



BULRIC Model for FTTH networks

Descriptive Manual

Axon Partners Group

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1. Introduction

This report describes the modelling approach, model structure and calculation process followed in the development of the Bottom-up Long Run Incremental Cost (BU-LRIC) Model for FTTH networks ('the Model') commissioned by the Belgian Institute for Postal services and Telecommunications (hereinafter, the BIPT) to Axon Partners Group (hereinafter, Axon Consulting).

The model has the following main characteristics:

- ▶ It calculates the network cost of the services under the LRIC+ cost standard which includes common costs.
- ▶ It is based on engineering modules that allow the consideration of a multiple year time frame.

This section presents the main methodological aspects that have been considered in the development of the Model and provides an overview of the structure of this Document.

1.1. Methodological choices

The key structural and methodological choices define the framework for the implementation of the Model.

The following table contains a summary of the methodological framework that has been set for the development of the Model.



Methodological Issue	Approach Adopted
Cost Standard	▶ LRIC+ (Long Run Incremental Costs Plus Common Costs)
Dimensioning method	▶ Bottom-up approach
Operator Type	<ul style="list-style-type: none">▶ Hypothetical efficient operators rolling-out modern efficient networks▶ The 3 modelled operators share characteristics with networks of Proximus, Fiberklaar and Unifiber
Assets valuation method	▶ Current Cost Accounting (CCA) ¹
Depreciation method	▶ Economic Depreciation.
Allocation of common costs	<ul style="list-style-type: none">▶ The allocation of network-related common costs is performed based on an Effective Capacity approach. This allocation is based on the capacity used by each service, as in the case of the allocation of pure incremental costs.▶ The allocation of non-network related common costs (G&A and IT costs) is performed based on an EPMU approach (Equi-Proportionate Mark Up).
Network Topology	<ul style="list-style-type: none">▶ Scorched Node approach, using the existing locations of operators' network nodes (Local Exchanges).▶ Alternatively, a Scorched Earth approach has been used in cases where no information was available about the locations of operators' network nodes.
Access Technologies	▶ FTTH networks
Time horizon	▶ 50 years



Geographical modelling	▶ Geotypes defined at sector level based on building density and the average number of households per building
Services	▶ Retail and wholesale services for access
Increment	▶ Access lines
Costs to be considered	▶ Network CapEx, Network OpEx and Overheads (G&A and IT costs)

Exhibit 1.1: Summary of the methodological framework. [Source: Axon Consulting]

1.2. Structure of the document

The remaining sections of this document describe:

- ▶ The modelling approach,
- ▶ Model structure, and
- ▶ The calculation process followed.

The document is structured as follows:

- ▶ **General Architecture of the Model**, introduces the general structure of the Model, from the Demand module to the Network Dimensioning and Costing modules.
- ▶ **Model inputs**, introduces the main inputs needed in the Model.
- ▶ **Dimensioning Drivers**, examines the conversion of demand (at service level) to network parameters, facilitating the dimensioning of network resources.
- ▶ **Geographical Analysis**, presents the treatment performed to the geographical characteristics of the country in order to adapt it to the needs of the BULRIC Model.

¹ Additionally, civil infrastructure assets (ducts, trenches, manholes, etc.) of copper access networks reused for fibre access networks take into account the application of a percentage of fully depreciated assets (see percentages defined in worksheet "1D INP UNITARY COSTS"). These refer to the assets that no longer generate any depreciation costs but are still being used by the operator. This is likely to be the result of a misalignment between the useful life considered financially for an asset and its technical useful life. Following the guidelines established by the EC's Recommendation 2013/466/EU, these fully depreciated assets are not considered to avoid an overvaluation of the modelled operator's cost base, and thus, are excluded from the total cost base estimated by the model. We also note that this adjustment is only applicable to Proximus.



