description	Purpose
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Key to Illustrations

X	Circuit Breaker (any voltage)
	Switch
	Transformer
●	Joint on cable
	High voltage ring main unit
	Existing cable
	Proposed cable
→	Normal Open Point (NOP)
G	Generator Customer
D	Demand Customer
	Point of Connection (POC)
SS	Sub Station
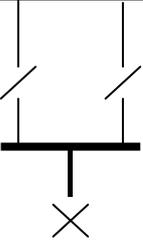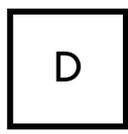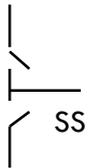
Example 1:   A new connection at LV

Purpose: To show extension assets are charged in full to the connecting customer.

A Customer requests a LV single phase connection to a new house. The Premises can be connected to an existing LV main cable in the street.
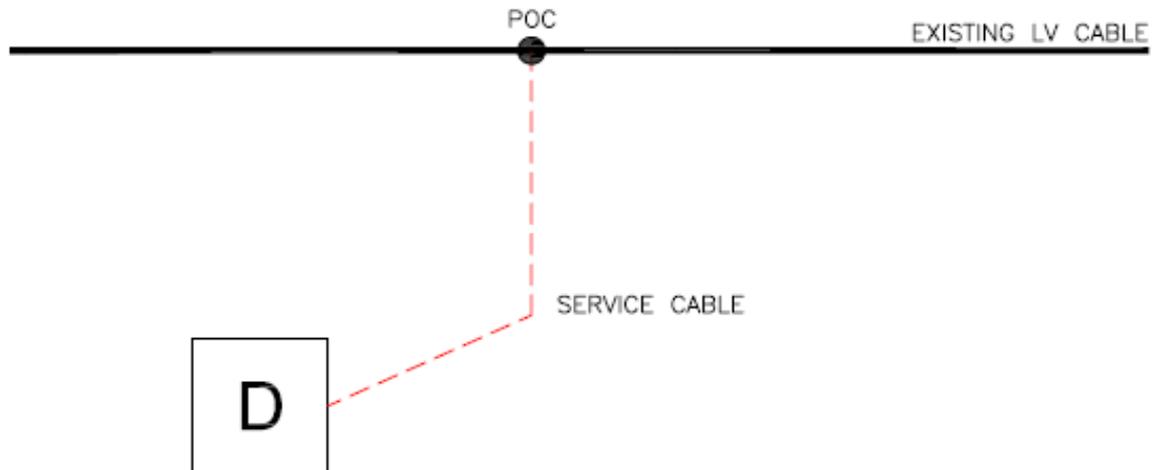
The Connection Charge for this Scheme is calculated as follows:

Extension Assets:

	Cost	Apportionment	Customer Contribution
15m service cable, excavation in footpath for joint hole to Customer laid duct, backfill and termination	£1,600	n/a	£1,600
Single service breech joint	£300	n/a	£300
Total Extension Asset Cost	**£1,900**		**£1,900**

Total cost of the work   = **£1,900**

Total Connection Charge to Customer   = **£1,900**

Example 2:   New connections at HV

Purpose: To show LV and HV extension assets are fully charged to the connecting customer.

A housing developer requests connection for 200 domestic Premises. The Required Capacity to supply the 200 homes is 250kVA. A new distribution substation will be established to provide the Required Capacity of the site. The Minimum Scheme requires the substation to be looped into the existing 11kV network.
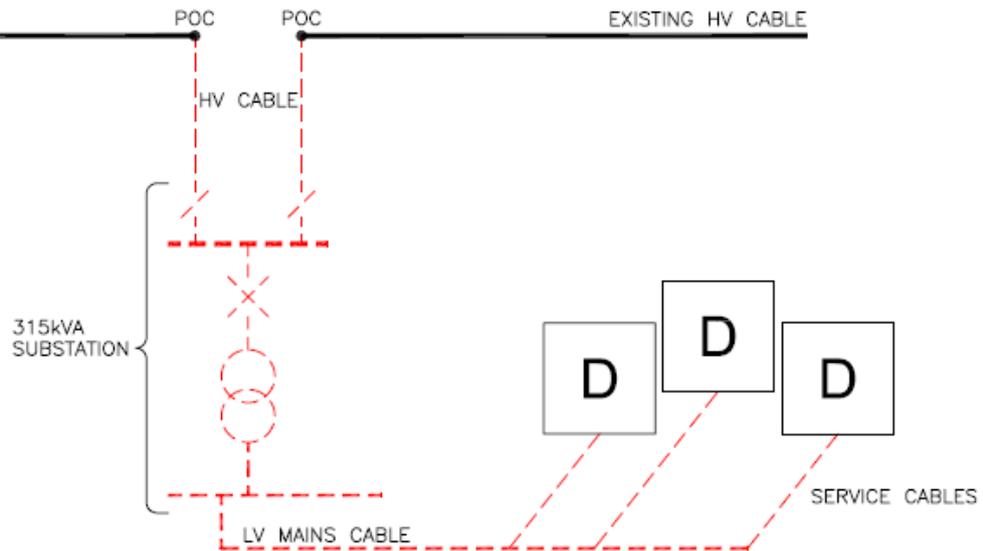
The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation 100m 11kV cable	£30,000	n/a	£30,000
315kVA substation	£60,000	n/a	£60,000
LV mains, service cables and terminations	£200,000	n/a	£200,000
Two 11KV cable joints	£6,000	n/a	£6,000
Total Extension Asset Cost	**£296,000**		**£296,000**

Total cost of the work   = **£296,000**
Total Connection Charge to Customer   = **£296,000**

Example 3:   A new connection on a domestic housing development with interconnection requested by the customer

Purpose: To illustrate Exception 2 where the interconnection is treated as Extension Assets and are fully charged to the connecting customer.

As in Example 2, a housing developer requests connections for 200 domestic Premises. The Required Capacity to supply the 200 homes is 250kVA. A new distribution substation will be established to provide the Required Capacity of the site. The Minimum Scheme requires the substation to be looped into the existing 11KV network. However, in this example there is an option to provide an additional LV cable to interconnect the distribution substation with the existing LV network. This option is over and above the Minimum Scheme.

Interconnecting into the existing LV network will increase the capacity of the existing Distribution System however the LV interconnector and the 11KV cables will not be considered Reinforcement .

In this case Exception 2 applies as the LV interconnector is over and above the minimum scheme and requested by the customer, therefore all assets (including the interconnecting LV cable) will be treated as Extension Assets and their costs will be borne in full by the Customer. As the interconnecting LV main and associated LV joint are over and above the Minimum Scheme, a charge for their future operation and maintenance will be made.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation 100m 11KV cable (from existing 11KV network to substation)	£30,000	n/a	£30,000
315kVA substation	£60,000	n/a	£60,000
LV mains, service cables and terminations (from substation to the customer's development)	£200,000	n/a	£200,000
Two 11KV cable joints	£6,000	n/a	£6,000

Extension Assets:	Cost	Apportionment	Customer Contribution
Interconnecting cable (from substation to existing LV network)	£12,000	In excess of Minimum Scheme	£12,000
LV cable joint	£300	In excess of Minimum Scheme	£300
Difference between Minimum Scheme and actual Scheme is £12,300. Operations & maintenance @ 20%* of £12,300		20%* of £12,300	£2,460
Total Extension Asset Cost	**£308,300**		**£310,760**

*Note, the 20% Operation and Maintenance percentage has been used for illustrative purposes only.

Total cost of the work = **£308,300**

**Total Connection Charge to Customer =** £308,300 + £2,460 = **£310,760**

Example 4:   **A new connection with interconnection requested by us**

Purpose: To illustrate Exception 1 where LV and HV extension assets are fully charged to the connecting customer, but the interconnection is paid in full by us.

As in Example 2, a housing developer requests connections for 200 domestic Premises. The Required Capacity to supply the 200 homes is 250kVA. A new distribution substation will be established to provide the Required Capacity of the site. The Minimum Scheme requires the substation to be looped into the existing 11KV network. However, in this Example there is an option to provide an additional LV cable to interconnect the distribution substation with the existing LV network. This option is over and above the Minimum Scheme.

Interconnecting into the existing LV network will increase the capacity of the existing Distribution System. Therefore, the assets that connect the 11KV and LV network would normally be considered to be Reinforcement. These assets (as shown on the diagram below) include the 11KV cable, the 315kVA substation and the interconnecting LV main. They exclude the LV mains and service cables from the 315kVA substation to the Customer's development. However, whether these assets are to be considered Reinforcement or Extension Assets depends upon who requested the LV interconnection.

In this case all the requirements of Exception 1 (paragraph 1.21) are met so the assets that connect the existing 11KV and LV Distribution System will be treated as Extension Assets and their costs will not be apportioned. The Customer will pay the costs associated with the Minimum Scheme in full. The interconnecting LV cable and associated LV joint, as they are over and above the Minimum Scheme and were requested by us, therefore the costs will be borne in full by us.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation 100m 11KV cable (from existing 11KV network to substation)	£30,000	n/a	£30,000
315kVA substation	£60,000	n/a	£60,000
LV mains, service cables and terminations (from substation to the customer's development)	£200,000	n/a	£200,000
Two 11KV cable joints	£6,000	n/a	£6,000
Interconnecting cable (from substation to existing LV network)	£12,000	In excess of Minimum Scheme	£0
LV cable joint	£300	In excess of Minimum Scheme	£0
Total Extension Asset Cost	**£308,300**		**£296,000**

Total cost of the work   = **£308,300**
Total Connection Charge to Customer   = **£296,000**

Example 5: A new connection where the Minimum Scheme is a new substation teed onto the existing HV network.

Purpose: Simple example of a commercial connection, extension assets only, so full cost to Customer.

A Customer requests a new LV three phase 600kVA connection to commercial Premises. Four scenarios for connection are considered in examples 5 to 8. The Minimum Scheme will be dependent on the specific circumstances as set out in paragraphs 1.1 to 1.7.

In this example the Minimum Scheme is a new 800kVA substation teed onto the existing 11KV network. The figure below shows the proposed network.
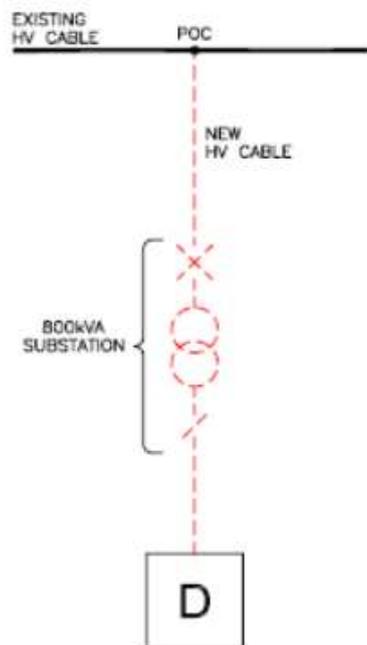
The Connection Charge for this Scheme is calculated as follows:

| Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation of 150m of 11KV cable	£45,000	n/a	£45,000
800kVA substation	£75,000	n/a	£75,000
Provision and installation LV cabling	£6,000	n/a	£6,000
LV Metering Panel	£4,000	n/a	£4,000
11KV joint to network	£3,000	n/a	£3,000
Total Extension Asset Cost	**£133,000**		**£133,000**

Total cost of the work = **£133,000**
Total Connection Charge to Customer = **£133,000**

Example 6: A new connection where the Minimum Scheme is a new substation looped into existing HV network.

Purpose: Simple example of looped connection, extension assets only so full cost to Customer.

In this variation to Example 5, the Customer is connected with a looped connection, as illustrated in the following diagram. The Minimum Scheme is a new 800kVA substation looped into existing 11KV network.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation of 300m of 11KV cable looped to network,	£90,000	n/a	£90,000
800kVA substation	£75,000	n/a	£75,000
Ring Main Unit	£25,000	n/a	£25,000
Provision and installation LV cabling	£6,000	n/a	£6,000
LV Metering Panel	£4,000	n/a	£4,000
11KV joints to network	£6,000	n/a	£6,000
Total Extension Asset Cost	**£206,000**		**£206,000**

**Total cost of the work**   = £206,000

Total Connection Charge to Customer   = £206,000

Example 7: A new connection where the Minimum Scheme is as for Example 5 but the Customer requests an enhanced connection arrangement where the substation is looped into existing HV network.

Purpose: Shows that for a customer requested Enhanced Scheme that the Customer pays costs above the Minimum Scheme plus O&M.

In this variation to Example 5, the Customer requests an enhanced connection arrangement where the substation is looped into existing 11KV network, as illustrated in the following diagram. The Minimum Scheme is as for Example 5.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation of 300m of 11KV cable looped to network	£90,000	n/a	£90,000
800kVA substation	£75,000	n/a	£75,000
Ring Main Unit	£25,000	n/a	£25,000
Provision and installation LV cabling	£6,000	n/a	£6,000
LV Metering Panel	£4,000	n/a	£4,000
11KV joints to network	£6,000	n/a	£6,000
Total Extension Asset Cost	**£206,000**		**£206,000**
Difference between Minimum and the actual Scheme is £73,000. Operation & Maintenance @20%* of £73,000		20%* of £73,000	£14,600
Total Extension Asset Cost incl O&M			**£220,600**

*Note, the 20% Operation and Maintenance percentage has been used for illustrative purposes only

Total cost of the work   = £206,000

Total Connection Charge to Customer   = £206,000 + £14,600   = £220,600

In this variation to Example 5, the Customer is connected with a looped connection, as illustrated in the following diagram. The Minimum Scheme is as for Example 5 but we request an Enhanced Scheme where the substation is looped into the existing 11KV network.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation of 300m of 11KV cable	£90,000	Minimum Scheme	£45,000
800kVA transformer	£75,000	n/a	£75,000
Ring Main Unit	£25,000	Minimum Scheme	0
Provision and installation LV cabling	£6,000	n/a	£6,000
LV Metering Panel	£4,000	n/a	£4,000
11KV joints to network	£6,000	Minimum Scheme	£3,000
Total Extension Asset Cost	**£206,000**		**£133,000**

Total cost of the work   = £206,000
Total Connection Charge to Customer   = £133,000

Example 9:	Additional load application requiring a new connection from the HV network and reinforcement.
Purpose:	To demonstrate the treatment of reinforcement cost for a Demand Connection that drives reinforcement.