- ▶ **Dimensioning Module**, illustrates the criteria followed in order to design the network and calculate the number of resources required to serve the coverage and capacity constraints.
- ▶ **CapEx & OpEx Costs Module**, presents the calculation of OpEx and CapEx over the years.
- ▶ **Depreciation Module**, presents the calculation of the depreciation method to distribute OPEX and CAPEX over the years (annualisation).
- ▶ **Cost allocation to services**, includes further explanations about the calculation of costs under the LRIC+ standard and also presents the methodology used for the allocation of resources' costs to the services.

Finally, a user manual has been produced, which is provided as a separate document.



2. General Architecture of the Model

This chapter of the document introduces the general structure of the Model. The following figure shows the function blocks and their interrelationship in the model.

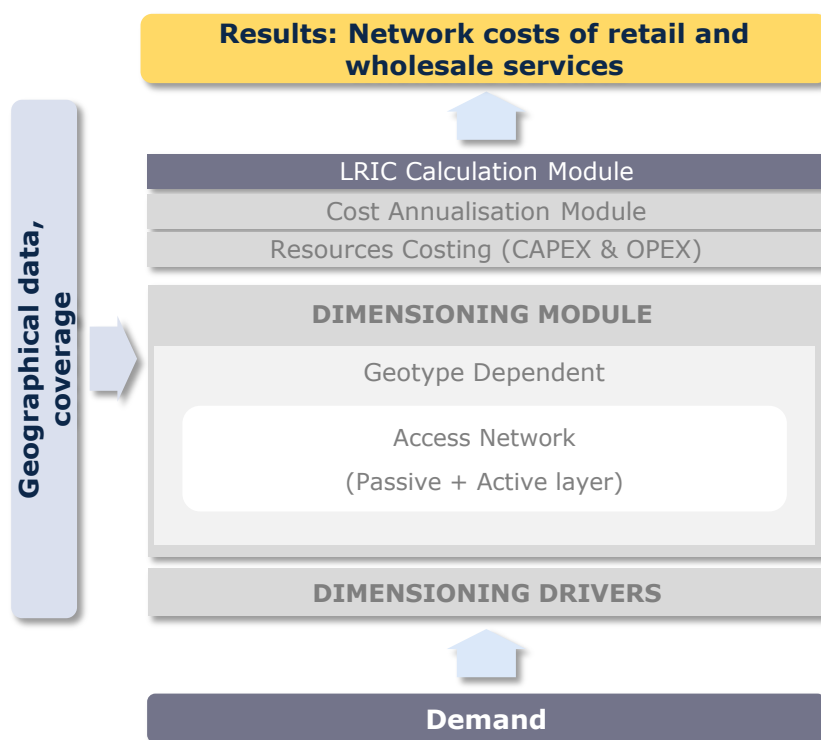


Exhibit 2.1: Structure of the model [Source: Axon Consulting]

Several function blocks can be identified but, as a first classification, the following parts are described below:

- ▶ **Dimensioning drivers:** Converting demand into dimensioning drivers, later assisting in dimensioning network resources.
- ▶ **Dimensioning module:** Computing the number of resources and building the network that can supply the main services provided by the reference operator.

The estimated demand for all modelled services is used by the Dimensioning Module.

Additionally, geographical data is introduced in the dimensioning module to take into consideration the relevant geographical aspects of the country.

The model recognises that the different parts of the reference operator's access network are geotype-dependent.



- ▶ **Cost Calculation (CapEx and OpEx):** Calculating cost of resources obtained after network dimensioning, both in terms of CapEx and OpEx.
- ▶ **Annualisation module:** Allocating CapEx and OpEx resources costs over time following the methodology defined, which is the economic depreciation method.
- ▶ **LRIC costs calculation module:** Obtaining pure incremental costs related to the different increments (each increment is defined as a group of services) and common costs.

The following sections further develop each block of the model.