A Customer requests to increase the Maximum Capacity of their existing LV connection from 200kVA to 850kVA; an increase of 650kVA (the Required Capacity). The Connection is a Demand Connection.

As the Customer's existing LV connection is unable to deliver the Required Capacity a new connection will be required from the local 11KV network. This will be a non-secure connection to a secure network. The Minimum Scheme is to overlay part of the nearest 11KV circuit (Feeder 2) which only has spare capacity of 200kVA. The Reinforcement to make the capacity available requires 1200m of existing 11KV cable to be overlaid with a larger capacity cable.
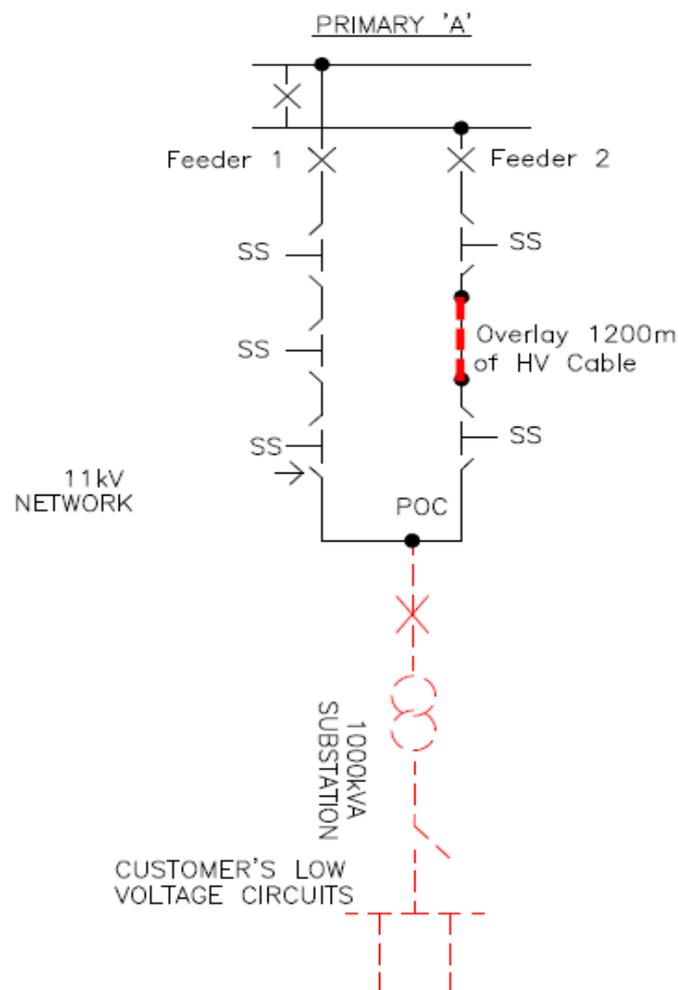
Reinforcement:

The Relevant Section of Network is the two feeder ring comprising Feeder 1 and Feeder 2.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement	Cost	Apportionment	Customer Contribution
Overlay 1200m of 11KV cable	£360,000	0%	£0
11KV Jointing	£6,000	0%	£0
Total Reinforcement Cost	**£366,000**		**£0**

Extension Assets	Cost	Apportionment	Customer Contribution
Provision and installation 11KV cable	£60,000	n/a	£60,000
1000kVA substation	£80,000	n/a	£80,000
Termination of Customer's LV cables	£4,000	n/a	£4,000
LV Metering panel	£4,000	n/a	£4,000
11KV Jointing	£3,000	n/a	£3,000
Total Extension Asset Cost	**£151,000**		**£151,000**

Total Cost of the Work   = £366,000 + £151,000   **= £517,000**

Total Connection Charge to Customer   **= £151,000**

Example 10:   A new connection that results in a Point of Connection further away than the nearest network.

Purpose: To show that the Minimum Scheme may result in a Point of Connection that is further away than the nearest network and may result in increased extension assets costs that are fully chargeable to the Customer.

A Customer applies for a new connection with a Maximum Capacity of 100kVA.

Assessment of the local network identifies that there is an existing LV cable to the front of the development, which is fed from a 315kVA transformer. The LV cable has sufficient spare capacity for the connection; however the transformer is at full capacity and would therefore require reinforcement work to upgrade it from a 315kVA to 500kVA transformer.

Two design options are considered. For the first option, the cost of this work is estimated to be £70,000, and the cost of the LV extension assets is estimated to be £5,000.
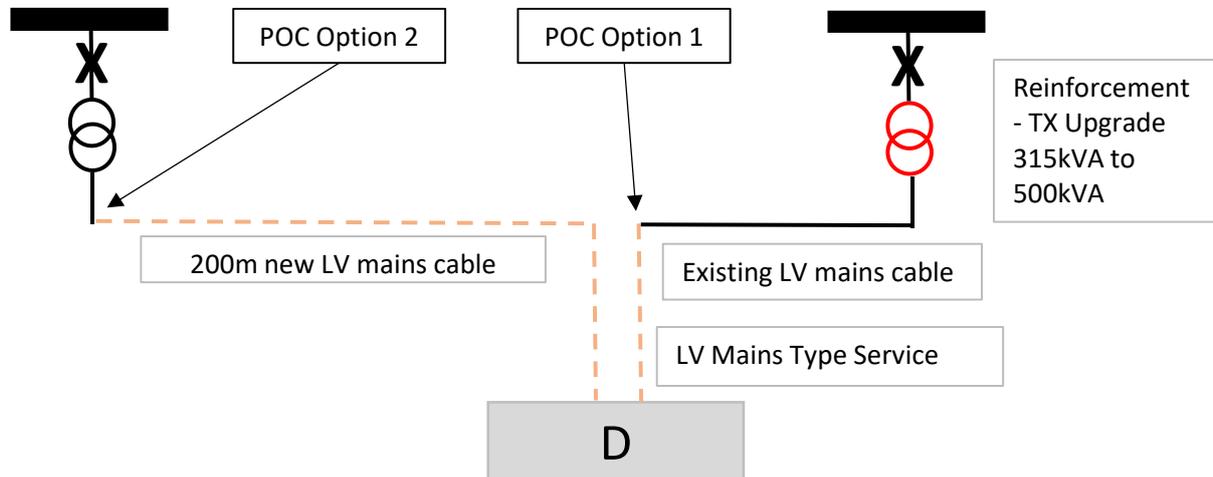
The Connection Charge for this Option 1 would be calculated as follows:

Reinforcement Assets:	Cost	Apportionment	Customer Contribution
Upgrade 315kVA transformer to 500kVA	£70,000	0%	£0
Total Reinforcement Asset Cost	**£70,000**		**£0**

Extension Assets:	Cost	Apportionment	Customer Contribution
LV extension assets	£5,000	n/a	£5,000
Total Extension Asset Cost	**£5,000**		**£5,000**

Total cost of the work   = £70,000 + £5,000   **= £75,000**

Total Connection Charge to Customer = £5,000   **= £5,000**

For the second option, there is a large cross-sectional LV cable 200m from the development which is fed from a 1000kVA transformer, and both the LV cable and transformer have sufficient spare capacity to provide a connection to the development without reinforcement work. This design requires extension assets involving 200m of LV Cable estimated to cost £40,000 and a mains type service; the cost of the LV extension assets is £5,000 consistent with the first option.

The Connection Charge for Option 2 would be calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
200m of LV mains cable	£40,000	n/a	£40,000
LV extension assets	£5,000	n/a	£5,000
Total Extension Asset Cost	**£45,000**		**£45,000**

Total cost of the work   **= £45,000**
**Total Connection Charge to Customer**   **=£45,000**

Option 2 has the lower overall capital cost of £45,000 (compared to £75,000 for Option 1) and therefore represents the Minimum Scheme. Whilst Option 2 results in a higher charge to the customer, it is the overall capital cost that is used to determine the Minimum Scheme. The connection offer to the customer would therefore be based on Option 2.

Example 11:   A new Generation Connection with capacity triggered Reinforcement

Purpose: To demonstrate the treatment of reinforcement cost for a Generation Connection which drives reinforcement using the security CAF.

A Customer requests a Generation Connection with a Required Capacity for export purposes of 3MW. The Minimum Scheme requires the Reinforcement of 500m of 11KV overhead line between points A and B to provide 7.6MVA of capacity.

The POC is to the existing 11KV network at point B and it is proposed to install 500m of 11KV underground cable from the POC to the Customer's installation.

NB: These primary CBs and Busbar need to be recoloured black as they are not being uprated
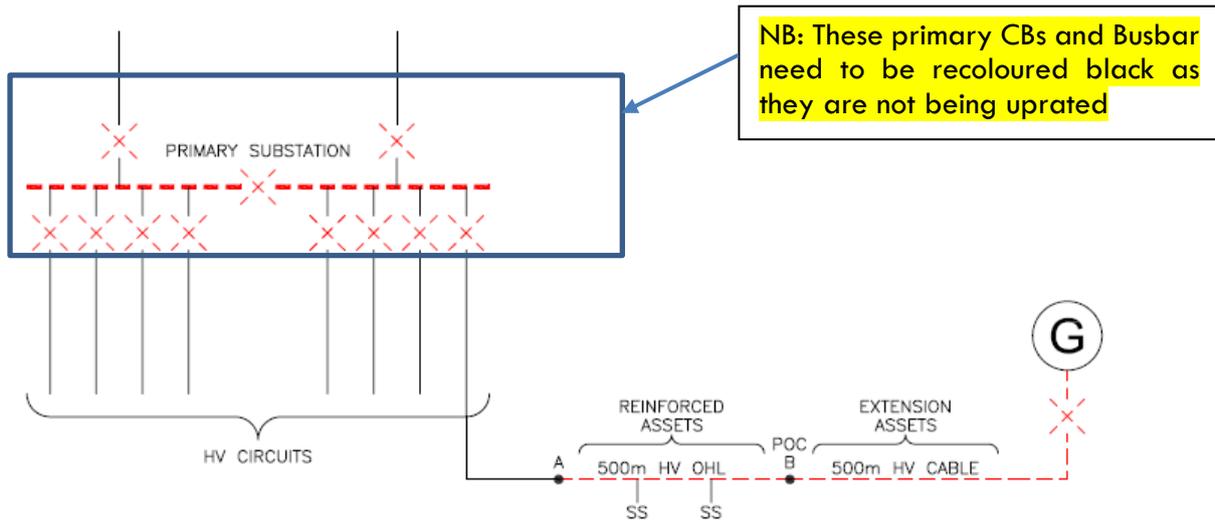
Reinforcement:

The Relevant Section of Network is the 11KV OHL between points A and B

Security CAF calculation: The numerator in the CAF calculation is based upon the Required Capacity of the new generation, i.e. 3MW. The numerator in the CAF calculation is based upon the Required Capacity of the Customer, i.e. 3MVA and the denominator is based on the New Network Capacity following Reinforcement, i.e. 7.6MVA.

Fault Level CAF calculation: This Scheme does not have any significant Fault Level contribution to the existing shared use distribution network and Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Re-conductor 500m of 11KV overhead line at a higher capacity (7.6MVA)	£60,000	3/7.6 x 100% = 39.5%	£23,700
Total Reinforcement Cost	**£60,000**		**£23,700**

Extension Assets:	Cost	Apportionment	Customer Contribution
Installation of 500m 11KV cable	£45,000	n/a	£45,000
11KV circuit breaker at Customer's substation	£25,000	n/a	£25,000
Total Extension Asset Cost	**£70,000**		**£70,000**

Total cost of the work = £60,000 + £70,000 **= £130,000**

Total Connection Charge to Customer = £23,700 + £70,000 **= £93,700**

Example 12:	A new Generation Connection with Fault Level-Triggered Reinforcement.
Purpose:	To demonstrate how the Fault Level CAF calculation is applied.

A Customer wishes to connect a new generator with a Required Capacity for export purposes of 6MVA. The connection of the generator requires the installation of 500m of 11kV cable and 1500m of overhead line between a new circuit breaker, added to the 11kV extensible switchgear panel at an existing primary substation and a new substation at the Customer's Premises. The 24MVA Fault Level contribution from the generator necessitates Reinforcement works to replace the 11kV switchgear at the existing primary substation with switchgear of a higher fault level rating.
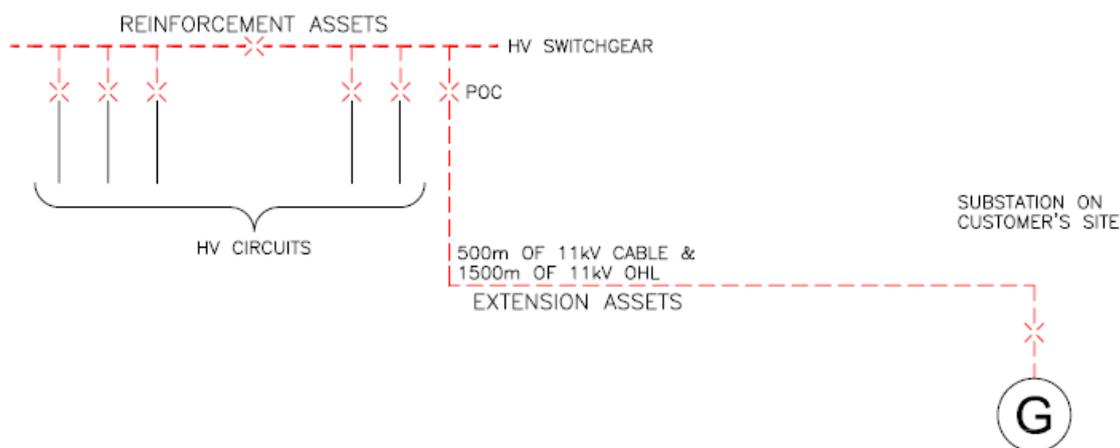
Reinforcement:

Fault Level CAF calculation: The numerator in the CAF calculation is based upon the Fault Level contribution from the Customer's new generator connection, in this Example 24MVA. The denominator is based upon the New Fault Level Capacity; in this Example the Fault Level capacity of the new 11kV switchboard, 315MVA.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Replacement 11KV switchboard (excluding Customer's sole use circuit breaker)	£800,000	3x (24/315) x 100% = 22.9%	£182,857
Total Reinforcement Cost	**£800,000**		**£182,857**

Extension Assets:	Cost	Apportionment	Customer Contribution
11KV circuit breaker at primary substation	£30,000	n/a	£30,000
Installation of a 500m 11KV cable	£150,000	n/a	£150,000
Installation of a 1500m 11KV overhead line	£120,000	n/a	£120,000
11KV circuit breaker at Customer substation	£25,000	n/a	£25,000
Total Extension Asset Cost	**£325,000**		**£325,000**

Total cost of the work   = £800,000 + £325,000   **= £1,125,000**
Total Connection Charge to Customer   = £182,857 + £325,000   **= £507,857**

Example 13	A new Generation Connection that requires Reinforcement involving both Security and Fault Level CAFs.
Purpose:	To demonstrate reinforcement charging principles for a Generation Connection where both security CAF and Fault Level CAF are applicable.

A Customer requests a connection to a generator with a Required Capacity for export purposes of 6MW. The Fault Level contribution at the primary substation from the generation connection is 10MW.

The POC is to the existing 11KV network at point B and it is proposed to install 500m of 11KV underground cable from the POC to the Customer's installation. This is a non-secure connection that requires reinforcement of a non-secure network.

The connection requires the Reinforcement of 500m of 11KV overhead line between points A and B for a thermal capacity requirement and replacement of the existing 11 panel 11KV switchboard at the primary substation in order to increase its fault level rating from 150MVA to 350MVA. However, the new fault level will be limited by the fault level rating of the local network of 250MVA.
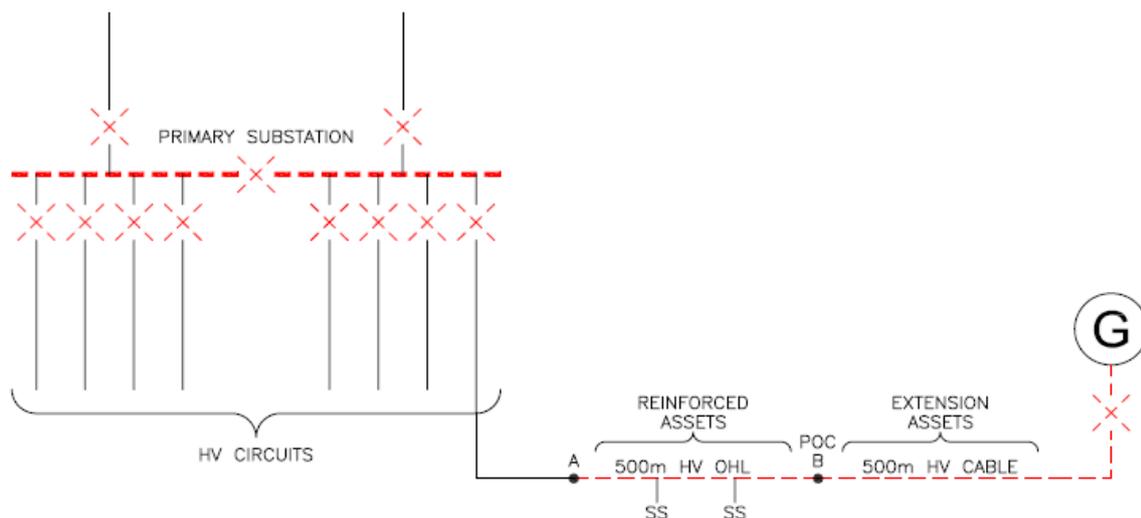
Reinforcement:

<u>The Relevant Section of Network is the 11KV network from the primary substation to Point B.</u>

Security CAF calculation: the numerator in the CAF calculation is based upon the Required Capacity of the Customer, ie 6MW. The denominator is based on the New Network Capacity following Reinforcement, which is 7.6MVA, ie after Reinforcement, in this particular case, the section of cable with the lowest rating.

The Relevant Section of Network is the 11kV switchboard at the primary substation.

Fault Level CAF calculation: The numerator in the CAF calculation is based upon the Fault Level contribution from the Customer's new generator connection, in this Example 10MVA. The denominator is based upon the New Fault Level Capacity, which is the lower of the Fault Level capacity of the new 11KV switchboard, 350MVA or of the local system, 250MVA in this Example.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement	Cost	Apportionment	Customer Contribution
Re-conductor of 500m of 11KV overhead line	£20,000	6/7.6 x 100% = 78.9% Security CAF	£15,789
Replacement 11KV switchboard	£800,000	3x (10/250) x 100% = 12.0% Fault Level CAF	£96,000
Total Reinforcement Cost	**£820,000**		**£111,789**

Extension Assets	Cost	Apportionment	Customer Contribution
Installation of 500m 11KV cable	£150,000	n/a	£150,000
11KV circuit breaker at Customer's substation	£12,000	n/a	£12,000
11KV pole top termination	£2,500	n/a	£2,500
Total Extension Asset Cost	**£164,500**		**£164,500**

**Total cost of the work:** = £820,000 + £164,500 **= £984,500**

Total Connection Charge to Customer = £111,789 + £164,500 **= £276,289**

Example 14.	A Generation Connection with reinforcement at a voltage above that of the point of connection.

Purpose: To illustrate that a Generation Connection does not contribute to reinforcement costs at a voltage level above the connection voltage.

A Customer requests a Generation Connection with a Required Capacity for export purposes of 3,MW. A new single circuit cable will be required to connect the customer to the existing 11KV network. There is sufficient spare capacity on the existing 11KV network main but the existing 7.5MW transformer at the local 11KV/33KV substation is fully loaded.

The Minimum Scheme is to provide a new 250m 11KV cable from the POC and to replace the 7.5MW transformer at the local substation with a 10MW transformer. 11KV and 33KV switchgear either side of the transformer also requires replacement due to exceedance of its thermal capacity.
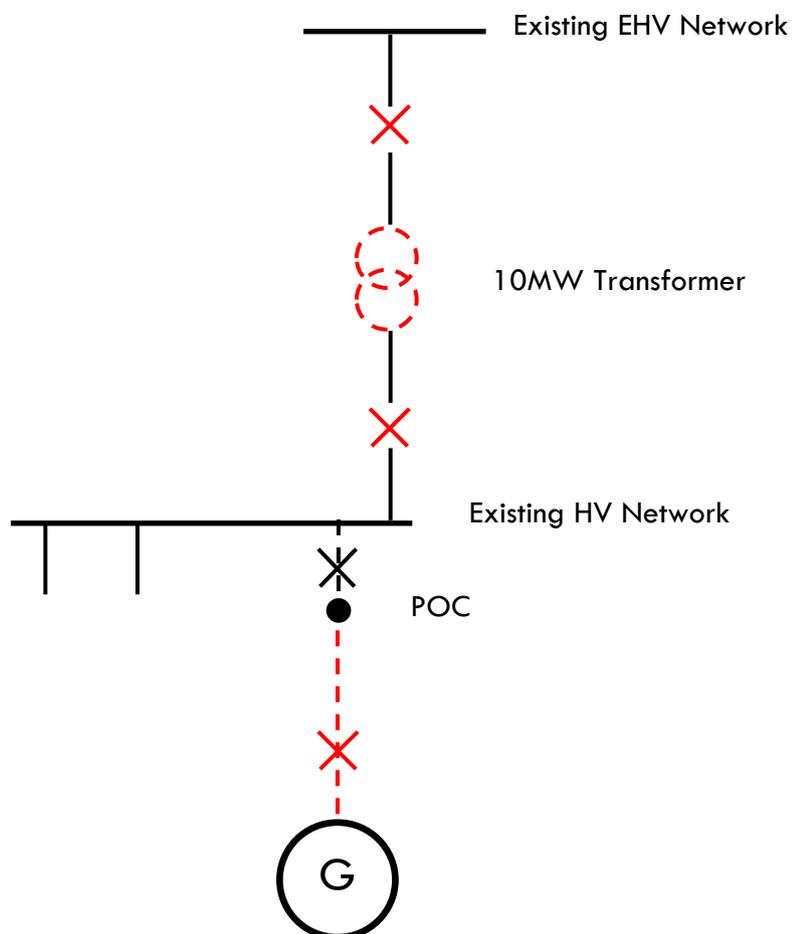
Reinforcement:

Security CAF calculation: The numerator in the CAF calculation is based upon the Required Capacity of the Customer, which is 3MW. The denominator is based on the New Network Capacity following Reinforcement, which is 10MW.

Reinforcement is required at both the 11KV and 33KV levels, however the CAF is only required at the same voltage of connection, which in this case is 11KV.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
11KV Jointing	£3,000	3/10 x 100% = 30% Security CAF	£900
11KV circuit breaker	£30,000	3/10 x 100% = 30% Security CAF	£9,000
33KV circuit breaker	£80,000	0%	£0
Transformer replacement	£1,500,000	0%	£0
Total Reinforcement Cost	**£1,613,000**		**£9,900**

| Extension Assets:	Cost	Apportionment	Customer Contribution
Install 200m of 11KV cable	£60,000	n/a	£60,000
11KV circuit breaker at Customer's substation	£25,000	n/a	£25,000
11KV Jointing	£3,000	n/a	£3,000
Total Extension Asset Cost	**£88,000**		**£88,000**

Total cost of the work   = £1,613,000 + £88,000   **= £1,701,000**

Total Connection Charge to Customer   = £9,900 + £88,000   **= £97,900**

Example 15:	A new Generation Connection where switchgear extension is not possible

Purpose: Illustrate Exception 4, if switchgear extension not possible, then treated as Extension Assets and Customer pays in full.

This example demonstrates the application of Exception 4 (paragraph 1.24**Error! Reference source not found.**).

A Customer requests to connect a new generator with a Required Capacity for export purposes of 3MW. The connection of the generator requires the installation of the works as provided in Example 12 above. In this scenario, however, there is no Fault Level issue but, as the connection cannot be facilitated by an extension of the existing switchgear equipment in our primary substation, a full replacement of the existing switchgear installation is required. As no capacity is added to the existing shared use distribution network, the Customer will be required to fund the full cost of the switchgear installation replacement.
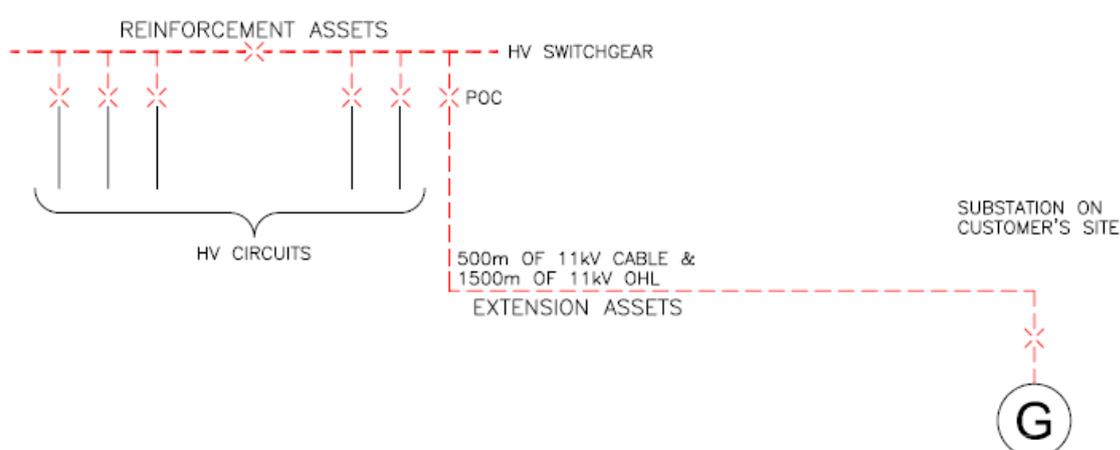
The existing switchgear had fault level rating of 250MVA. The company no longer uses switchgear with a fault level rating of 250MVA, so uses the closest equivalent switchgear used by it as standard, which has a slightly higher rating. Whilst the replacement switchgear increases the fault level capacity and could be considered Reinforcement, in this case this is due solely to the fault level rating of the standard equipment used by the company being higher than the fault level rating of the existing switchgear. The increase in fault level capacity is not required to connect the customer. Therefore, Exception 4 (Paragraph 1.24**Error! Reference source not found.**) applies and the switchgear is considered Extension Assets and its costs will be charged in full to the customer.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
Installation of a 500m 11KV cable	£150,000	n/a	£150,000
Installation of a 1500m 11KV overhead line	£120,000	n/a	£120,000
11KV circuit breaker at Customer substation	£25,000	n/a	£25,000
Replacement 11kV switchboard	£450,000	n/a	£450,000
New Extension Asset circuit breaker	£25,000	n/a	£25,000

Total Extension Asset Cost	**£770,000**		**£770,000**

Total cost of the work = £770,000

Total Connection Charge to Customer = £770,000

A customer wishes to connect a Battery with 20MVA import and 20MW export Required Capacity. The connection will be via a single independent 33kV metered connection in the customer substation C. The works required include:

(i) the extension of existing substation A with the installation of a new 33kV switchboard including metered incoming 33kV circuit breaker;

(ii) one circuit breaker for connection to the 33kV network; and

(iii) the provision of a radial circuit to new Substation B with the installation of 400m of 33kV underground cable between the proposed new customer substation and the point of connection.