3. Model inputs

The following list describes the main inputs that are needed in the BULRIC Model for FTTH networks:

- ▶ **Demand:** The demand is the main input of the Model, and it represents the volume that must be supported by the network to be dimensioned. The demand is included in the model disaggregated based on the list of services defined in the worksheet "0A PAR SERVICES". The demand input is included in worksheet "1A INP DEMAND" of the model.
- ▶ **Coverage:** The coverage achieved (in terms of households passed) has a considerable impact in the results of the Model. Therefore, historical and forecast coverage by geotype needs to be introduced into the Model. The coverage input is included in worksheet "1C INP COVERAGE" of the model.
- ▶ **Unitary costs:** Each resource dimensioned in the Model is assigned to a unitary cost, differentiating between CapEx and OpEx costs. CapEx and OpEx unit costs are defined in the Model for the historical period and forecasted towards future years based on Year-over-Year price trends. Unitary cost inputs are included in worksheets "1D INP UNITARY COSTS" and "1E INP COST TRENDS" of the model.
- ▶ **Network dimensioning parameters and equipment capacity:** dimensioning algorithms need information about the characteristics of the network equipment in terms of capacity. Dimensioning inputs are included in worksheet "2A INP NW" of the model.
- ▶ **Geographical information:** the dimensioning of the network requires to take into consideration specific information about the different areas of the country. This information is aggregated in geotypes. Geographical information is produced by applying the methodology described in section 5. Geographical information is included in worksheets "2B INP GEO DISTANCES" and "2C INP GEO NW CHARAC" of the model.



4. Dimensioning Drivers

The rationale of the dimensioning drivers is to express demand (at service level) in a way that facilitates the dimensioning of network resources.

This section presents the following aspects about the dimensioning drivers:

- ▶ Dimensioning drivers concept,
- ▶ Mapping services to drivers,
- ▶ Conversion Factors from Services to Drivers.

4.1. Dimensioning drivers concept

The explicit recognition of a dimensioning "Driver" in the model aims at simplifying and increasing transparency of the network dimensioning process.

The following list contains the drivers used in the BULRIC model for FTTH networks:

VARIABLE
DRIV.Proximus.FIBRE.Connections.Total Active connection
DRIV.Proximus.SHARING INFRASTRUCTURE.Ducts.Access Ducts
DRIV.Proximus.FIBRE.Connections.Total Terminated lines
DRIV.Fiberklaar.FIBRE.Connections.Total Active connection
DRIV.Fiberklaar.SHARING INFRASTRUCTURE.Ducts.Access Ducts
DRIV.Fiberklaar.FIBRE.Connections.Total Terminated lines
DRIV.Unifiber.FIBRE.Connections.Total Active connection
DRIV.Unifiber.SHARING INFRASTRUCTURE.Ducts.Access Ducts
DRIV.Unifiber.FIBRE.Connections.Total Terminated lines
DRIV.Proximus.FIBRE.Connections.Total Active connections on Fiberklaar's passive network
DRIV.Proximus.FIBRE.Connections.Total Active connections on Unifiber's passive network
DRIV.Proximus.FIBRE.Connections.Total Active connections on own passive network

Exhibit 4.1: List of Drivers used in the model (Sheet '0C PAR DRIVERS'). [Source: Axon Consulting]

Two steps are required to calculate the drivers:



1. Mapping services to drivers,
2. Conversion Factors from Services to Drivers.

Each of these two steps is discussed below in more detail.

4.2. Mapping services to drivers

In order to obtain the drivers, it is necessary to indicate which services are related to them

The following exhibit shows an example of the mapping of services into drivers:

List of relationships	
SERVICE (Variable Name) ²	DRIVER (Variable Name)
Proximus passive access.Access.Fibre.Retail and Wholesale.Passive access (Point-to-Multipoint)	DRIV.Proximus.FIBRE.Connections.Total Active connection
Proximus passive access.Ducts.Ducts.Ducts.Access Duct	DRIV.Proximus.SHARING INFRASTRUCTURE.Ducts.Access Ducts
Proximus passive access.Access.Fibre.Retail and Wholesale.Terminated lines (support service, no results applicable)	DRIV.Proximus.FIBRE.Connections.Total Terminated lines
Fiberklaar.Access.Fibre.Wholesale.Passive access from user's premise to Area PoP	DRIV.Fiberklaar.FIBRE.Connections.Total Active connection
Fiberklaar.Access.Fibre.Wholesale.Passive access from user's premise to Central PoP	DRIV.Fiberklaar.FIBRE.Connections.Total Active connection
...	...

Exhibit 4.2: Example from the Mapping of Services into Drivers (Sheet '3A MAP SERV TO DRIV')
 [Source: Axon Consulting]

4.3. Conversion Factors from Services to Drivers

Once services have been mapped to drivers, volumes need to be converted to obtain drivers in proper units.

² Services' descriptions are included in Annex A.



For that purpose, a conversion factor has been defined representing the number of driver units generated by each demand service unit. In general, conversion factors calculation consists of two subfactors, in compliance with the following structure:

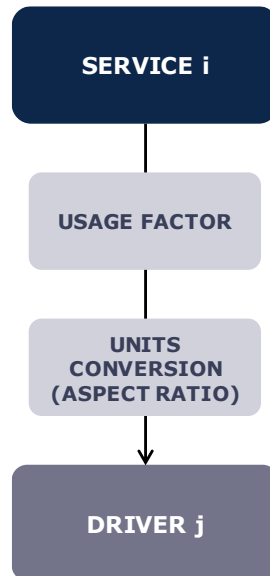


Exhibit 4.3: Conversion Process from Services to Drivers [Source: Axon Consulting]

The conversion factor (CF) thus includes the following items:

1. Usage Factor (UF)
2. Units Conversion Factors (UCF)

Finally, the relationship between a given service and a driver is obtained by applying the formula outlined below:

$$CF = UF * UCF$$

Usage factor represents the number of times a service makes use of a specific resource. These factors are defined in the column D of worksheet `3A MAP SERV TO DRIV`.

Unit conversion represents the need to adapt services' units to those used by the driver. In the event that the service and the driver present exactly the same unit, this unit conversion factor must be set to 1. These factors are defined in the column I of worksheet `3A MAP SERV TO DRIV`.



5. Geographical Analysis

The design of fixed access networks requires an extensive analysis of the geographical zones to be covered, as it will have a direct impact on the length of cables that need to be deployed.

The main purpose of this analysis is to aggregate nodes locations into geotypes, characterising the zones covered under each geotype in terms of distances between network elements. This information is later used for the dimensioning of the operators' access networks, as described in further detail in section 6.

The steps followed in order to carry out the geographical analysis have been split according to their nature between:

- ▶ Characterisation of geotypes
- ▶ Determination of nodes location
- ▶ Calculation of distances between network elements

5.1. Characterisation of geotypes

Based on the available information at sector level across the country, we have proceeded to classify all sectors into geotypes. The number of geotypes has been set to 6 in order to represent six different types of areas: Urban-Dense, Urban, Suburban-Dense, Suburban, Rural-Dense and Rural.

The geotype definition has been performed through a cluster analysis. This cluster exercise is carried out by means of a "k-means" algorithm³, considering two main variables that have been selected to characterize the geotypes:

- ▶ Buildings density (buildings/km²), i.e. the number of buildings by area.
- ▶ Household density (households/building), i.e. the average number of households per building.

The followed process has comprised a set of steps:

³ This is an iterative algorithm that is used to classify a given data set into a number of clusters.



1. Calculating cluster variables. The buildings density and average number of households per building have been calculated at statistical sector level⁴. The source of information employed for this calculation has been Belgian National Geographic Institute (NGI) for the buildings data, and STATBEL for the sector data.
2. Scaling both variables. Before performing the cluster exercise, both variables have been scaled.
3. Executing k-means algorithm. The algorithm of Hartigan and Wong (1979)⁵ is used by default.
4. Assignment of obtained clusters to each sector. Once the six clusters have been calculated, they are assigned to their associated sectors.