To accommodate the export capacity, Reinforcement is required due to increased fault level requires the replacement of the 33kV switchgear within substation C. The reinforcement cost will be apportioned using the Fault Level CAF. The cost of the switchgear replacement is £400,000. The fault level contribution from the customer at substation C is 0.7kA and the new fault level capacity is 36.16kA.

To accommodate the import capacity requested, an overlay of the 33kV circuit with 1250km of a larger capacity cable is required at a cost of £500,000 which will be apportioned using the Security CAF. The Required Capacity is 20MW and the new network capacity created by the overlay is 25MW.
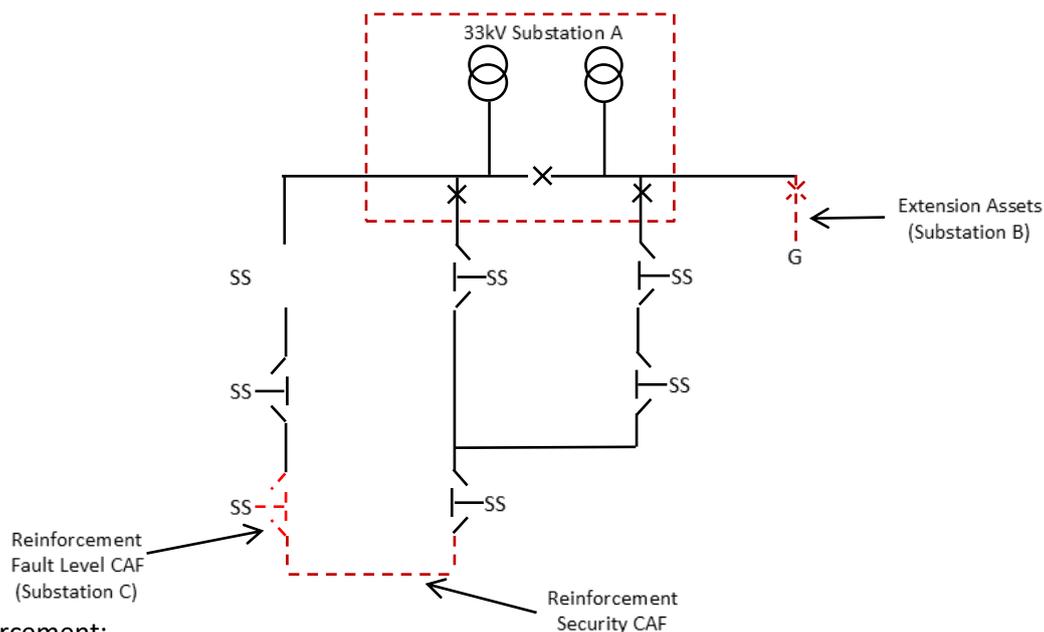
Reinforcement:

Fault Level CAF calculation: the numerator in the CAF calculation is the customer's Fault Level contribution to the existing Substation C which is 0.7kA. The denominator is the New Fault Level Capacity at the substation which is 36.16kA.

Security CAF calculation: the numerator in the CAF calculation is the Required Capacity of the Customer, i.e. 20,000kVA. The denominator is the New Network Capacity following Reinforcement, which is 25,000 kVA.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Substation C switchgear replacement	£400,000	3 x 0.7/36.16 x 100% = 5.8%	£23,200
Overlay 1250km of cable	£500,000	20,000 / 25,000 x 100% = 80%	£400,000
Total Reinforcement Cost	£900,000		**£423,200**

Extension Assets:	Cost	Apportionment	Customer Contribution
400m 33kV underground cable	£220,000	n/a	£220,000
33kV switchboard	£543,000	n/a	£543,000
Total Extension Asset Cost	**£763,000**		**£763,000**

Total cost of the work = £900,000 + £763,000 = £1,663,000

Total Connection Charge to Customer = £423,200 + £763,000 = £1,186,200

Example 17:   Connection of housing development

Purpose: To demonstrate the application of Exception 5.

A new housing development has a Required Capacity of 1MVA to serve 450 plots. The local 11kV feeder has a network capacity of 7.7MVA based upon the limitation of the existing 400 Amp circuit breakers at Primary Substation A. The existing load on the circuit is 7.6MVA. The new load will be connected to the existing 11kV feeder from Primary Substation A with 100m of 11kV cable from POC A to the point D at the boundary of the and provide interconnection with 700m of 11kV cable from POC B at Primary Substation B to the boundary of the site at point C. In this example:

- 200m of 11kV cable on site (between points C and D) is required to provide connectivity within the development and is considered to be Extension Assets.
- 100m of 11kV cable from POC B to the point D.
- 700m of 11kV cable from POC A to the point C

The Minimum Scheme requires the site to be connected onto the existing network. In this case the lowest cost feeder is the 11kV cable from B to D and is treated as an Extension Asset. The alternative connection to POC A at Primary Substation B is required to meet the minimum network security requirements and is treated as Reinforcement.

The figure below shows the proposed network.
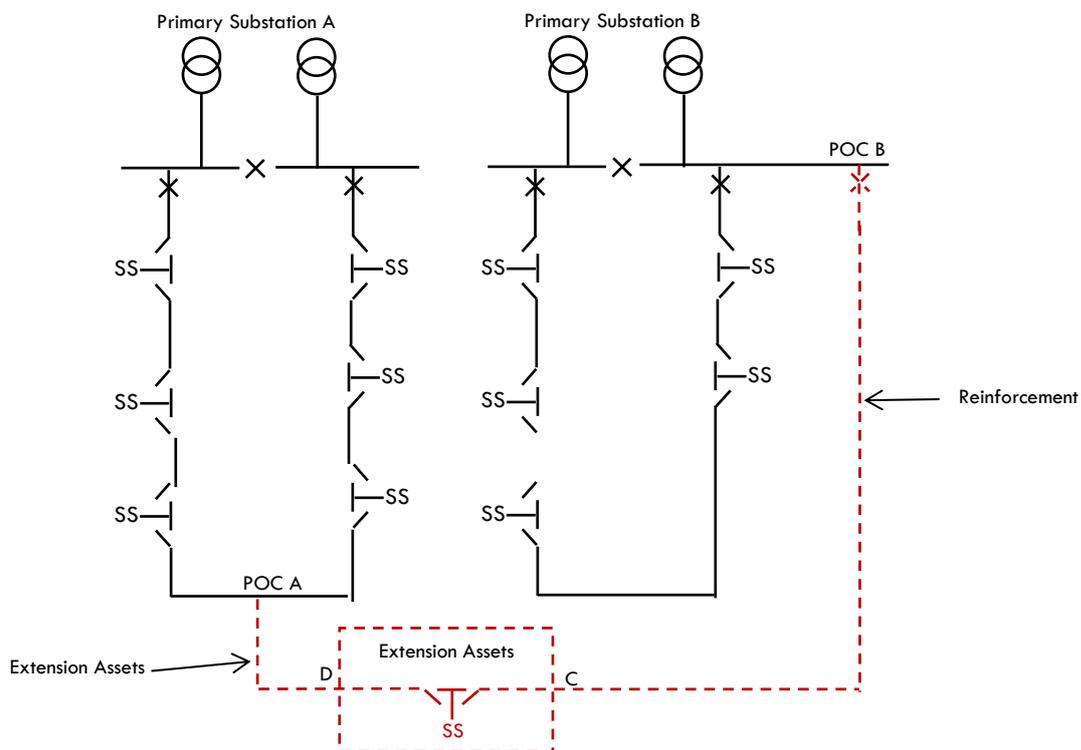
Reinforcement:

The work to provide the connection will increase the capacity of the existing shared use Distribution System from 7.7MVA to 15.4MVA. The New Network Capacity (under secure N -1 conditions) following the Reinforcement works is equal to (3 − 1) x 7.7MVA = 15.4MVA

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
1 new HV Circuit Breaker from POC B	£30,000	0%	£30,000
2 by HV closing joints	£6,000	0%	£6,000
700m of HV cable from POC B to point C	£210,000	0%	£210,000
Total Reinforcement Cost	**£246,000**		**£246,000**

Extension Assets:	Cost	Apportionment	Customer Contribution
100m of HV cable from POC A to point D	£30,000	n/a	£30,000
200m of HV cable on site	£60,000	n/a	£60,000
One 1000KVA Substation	£225,000	n/a	£225,000
On site LV mains and services	£24,900	n/a	£24,900
2 by HV cable box terminations	£24,000	n/a	£24,000
Total Extension Asset Cost	**£363,900**		**£363,900**

Total cost of the work   = £246,000 + £363,900   **= £609,900**

Total Connection Charge to Customer = £363,900   **= £363,900**

Example 18:	Connection of a housing development

Purpose: To demonstrate the application of Exceptions 6.

This example demonstrates the application of Exception 6 (paragraph 1.26)

A new housing development (a Demand Connection) has a Required Capacity of 2MVA to serve 900 plots. The local 11KV feeder has a network capacity of 7.7MVA based upon the limitation of the existing 400 Amp circuit breakers at Primary Substation A. The existing load on the circuit is 7.6MVA. It is therefore not possible to connect the new load to this circuit without Reinforcement works. The Minimum Scheme is to connect the new load to the new 11KV feeder from Primary Substation B and provide interconnection to an existing secure 11KV feeder from Primary Substation A. In this Example 600m of 11KV cable on site (between Points C and D) is required to provide connectivity within the development and is considered to be Extension Assets.

The figure below shows the proposed network.
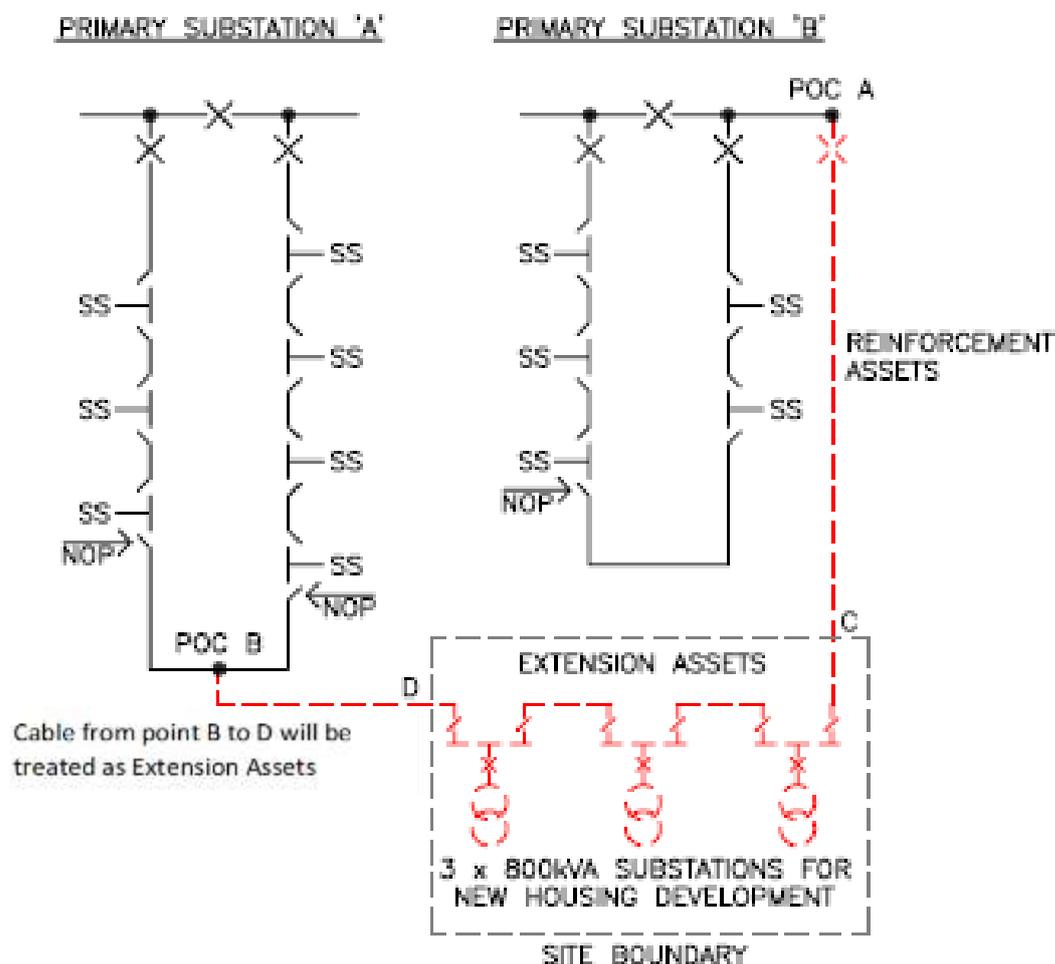
Reinforcement:

As per exception 6 only the higher cost feeder connecting POC A and POC B to the existing network will be treated as Reinforcement. These comprise –

- the assets between the Customer's site and POC A (POC A to point C);

- the assets between the Customer's site and POC B (POC B to point D) will be considered as an Extension Asset because it is the lowest cost feeder and is therefore fully chargeable to the Customer

- the 600m of 11KV cable on site.

The three 800kVA substations are not considered to provide connection between POC A and POC B. The 600m of 11KV cable on site is additional network length to provide connectivity between multiple exit points on the Customer's site. Therefore, Exception 6 applies and the 600m of 11KV cable on site will be treated as Extension Assets and its costs will be charged in full to the customer. Reinforcement:

The Relevant Section of Network for the Reinforcement is considered to be the secure three feeder 11kV network comprising the two feeders from Primary Substation A and the new feeder from Primary Substation B.

The work to provide the connection will increase the capacity of the existing shared use Distribution System from 7.7MVA to 15.4MVA. The New Network Capacity (under secure N -1 conditions) following the Reinforcement works is equal to $(3 - 1)$ x 7.7MVA = 15.4MVA

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
1 new 11KV Circuit Breaker tailed out from Primary Substation B (POC A)	£30,000	0%	£0
2 by 11KV closing joints	£6,000	0%	£0
700m of 11KV cable from Primary Substation B to site	£210,000	0%	£0
Total Reinforcement Cost	£246,000		£0

Extension Assets:	Cost	Apportionment	Customer Contribution
600m of 11KV cable on site	£180,000	n/a	£180,000
3 by 800KVA unit Substation	£225,000	n/a	£225,000
On site LV mains and services	£24,900	n/a	£24,900
2 by 11KV cable box terminations	£24,000	n/a	£24,000
600m of 11KV cable from POC B to site	£180,000	0%	£180,000
Total Extension Asset Cost	£633,900		£633,900

Total cost of the work = £246,000 + £633,900 = **£879,900**

Total Connection Charge to Customer = £0 + £633,900 = **£633,900**

Purpose: To show treatment where capacity is created on a different part of the network and a load transfer is required to allow the connection. Example again demonstrates which elements are reinforcement and which are extension assets.

This variation of Example 18 shows the arrangements that will apply where it is necessary to reinforce a different part of the Distribution System so that existing load may be transferred in order to release capacity for the new connection.

A Customer requests a Generation Connection with a Required Capacity of 2MW. The local 11KV feeder has a network capacity of 7.7MW based upon the limitation of the existing 400 Amp circuit breakers at Primary Substation A. The existing load on the circuit is 7.7MW. It is therefore not possible to connect the new generation to this circuit without Reinforcement works.

It is proposed to reinforce an adjacent network so that two existing substations may be transferred on to it, in order to release capacity so that the new connection can be made. Primary Substation B has sufficient spare capacity to accommodate the two existing substations. A new circuit breaker is to be installed at Primary Substation B and a new 11KV feeder (also rated at 7.7MW) is to be installed between points A – B and between points E – F for connection to the local 11KV circuit at point F. The existing circuit will be cut at point BE so that the new joints can be made. This will convert the Primary Substation B network from a two-feeder to a three-feeder network. The total new cable length between points A – B and points E - F is 500m. The network will be reconfigured by the installation of two short straps C – D and G - H in order to maintain connectivity.

This Reinforcement will allow a POC to be taken from the local 11KV circuit to supply the new generation. The newly installed cable to connect the generation from the POC is 1200m long. The above work represents the Minimum Scheme to provide connections to the new site.

The figure below shows the original network.
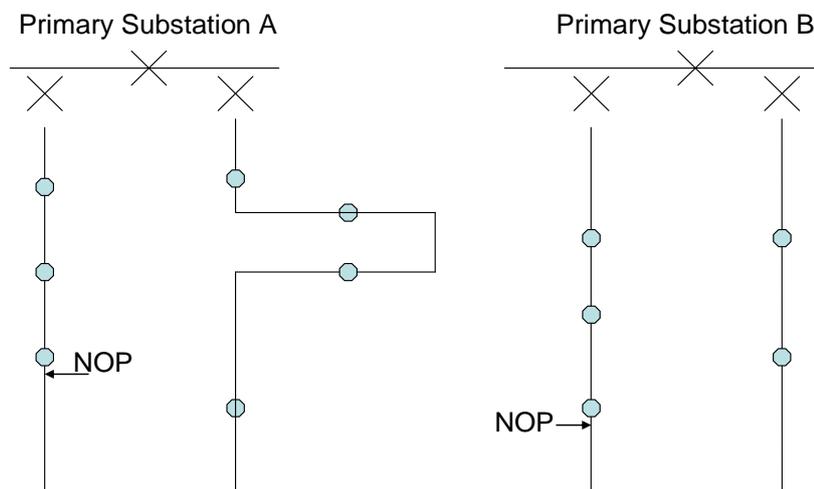
The figure below shows the proposed network.
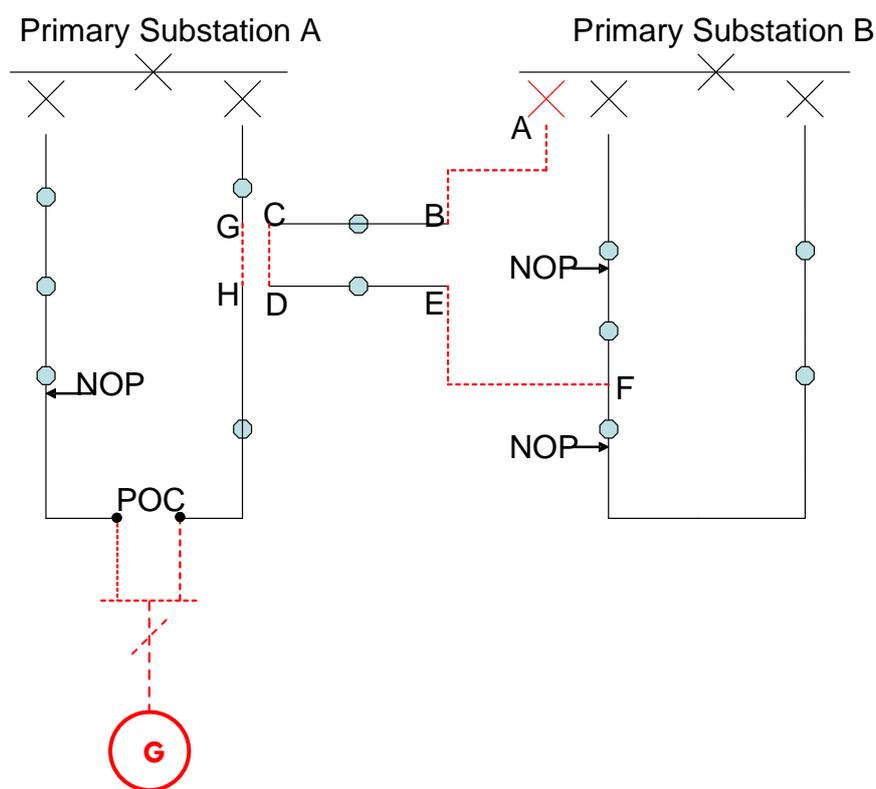
Reinforcement:

The Relevant Section of Network is the three-feeder network from Primary Substation B which supplies the loads on the existing two feeders from Primary Substation B as well as the loads at points C and D transferred from the network from the Primary Substation A. The RSN does not supply the new generation in this case. The numerator in the CAF calculation is based upon the Required Capacity of the new generation, i.e. 2MW. In this case, the New Network Capacity (under N-1 conditions) following the Reinforcement works is equal to (3 – 1) x 7.7MW = 15.4MW.

Fault Level CAF calculation: This Scheme does not have any significant Fault Level contribution to the existing shared use distribution network and Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
500m of 11KV cable: A-B, C-D, E-F	£150,000	2/15.4 X 100% = 13%	£19,480
11KV Circuit Breaker at Primary Substation B	£30,000	As above	£3,896
11KV jointing at Points A,B,C,D,E,F	£18,000	As above	£2,337
Total Reinforcement Cost	**£198,000**		**£25,713**

Extension Assets:	Cost	Apportionment	Customer Contribution

1200m of 11KV cable inc. strap at G – H	£360,000	n/a	£360,000
3 by 800kVA distribution substations	£225,000	n/a	£225,000
On site LV mains and services	£24,900	n/a	£24,900
4 by 11KV closing joints at POC and at points G,H	£12,000	n/a	£12,000
Total Extension Asset Cost	**£621,900**		**£621,900**

Total cost of the work = £198,000 + £621,900 **= £819,900**

Total Connection Charge to Customer = £25,713 + £621,900 **= £647,613**

Example 20: Connection with load transfer

Purpose: Variation to Example 19 where a load transfer is required to free up capacity but no new capacity is created. Demonstrates why elements become Extension Assets.

This variation of Example 19 shows the arrangements that will apply where it is necessary to reconfigure the Distribution System so that existing demand may be transferred in order to release capacity for the new connection.

A new housing development has a Required Capacity of 2MVA to serve 900 plots. The local 11KV feeder has a network capacity of 7.7MVA based upon the limitation of the existing 400 Amp circuit breakers at Primary Substation A. The existing load on the circuit is 7.6MVA. It is therefore not possible to connect the new load to this circuit as presently configured.

The figure below shows the original network.

The figure below shows the proposed network.

3 x 800kVA substations for
New housing development
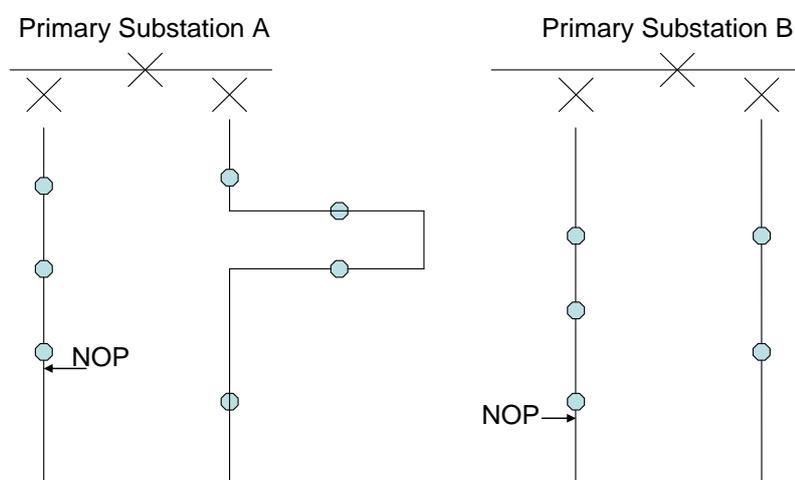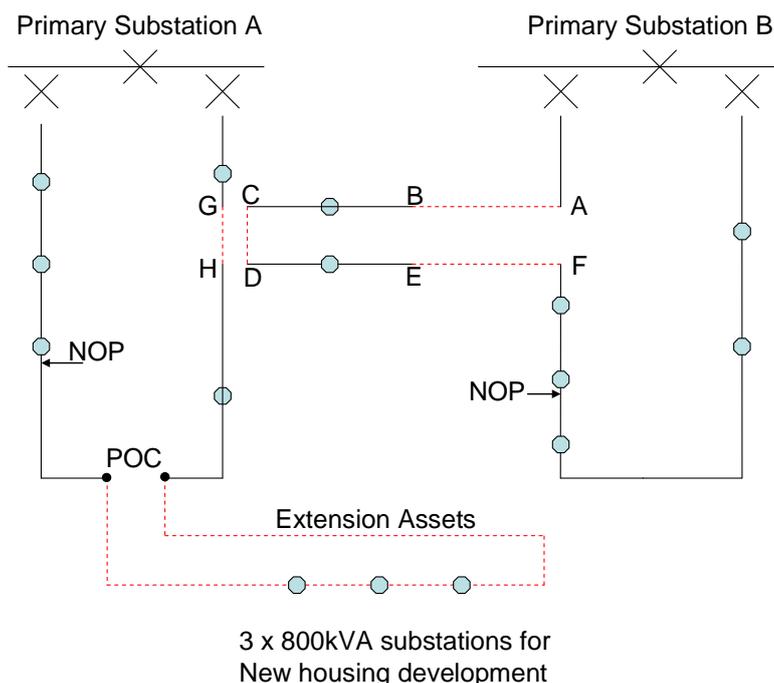
Reinforcement:

It is proposed to reconfigure the Distribution System such that two existing substations may be transferred on to an adjacent network, in order to release capacity so that the new connections can be made. Primary Substation B has sufficient spare capacity to accommodate the two existing substations. New cables are to be installed between points A – B and between points E – F. The existing circuit will be cut at point B & E so that the new joints can be made. The total new cable length between points A – B and points E - F is 100m. The network will be reconfigured by the installation of two short straps C – D and G - H in order to maintain connectivity.

This transfer of existing demand will allow a POC to be taken from the local 11KV circuit to supply the new development. The newly installed cable to connect the development from the POC is 1200m long. Three 800kVA distribution substations are to be established onsite. The above work represents the Minimum Scheme to provide connections to the new site.

The Connection Charge for this Scheme is calculated as follows:

Extension Assets:	Cost	Apportionment	Customer Contribution
1300m of 11KV cable including A-B, C-D, E-F, G-H and from POC to the development	£390,000	n/a	£390,000
3 by 800kVA distribution substations	£225,000	n/a	£225,000
On site LV mains and services	£24,900	n/a	£24,900
10 by 11KV closing joints at POC and at points A,B,C,D,E,F,G,H	£30,000	n/a	£30,000
Total Extension Asset Cost	**£669,900**		**£669,900**

Total cost of the work = £0 + £669,900 = **£669,900**

Total Connection Charge to Customer = £0 + £669,900 = **£669,900**

Purpose: To show how the Security CAF calculation is applied where the DNO requests an Enhanced Scheme.