The following exhibit shows the results of the geotype characterisation:

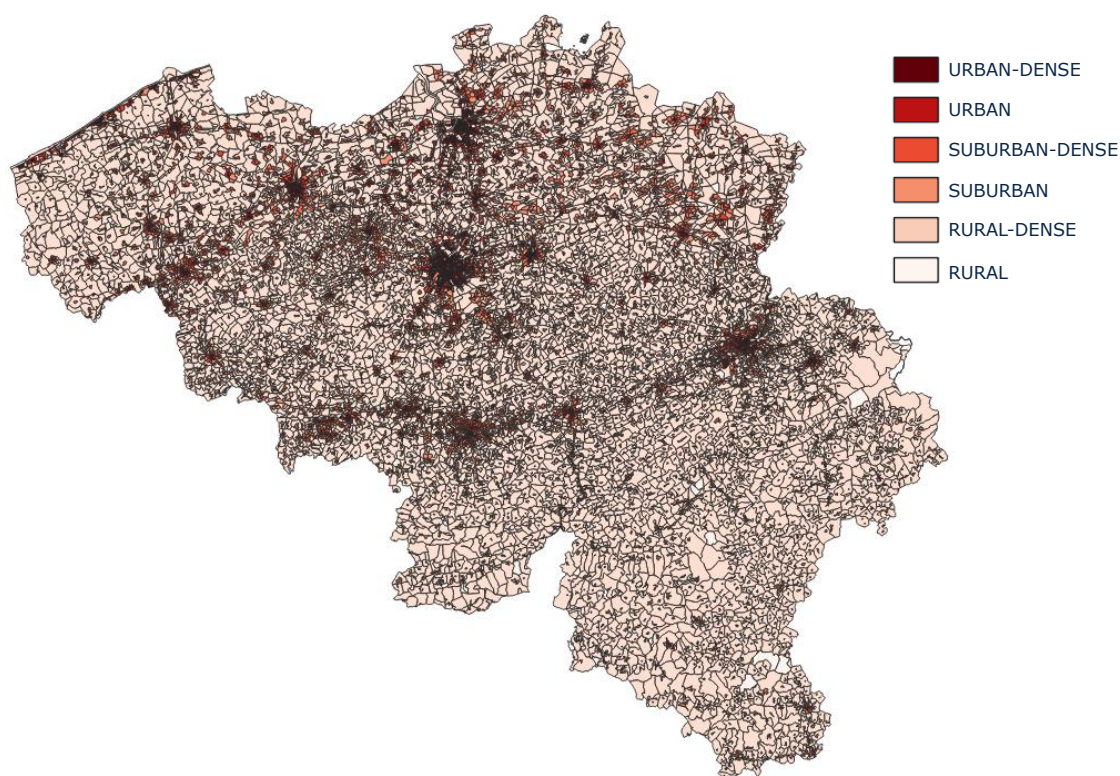


Exhibit 5.1: Classification into geotypes of Belgium sectors for the geographical analysis [Source: Axon Consulting]

⁴ A statistical sector is the smallest basic territorial unit in Belgium for which socio-economic statistics are still being compiled.

⁵ More details in: <https://www.tqmp.org/RegularArticles/vol09-1/p015/p015.pdf>



As it can be extracted from the exhibit, more dense areas in the country are classified as urban geotype whereas less populated sectors are identified as rural.

5.2. Determination of nodes location

The GIS database available⁶ contains the coordinates of all the buildings across the entire country. This information has been employed in order to determine the optimal position of the aggregation nodes (OFPs in the case of Proximus, Customer and Distributed Points in the case of Unifiber, and Distributed Point in the case of Fiberklaar).

For that purpose, the algorithm requires an initial definition of the number of “k” households per aggregation node (obtained from the ratio between the average number of households per aggregation node).