Please refer to Example 11, which is the Minimum Scheme for this project. In this example, a Customer requests a Generation Connection with a Required Capacity for export purposes of 3MW. The Minimum Scheme requires the Reinforcement of 500m of 11KV overhead line between points A and B to provide 7.6MVA of capacity. However, the DNO has decided to install an Enhanced Scheme by increasing the capacity of the 11KV overhead line to 13MVA.

The POC is to the existing 11KV network at point B and it is proposed to install 500m of 11KV underground cable from the POC to the Customer's installation.

NB: These primary CBs and Busbar need to be recoloured black as they are not being uprated
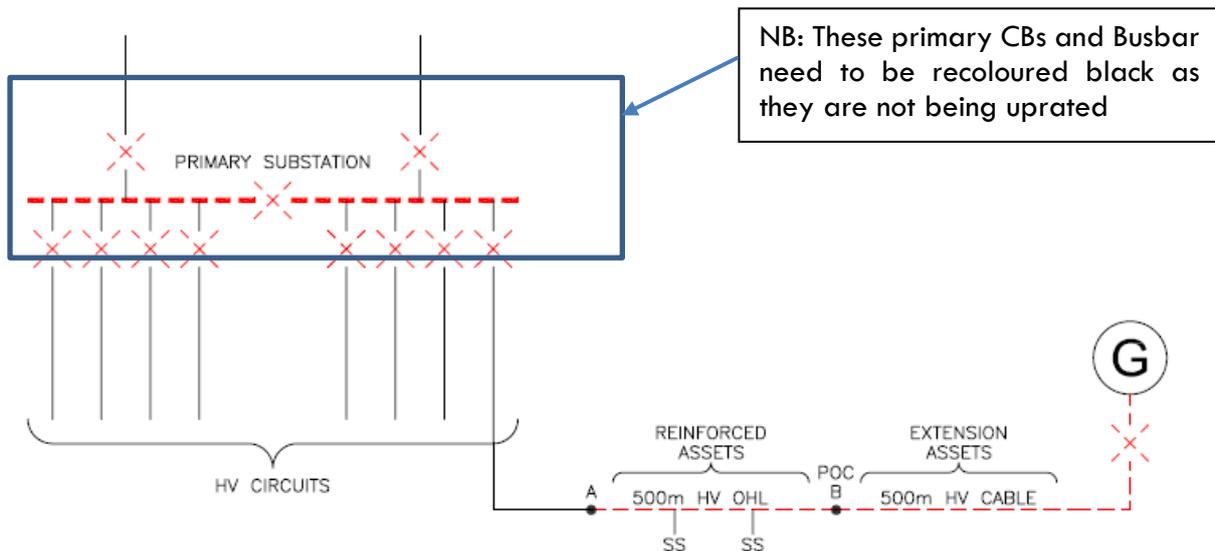
Reinforcement:

The Relevant Section of Network is the 11KV OHL between points A and B

Security CAF calculation: The numerator in the CAF calculation is based upon the Required Capacity of the new generation, i.e. 3MW. In this example the DNO has decided to install an Enhanced Scheme and the Connection Charge that will apply will be the lower of the Connection Charge associated with the Minimum Scheme (see Example 11) and the Enhanced Scheme. The numerator in the CAF calculation is based upon the Required Capacity of the Customer, i.e. 3MW and the denominator is based on the Enhanced Scheme New Network Capacity following Reinforcement, i.e. 13MVA.

Fault Level CAF calculation: This Scheme does not have any significant Fault Level contribution to the existing shared use distribution network so the Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Re-conductor 500m of 11KV overhead line at a higher capacity (13MVA)	£70,000	3/13 x 100% = 23.1%	£16,170
Total Reinforcement Cost	**£70,000**		**£16,170**

| Extension Assets:	Cost	Apportionment	Customer Contribution
Installation of 500m 11KV cable	£45,000	n/a	£45,000
11KV circuit breaker at Customer's substation	£25,000	n/a	£25,000
Total Extension Asset Cost	**£70,000**		**£70,000**

Total cost of the work = £70,000 + £70,000 = **£140,000**

Total Connection Charge to Customer = £16,170 + £70,000 = **£86,170**

Example 22: A new Generation Connection on a meshed HV distribution system requiring Reinforcement.

Purpose: To show that a contribution is required where reinforcement is carried out at the same voltage as the point of connection for a Generator Connection.

A Customer requests a new Generation Connection requiring a 4MVA 11KV metered connection. The local 11KV network is of a meshed design whereby the 11KV network is supplied from single 33/11KV primary transformers via 33KV radial feeds as shown below.
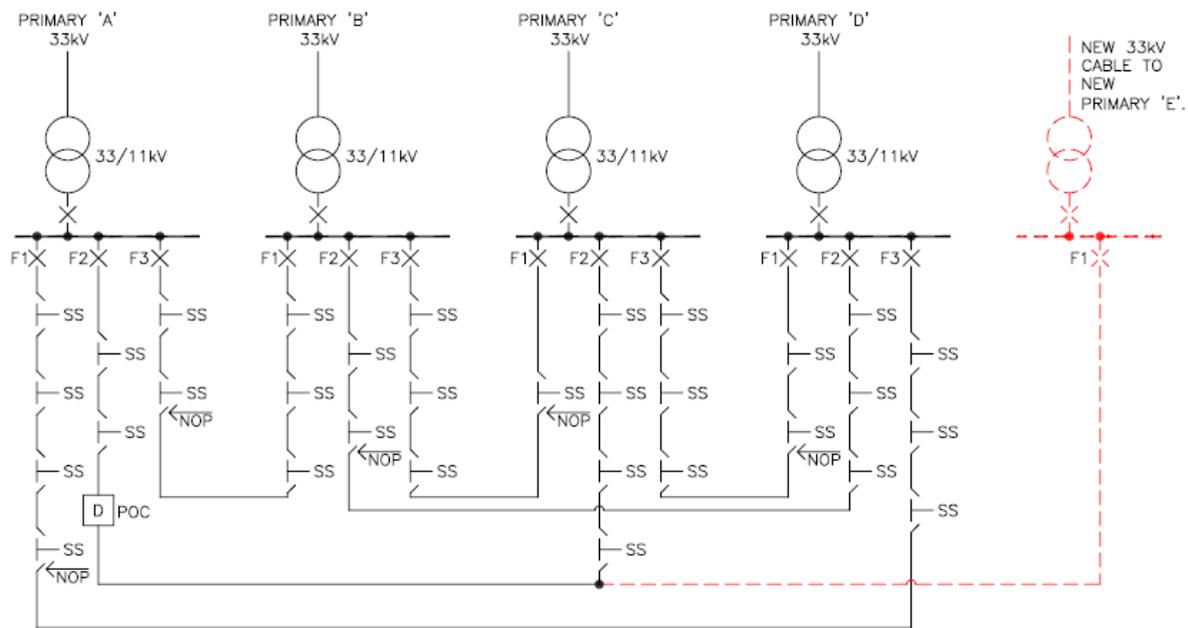
The existing network consists of four 10MVA primary transformer substations and associated 11KV switchgear. A new connection of 4MVA has been requested in the vicinity of F2 from Primary A.

The existing relevant primary transformer group is loaded to its secure capacity so the primary transformer group will require Reinforcement to enable the new connection to progress.

To provide the Required Capacity, the 11KV network will be reinforced by the installation of a new primary substation connected to the nearest 33KV circuit. The new primary substation (Primary E) will contain a 10MVA transformer, associated 11KV switchgear and a new 11KV (7.7 MVA) cable installed to interconnect into the existing 11KV network (from F2 at Primary A to F2 at Primary C).

Reinforcement:

Security CAF calculation: In this example there are two different security CAFs applied. This is because the Relevant Section of Network is different when considering the new network capacity in respect of different elements of the Reinforcement works.

The Relevant Section of Network for the Reinforcement comprising the 11KV Cable Works:

For the 11KV cable assets the Relevant Section of Network is considered to be the secure three feeder 11KV network from Primary A (Feeder 2), Primary C (Feeder 2) and Primary E (Feeder 1). In this case the New Network Capacity (under secure N -1 conditions) following the Reinforcement works is equal to

(3 – 1) x 7.7MVA = 15.4MVA

This is due to the fact that following the Reinforcement work both of the existing circuits; Primary A, Feeder 2 and Primary C, Feeder 2 can be loaded to their full capacity and will have the newly installed clean feeder from Primary E to act as a back feed to meet the requirements of P2.

The security CAF for these assets will therefore be 4/15.4 X 100% = 26.0%

The Relevant Section of Network for the Reinforcement comprising the Primary substation assets:

In this instance the Relevant Section of Network comprises Primary A, C and E within the group that can be used to supply the customer in normal and abnormal conditions. The New Network Capacity of this Relevant Section of Network (under secure N -1 conditions) following the Reinforcement works is equal to 17.7MVA. (10MVA from either Primary A or Primary C and 7.7MVA from Primary E which is limited by the single 11KV cable connected to it.

The security CAF for these assets will therefore be 4/17.7 X 100% = 22.6% towards the 11KV assets to be installed.

Due to the voltage rule, contributions will not be required towards the 33KV assets.

Fault Level CAF calculation: This Scheme does not have any significant Fault Level contribution to the existing shared use distribution network and Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:

Reinforcement:	Cost	Apportionment	Customer Contribution
500m 11KV cable from new primary substation E	£150,000	4/15.4 X 100% = 26.0%	£39,000
1 by 11KV closing joints	£3,000	As above	£780
11KV switchgear at new Primary E	£30,000	4/17.7 X 100% = 22.6%	£6,780
Primary transformer	£6,500,000	0%	£0
2.5km of 33KV cable installation	£1,000,000	0%	£0
33KV Circuit Breaker	£80,000	0%	£0
33KV Termination	£30,000	0%	£0
Total Reinforcement Cost	**£7,793,000**		**£46,560**

Extension Assets:	Cost	Apportionment	Customer Contribution
11KV ring main unit	£25,000	n/a	£25,000
11KV metering unit	£12,000	n/a	£12,000
500m of 11KV cable	£150,000	n/a	£150,000
2 by 11KV closing joints	£6,000	n/a	£6,000
Total Extension Asset Cost	£193,000		**£193,000**

**Total cost of the work** = £7,793,000 + £193,000 **= £7,986,000**

Total Connection Charge to Customer = £46,560 + £193,000 **= £239,560**

Example 23:	A non-secure Generation Connection with non-secure Reinforcement
Purpose: To show that a contribution is required where reinforcement is carried out at the same voltage as the point of connection for a Generation Connection in relation to a non-secure system.	

A Customer wishes to connect a new generator (a Generation Connection) with a Required Capacity for export purposes of 5 MVA. The connection of the generator requires the installation of 1,000m of 33KV cable and an 33KV metering circuit breaker, these being Extension Assets. An existing spare circuit breaker at the substation is utilised which, in this case, is not chargeable to the Customer.

As there is insufficient capacity in the existing 24.0 MVA thermal capacity rated 33KV feeder for the new generation due to the presence of existing generation, the connection also requires the installation of a new 33KV feeder, which also has a thermal capacity of 24.0 MVA, as Reinforcement. This is the Minimum Scheme as it is cheaper to do this, to the extent as shown in the diagram below, rather than upgrade the existing 33KV feeder to the same point along it.
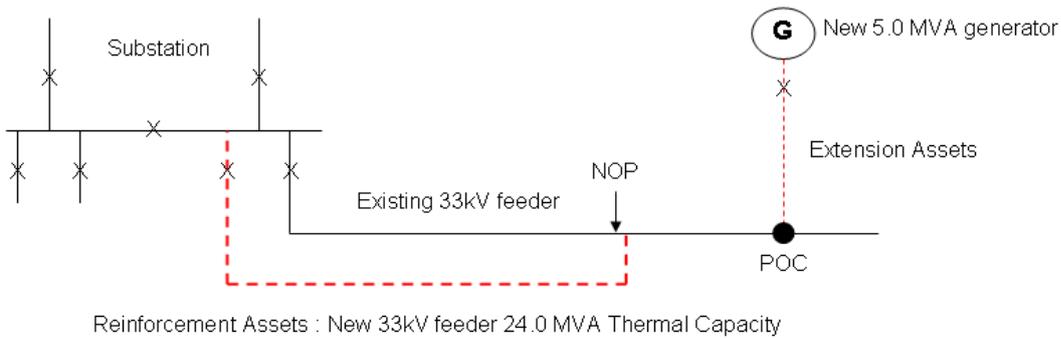
Reinforcement:

The numerator in the CAF calculation is the Required Capacity of the new generator, which is 5.0 MVA.

The RSN in this case is the existing 33KV feeder and the new 33KV feeder. The New Network Capacity is calculated using the non-secure capacity and is therefore the sum of the thermal capacities of the two feeders, which is 48.0 MVA. This is the denominator in the CAF calculation.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:

Reinforcement:	Cost	Apportionment	Customer Contribution
Installation of new 33KV feeder	£ 500,000	5.0 / 48.0 x 100% = 10.4%	£ 52,000
Total Reinforcement Cost	**£500,000**		**£ 52,000**

Extension Assets:	Cost	Apportionment	Customer Contribution
Installation of 1,000m 33KV cable	£ 400,000	n/a	£ 400,000
Installation of 33KV metering circuit breaker	£ 80,000	n/a	£ 80,000
11KV Jointing x2	£6,000	n/a	£6,000
Total Extension Asset Cost	£486,000		**£486,000**

Total cost of the work   = £500,000 + £486,000   **= £986,000**

Total Connection Charge to Customer   = £52,000 + £486,000   **= £538,000**

Example 24:	A new non-secure Generation Connection with secure Reinforcement.
Purpose: To show the application of the apportionment rule where secure Reinforcement is provided but the connection for a Generation Connection is non-secure.	

A Customer applies for a new generator (a Generation Connection) requiring an 8 MW metered connection. In this case, the Customer has exercised their option to request non-secure Extension Assets in the provision of the connection.

The existing network comprises a substation which has 2 x 15 MVA transformers. The Minimum Scheme to provide the connection is to install 750m of 11KV cable from the substation to the industrial premises, as Extension Assets. As there is insufficient capacity available from the existing 2 x 15 MVA transformers and the existing 11KV cable between the substations to provide the new connection, it will be necessary to upgrade the transformers to 2 x 24 MVA units and upgrade the 11KV cable. The reinforcement is required to ensure the 11KV network load can be maintained during planned or unplanned outages of one of the transformers. Although the Customer wishes to accept a non-secure connection, the substation must provide secure capacity to its Group Demand (which includes the Customer) to comply with the requirements of Engineering Recommendation P2. As the Extension Assets will be provided solely for the Customer, these can be provided on the basis of a single circuit to provide a non-secure connection, at the Customer's request.
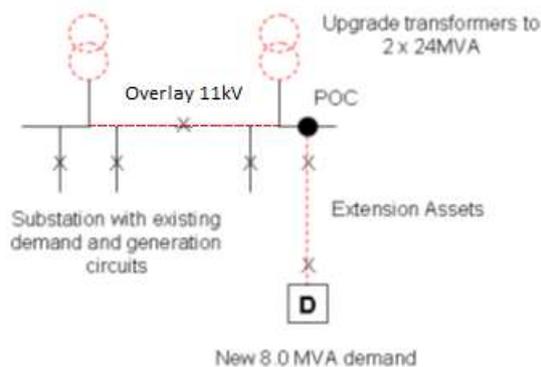
Reinforcement:

As the substation reinforcement is a voltage above, the generator will not contribute towards this part of the works.

The numerator in the CAF calculation for the 11KV cable overlay is the Required Capacity, which is 8.0 MVA.

The Relevant Section of Network in this case is the 11KV cable overlay. The New Network Capacity is the secure capacity of the 11KV cable, which is 24 MVA. This is the denominator in the CAF calculation.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Installation of 2 x 24MVA 33/11KV transformers	£6,500,000	0%	£0
Overlay 2km 33KV cable	£600,000	8 / 24 x 100% = 33.3%	£198,000
Total Reinforcement Cost	£7,100,000		**£198,000**

Extension Assets:	Cost	Apportionment	Customer Contribution
750m 11KV cable	£225,000	n/a	£225,000
11KV metering circuit breaker	£30,000	n/a	£30,000
11KV joints x2	£6,000	n/a	£6,000
Total Extension Asset Cost	£261,000		**£261,000**

Total cost of the work = £7,100,000 + £261,000 **= £7,361,000**

Total Connection Charge to Customer = £198,000 + £261,000 **= £459,000**

Example 25:   A new Generation Connection with voltage rise triggered Reinforcement.

Purpose: To show that a Generation Connection pays for reinforcement at the voltage level of connection based on the CAF.

A Customer wishes to connect a new generator (a Generation Connection) with a Required Capacity for export purposes of 2MVA.

The local 11kV feeder has a large amount of generation already connected and will need to be reinforced in order to keep voltage rise within acceptable limits.

The Minimum Scheme requires Reinforcement of the existing 185mm^2 11kV underground cable with 300mm^2 underground cable and installation of a new substation for connection of the 2MW export capacity. The total length of the reinforced cable is 2km. The thermal rating of the 300mm^2 underground cable is 8MVA. The 11kV underground cable on the other side of the normal open point is already 300mm^2 and does not require to be reinforced.
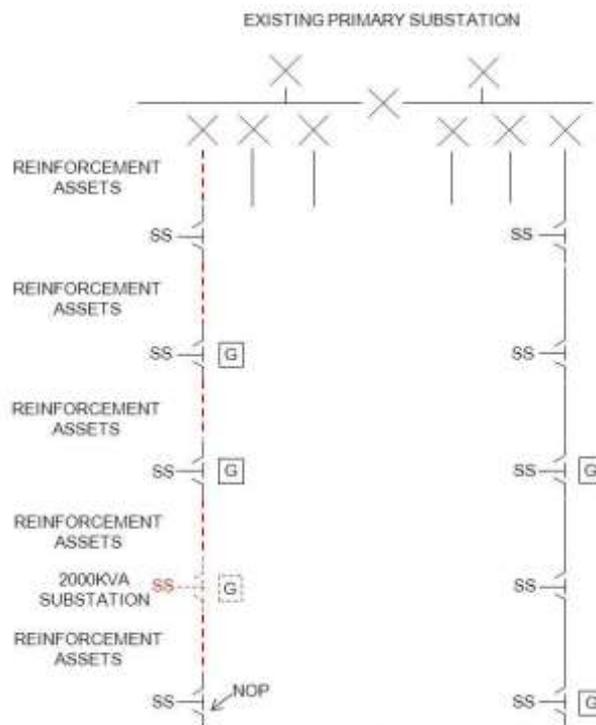
Reinforcement:

The Relevant Section of Network for the Reinforcement is the 11kV feeder.

Security CAF calculation: the numerator in the CAF calculation is the Required Capacity of the Customer, i.e. 2MW. The denominator is the New Network Capacity following Reinforcement, this being the maximum generation that could be connected whilst keeping the voltage rise within acceptable limits, i.e. 8MVA in this case.

Fault Level CAF calculation: this scheme does not have any significant Fault Level contribution to the existing shared use distribution network and Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
2km 300mm 11kV Cable	£600,000	2 / 8 x 100% = 25%	£150,000
Total Reinforcement Cost	£600,000		**£150,000**

| Extension Assets:	Cost	Apportionment	Customer Contribution
2MVA 11kV Substation	£160,000	n/a	£160,000
2 by 11kV Closing Joints	£6,000	n/a	£6,000
Total Extension Asset Cost	£166,000		**£166,000**

Total cost of the work = £600,000 + £166,000 **= £766,000**

Total Connection Charge to Customer = £150,000 + £166,000 **= £316,000**

Example 26	**A new Generation Connection with voltage rise triggered Reinforcement.**

Purpose: To show that if voltage rise reinforcement is tailored so that just the amount of network is upgraded to meet the customer requirements, the CAF is 100% for a Generation Connection.

A Customer wishes to connect a new generator (a Generation Connection) with a Required Capacity for export of 250kW. The Minimum Scheme for connection of the generator requires the local 11kV overhead line to be reinforced with 100mm² conductor over part of its length in order to keep voltage rise within acceptable limits. The thermal capacity of the 100mm² overhead line is 5MVA. The thermal capacity of the original 50mm2 overhead line is 3MVA. A new 315kVA ground mounted substation requires to be installed at the premises. The overhead line is 1km in length but only 500m is required to be reinforced in order to keep voltage rise within acceptable limits.
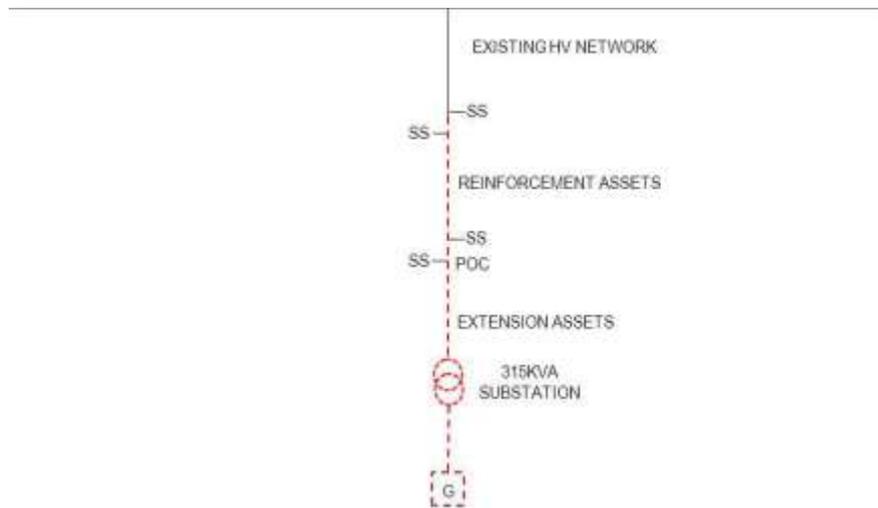
Reinforcement:

<u>The Relevant Section of Network for the Reinforcement is the 11kV overhead line</u>

Security CAF calculation: the numerator in the CAF calculation is the Required Capacity of the Customer, i.e. 250kW. The denominator is the New Network Capacity following Reinforcement, this being the maximum generation that could be connected whilst keeping the voltage rise within acceptable limits. As the length of overhead line to be reinforced has been determined to accommodate the 250kW requirement only, then this is also 250kW in this case.

Fault Level CAF calculation: this scheme does not have any significant Fault Level contribution to the existing shared use distribution network and Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Replacement 11kV overhead line conductor	£40,000	250 / 250 x 100% = 100%	£40,000
Total Reinforcement Cost	**£40,000**		**£40,000**

| Extension Assets:	Cost	Apportionment	Customer Contribution
Provision and installation of 315kV substation	£60,000	n/a	£60,000
11kV joint to network	£3,000	n/a	£3,000
Total Extension Asset Cost	**£63,000**		**£63,000**

Total cost of the work = £40,000 + £63,000 **= £103,000**

Total Connection Charge to Customer = £40,000 + £63,000 **= £103,000**

Example 27:   A new Generation Connection with Fault Level Triggered Reinforcement and transmission works.

Purpose: To show how the Fault Level CAF calculation is applied and how the cost of transmission works are treated for a Generation Connection.

A Customer requests a 65MW connection for a new 132kV generator (a Generation Connection) and the 85MVA Fault Level contribution from the generator necessitates Reinforcement works to replace the 132kV switchgear at the existing grid supply point with switchgear of a higher fault level rating. The Fault Level contribution also requires upgrades to the transmission system to replace the 132kV transformer tails and associated switchgear. New 132kV Extension Assets from the existing 132kV system will be required to connect the generator.
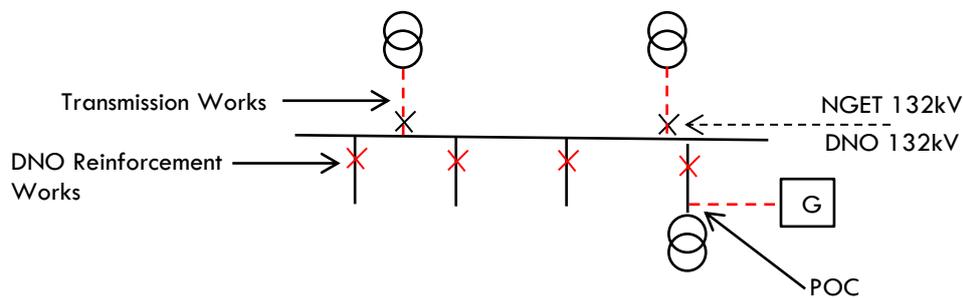
Reinforcement

In this example the Reinforcement is at the voltage level of the POC and the Fault Level CAF is applied to the DNO works only.

Fault Level CAF calculation: The numerator in the CAF calculation is based upon the Fault Level contribution from the Customer's new generator connection, i.e. 85MVA. The denominator is based upon the New Fault Level Capacity, in this Example the Fault Level capacity of the new 132kV switchgear, i.e. 9140MVA.

Transmission

The cost of the transmission works are fully funded by the connecting customer.

The Connection Charge for this Scheme is calculated as follows:

Transmission Works:	Cost	Apportionment	Customer Contribution
Replace the 132kV transformer tails and associated switchgear	£5,000,000	N/A	£5,000,000
Total Transmission Cost	**£5,000,000**		**£5,000,000**

Reinforcement:	Cost	Apportionment	Customer Contribution
Reinforcement: replace the existing 132kV switchgear	£12,000,000	3x(85/9140) x 100% = 2.8%	£336,000

Total Reinforcement Cost	£12,000,000		£336,000

| Extension Assets:	Cost	Apportionment	Customer Contribution
Installation of 200m 132kV underground cable	£400,000	N/A	£400,000
Total Extension Asset Cost	£400,000		£400,000

Total cost of the work = £5,000,000 + £12,000,000 + £400,000 **= £17400,000**

Total Connection Charge to Customer = £5,000,000 + £336,000 + £400,000 **= £5,736,000**

A Customer requests an 8MW connection for a new 33kV generator (a Generation Connection) and the 24MVA Fault Level contribution from the generator necessitates Reinforcement works to replace the 132kV switchgear at the existing grid supply point with switchgear of a higher fault level rating. The Fault Level contribution also requires upgrades to the transmission system to replace the 132kV transformer tails and associated switchgear. New 33kV Extension Assets from the existing 33kV system will be required to connect the generator.
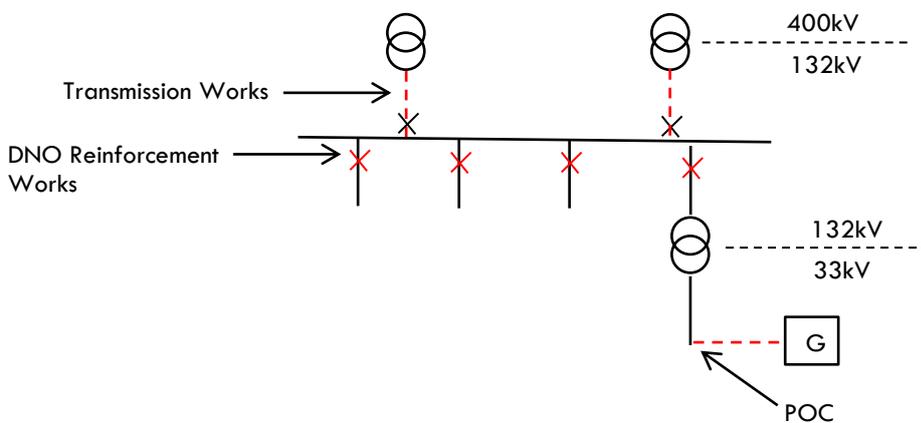
Reinforcement

In this example the Reinforcement is at the voltage level above the POC and fully funded by the DNO.