After that, the algorithm proceeds to assign each household to its nearest aggregation node. As a result of this analysis, the specific location in which the aggregation nodes should be placed are obtained, and at the same time, it also produces the grouping between aggregation and households.

The following figure provides an illustrative overview of the implementation of this algorithm in an URBAN geotype, where the pink circles would represent the optimal locations of the aggregation nodes (OFPs) and the rest of the circles outline buildings associated to different aggregation nodes.

⁶ Source: National Geographic Institute (NGI)

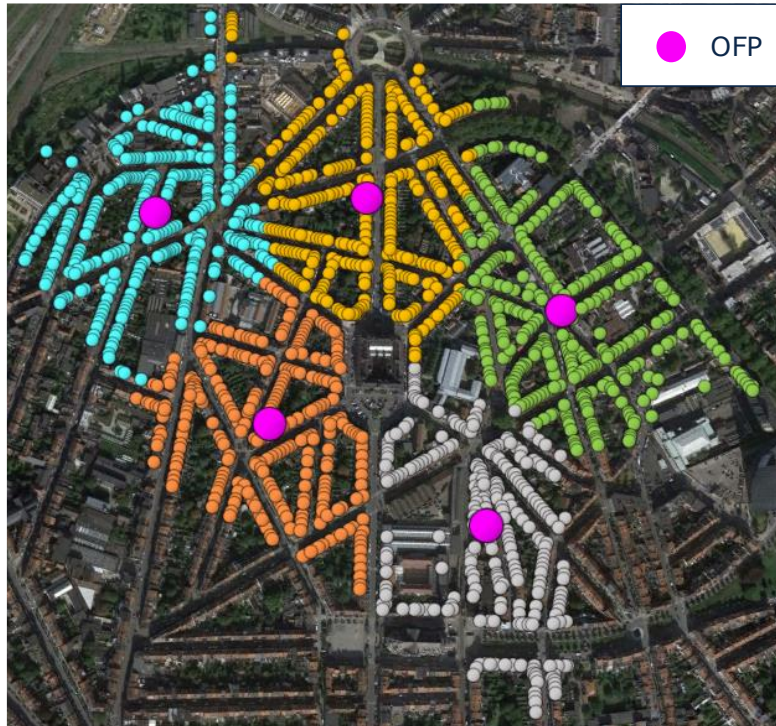


Exhibit 5.2: Aggregation nodes (OFPs) that would need to be deployed for an area situated in an URBAN geotype [Source: Axon Consulting]

In the case of the position corresponding to the Local Exchanges (following point of aggregation after the aggregation nodes, named as Local Exchange in Proximus' network and Area Pop in Unifiber and Fiberklaar networks), it is worth noting that this information has been obtained as follows:

- ▶ In the case of Proximus, this information has been gathered during the data request process, in which the operator has provided the exact location of its Local Exchanges.
- ▶ In the case of Unifiber and Fiberklaar, the location of the Area PoP has been determined applying an optimisation algorithm, based on the number of households per Area PoP, in similar manner to the approach adopted for the determination of the location of aggregation nodes (Customer and Distributed Points) as explained in previous paragraphs.

Once the location of both the aggregation nodes and the Local Exchanges/Area PoPs is known, the calculation of distances between network elements is performed in the following section.



5.3. Calculation of distances between network elements

Knowing all the necessary information about the position of the network elements in the access network, the next step consists of the characterisation of the links between them.

As the routes of the network are mainly used to determine the total distance needed for cables, trenches, etc., the results extracted from this analysis are relevant for the network dimensioning.

The process to calculate the routes is based on the calculation of the shortest path (optimal path) between the households and aggregation nodes, considering the different possible paths through the available routes. Once this process is completed for the connections between households and aggregation nodes, it is repeated again for the connections between aggregation nodes and Local Exchanges/Area PoPs locations to characterise all the required connections in the access network.