Transmission

The Connection Charge for this Scheme is calculated as follows:

Transmission Works:	Cost	Apportionment	Customer Contribution
Replace the 132kV transformer tails and associated switchgear	£5,000,000	N/A	£5,000,000
Total Transmission Cost	£5,000,000		**£5,000,000**

Reinforcement:	Cost	Apportionment	Customer Contribution
Replacement 132kV switchboard (excluding Customer's sole use circuit breaker)	£12,000,000	N/A	£0
Total Reinforcement Cost	£12,000,000		**£0**

Extension Assets:	Cost	Apportionment	Customer Contribution
Installation of a 500m 33kV cable	£40,000	N/A	£40,000
33kV circuit breaker at Customer substation	£25,000	N/A	£25,000
Total Extension Asset Cost	£75,000		**£75,000**

Total cost of the work   = £5,000,000 + £12,000,000 + £75,000   = **£17,075,000**

Total Connection Charge to Customer   = £5,000,000 + £75,000   = **£5,075,000**

Example 29:	A new Demand Connection that has reinforcement above the high-cost project threshold.
Purpose: To show how the Demand high-cost project threshold is applied.	

A Customer wishes to connect a new supply to a commercial premise for 70kVA (the Required Capacity). This will be a non-secure Demand Connection to a secure network.

The Minimum Scheme is to overlay part of the nearest 11KV circuit (Feeder 2) which only has spare capacity of 50kVA. The Reinforcement to make the capacity available requires 1200m of existing 11KV cable to be overlaid with a larger capacity cable.

Following the Reinforcement the New Network Capacity will be 8000kVA. (i.e. after Reinforcement, in this particular case, the section of cable with the lowest rating in the ring represented by Feeder 1 and Feeder 2 is rated at 8000kVA).
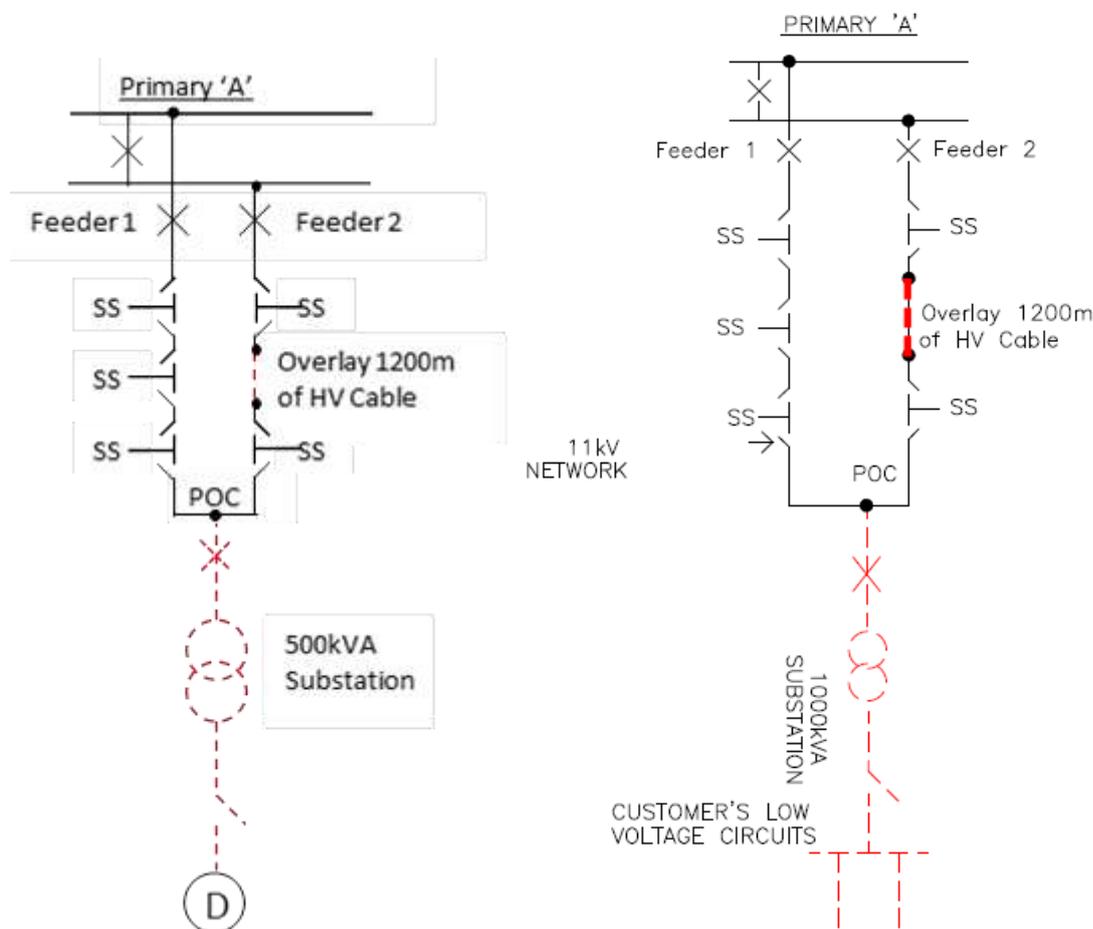
Reinforcement:

The Relevant Section of Network is the two feeder ring comprising Feeder 1 and Feeder 2.

As this is a Demand Connection, no CAF contribution is required.

The High-Cost Project Threshold (HCPT) applied is the Required Capacity x HCPT of £1,720 per kVA.

In this instance;

70 x £1,720 = £120,400. The customer will pay the costs in excess of £120,400 for works up to one voltage above the point of connection, therefore £363,000 (i.e. total Reinforcement cost - £120,400 = £242,600.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Overlay 1200m of 11KV cable	£360,000	Total cost exceeding HCPT £363,000- £120,400	£242,600
11KV Jointing	£3,000		
Total Reinforcement Cost	**£363,000**		**£242,600**

Extension Assets:	Cost	Apportionment	Customer Contribution
500m 11KV cable	£150,000	n/a	£150,000
500kVA substation	£70,000	n/a	£70,000
Termination of Customer's LV cable	£2,000	n/a	£2,000
LV Metering panel	£4,000	n/a	£4,000
11KV Jointing x2	£6,000	n/a	£6,000
Total Extension Asset Cost	**£232,000**		**£232,000**

Total cost of the work   = £363,000 + £232,000   **= £595,000**
Total Connection Charge to Customer   = £242,600 + £232,000   **= £474,600**

Example 30: **A new Generation Connection that has reinforcement above the high-cost project threshold**

Purpose: **To show how a Generation Connection that triggers the Generation high-cost project threshold is charged when the reinforcement required is at the same voltage of connection.**

A customer wishes to connect a 225kVA wind farm (a Generation Connection).

In order to connect the wind farm the following works will be required: install 590m of 11kV overhead line; install 350m of 11kV cable and carry out associated jointing and install switchgear into the substation. In addition, the reinforcement required is to replace the 33/11kV transformer to facilitate reverse power flow. The New Network Capacity following reinforcement is 19,700 kVA. The total cost of the reinforcement is £475,400.

The High-Cost Project Threshold (HCPT) applies to this connection. The HCPT is £200/kVA and costs in excess of this threshold will be charged in full to the customer.
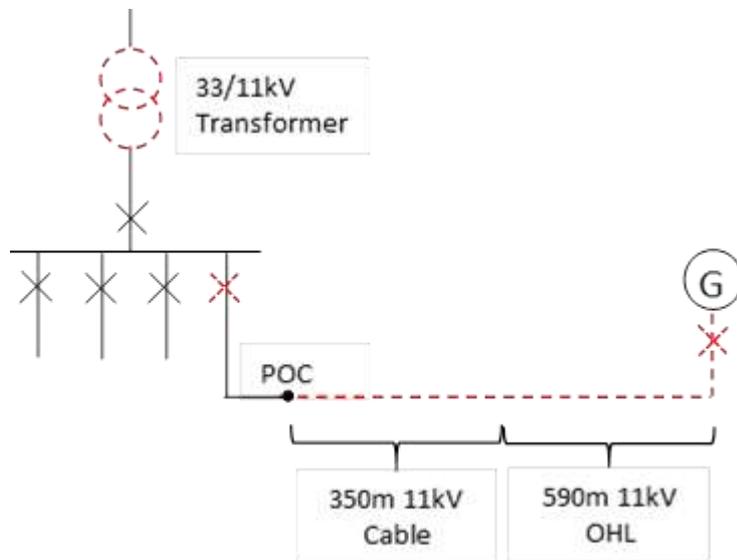
Reinforcement:

The Relevant Section of Network for the Reinforcement is the 33/11kV transformer

HCPT: £200 x 225 = £45,000

   £475,400 - £45,000 = £430,400

Security CAF calculation: the numerator in the CAF calculation is the Required Capacity of the Customer, i.e. 225kVA. The denominator is the New Network Capacity following Reinforcement, this being the maximum generation that could be connected whilst keeping the voltage rise within acceptable limits. This is 19,700kVA.

Fault Level CAF calculation: this scheme does not have any significant Fault Level contribution to the existing shared use distribution network and Fault Level CAF is therefore not applicable here.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
33/11kV Transformer Replacement	£475,400	Total cost exceeding HCPT £475,400 - £45,000	£430,400
		225/19700 x 100% = 1.14% x Costs up to HCPT	1.14% x £45,000 = £513
Total Reinforcement Cost	**£475,400**		**£430,913**

Extension Assets:	Cost	Apportionment	Customer Contribution
Electrical substation works	£34,500	n/a	£34,500
Install 590m of 11kV Overhead Line	£53,500	n/a	£53,500
Install 350m of 11kV XLPE cable	£14,000	n/a	£14,000
Total Extension Asset Cost	**£102,000**		**£102,000**

**Total cost of the work**   = £475,400 + £102,000   **= £577,400**

Total Connection Charge to Customer = £423,400 + £102,000   **= £525,400**

Purpose: To illustrate that the customer specifically requesting a three phase connection where the existing network is not of a sufficient number of phases pays for any reinforcement.

A Customer with an existing single phase domestic connection with rated at 100 Amps (23 kVA) requests a three-phase connection to allow them to connect a three-phase load (e.g. a three-phase domestic welder). The property is located halfway along on a single phase 100m LV overhead line, which connects to a single phase 50kVA pole-top transformer feeding four properties. The pole-top transformer connects to the local Primary substation via a three-phase underground cable.

The existing network has sufficient capacity to accommodate the Required Capacity but the existing 50kVA pole-top transformer and 100m LV overhead line do not have a sufficient number of phases.
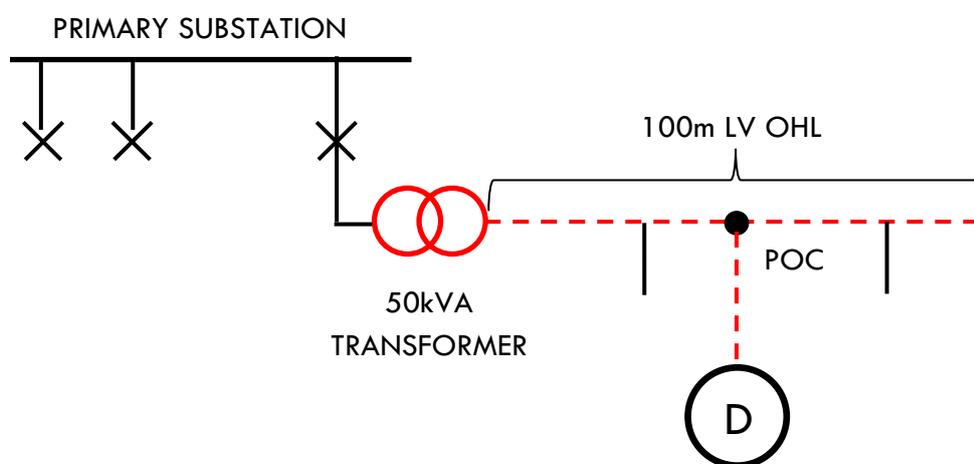
Reinforcement:

The Minimum Scheme is to replace the existing 100m LV overhead line in its entirety with a three-phase overhead line. The existing single phase 50kVA pole-top transformer will need to be replaced with a three-phase equivalent. The existing three-phase cable feed and the Primary substation are of sufficient capacity.

As the reinforcement is only to accommodate the required number of phases, no cost apportionment will be applied.

The Connection Charge for this Scheme is calculated as follows:

Reinforcement:	Cost	Apportionment	Customer Contribution
Replace existing single-phase LV Overhead Line with new 100m three-phase LV Overhead Line	£12,600	100%	£12,600
New three-phase 50kVA pole-top transformer	£20,000	100%	£20,000
LV Jointing	£300	100%	£300
Total Reinforcement Cost	**£32,900**		**£32,900**
Operation & Maintenance @32%* of £32,900	**£10,528**		**£10,528**

*Note, the 32% Operation and Maintenance figure is illustrative.

Extension Assets:	Cost	Apportionment	Customer Contribution
New 30m three-phase 100A service	£1,600	n/a	£1,600
Single service breach joint	£300	n/a	£300
Total Extension Asset Cost	**£1,900**		**£1,900**

Total cost of the work = £43,428 + £1,900 **= £45,328**

Total Connection Charge to Customer = £43,428 + £1,900 **= £45,328**