As a result of this calculation, the total distances between the different network elements can be obtained for each geotype as the sum of the different sections:

- ▶ Distances from households to aggregation nodes,
- ▶ Distances from aggregation nodes to Local Exchange/Area PoP.

The following illustration provides an overview of the links dimensioned between buildings and their aggregation node in an URBAN geotype.

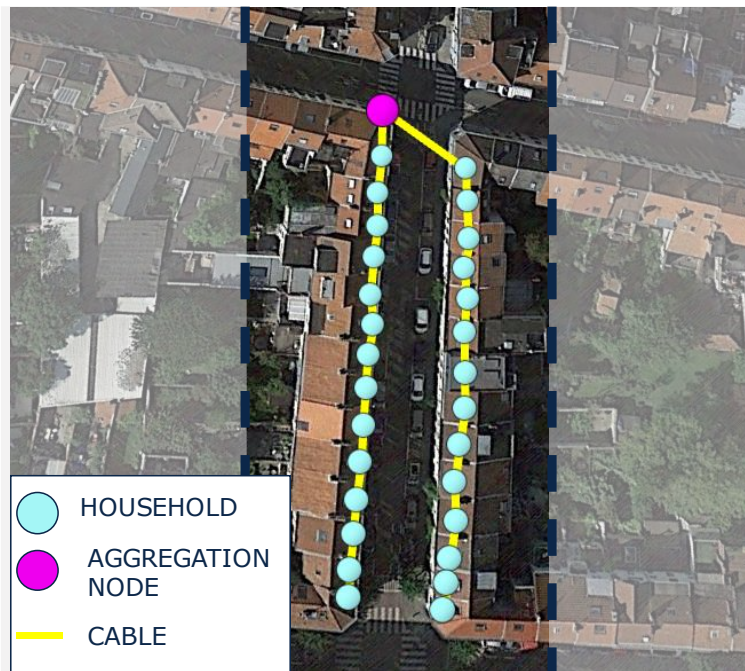


Exhibit 5.3: Illustrative example of the routes between buildings and their aggregation node
[Source: Axon Consulting]

Based on all the information extracted from the previous steps, the last stage consists of processing these data in order to be usable in the BULRIC Model. For this purpose, this last step consists in aggregating the information calculated in the geographical modelling for each of the 6 geotypes defined in the territory of Belgium.

The information calculated contains the routes distances between the different network elements. Such information contains, among others, routes distances, percentage of sharing between different network sections, etc. which is later used in the model for the dimensioning and costing of the cable and network elements required.

In this regard, knowing all the necessary information about the position of the network elements in the access network, this step consists of the characterisation of the links between them, since these links may be sequentially aggregated so as to save digging, ducting, and cabling costs. An illustrative representation of these aggregations is provided in the exhibit below:

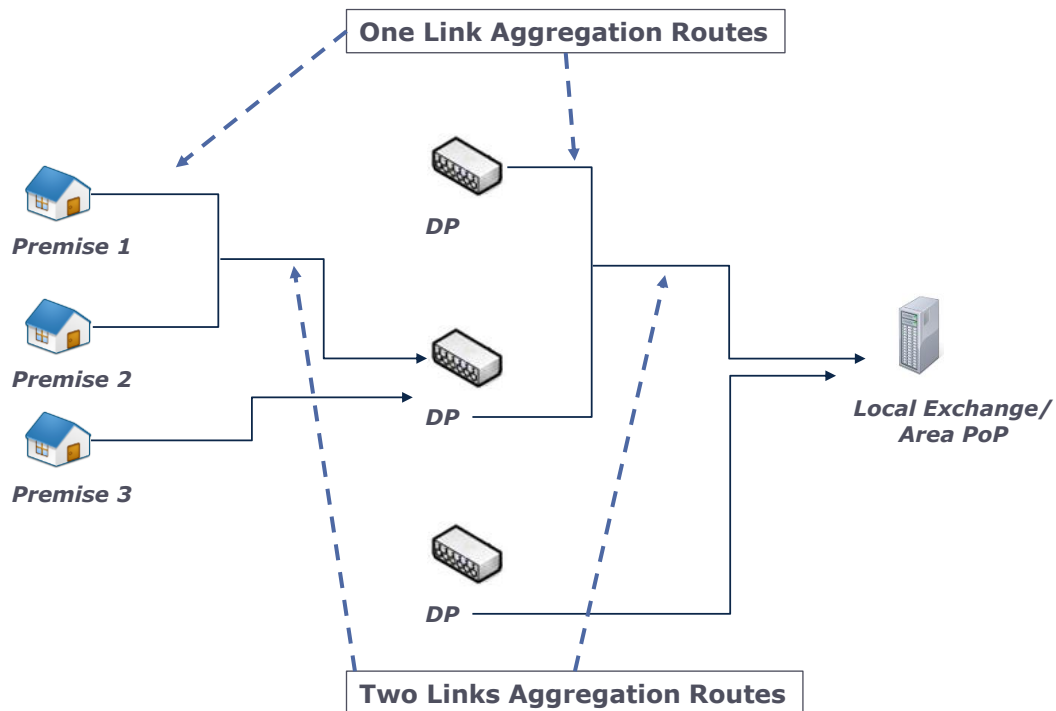


Exhibit 5.4: Illustrative representation of the connection of network elements

Therefore, for the geographical calculations, it is necessary to divide the sections into different aggregation links. This division is made at different network levels, for: primary, secondary, tertiary, etc. The steps carried out for this calculation are detailed below, and are the same for all network levels:

1. The routes are assigned to a specific geotype according to their location.
2. The number of links per section represents the number of times that the different routes coming from the buildings pass through that specific section in their way until the assigned node in each case.
3. The sections are classified according to the number of aggregation links they have (and rounded up whenever required), and the total distance of these sections is calculated. In this regard, it must be noted that not all configurations in terms of number of aggregation links are available in the model. The reason is that possibilities in terms of available numbers of aggregation links must be aligned with the fibre cable configurations used by the modelled operator, measured in number of fibre strands.

The following table illustrates an example of results extracted from the geographical analysis which will be taken as inputs in the model (see worksheet 2B INP GEO DISTANCES).



PRIMARY NETWORK

Average distance in the primary network [from the aggregation point (DP) to the final aggregation point (Area PoP)] per aggregation link

Section	Units	URBAN - DENSE	URBAN	SUBURBAN-DENSE	SUBURBAN	RURAL - DENSE	RURAL
Aggregation of 1 links	metres	1,85	4,97	7,58	12,64	26,07	59,66
Aggregation of 2 links	metres	-	-	-	-	-	-
Aggregation of 4 links	metres	-	-	-	-	-	-
Aggregation of 8 links	metres	-	-	-	-	-	-
Aggregation of 10 links	metres	-	-	-	-	-	-
Aggregation of 12 links	metres	165,10	275,99	353,22	496,49	799,33	993,03
Aggregation of 16 links	metres	-	-	-	-	-	-
Aggregation of 20 links	metres	-	-	-	-	-	-
Aggregation of 24 links	metres	105,61	154,83	182,35	253,99	237,41	192,67
Aggregation of 48 links	metres	-	-	-	-	-	-
Aggregation of 96 links	metres	199,15	195,96	178,22	178,66	126,42	115,15
Aggregation of 192 links	metres	39,81	8,49	2,75	1,66	0,50	-
Aggregation of more than 192 links	metres	8,67	-	-	-	-	-

Average number of DPs in the primary network [from the aggregation point (DP) to the final aggregation point (Area PoP)] sharing the aggregation link

Section	Units	URBAN - DENSE	URBAN	SUBURBAN-DENSE	SUBURBAN	RURAL - DENSE	RURAL
Aggregation of 1 links	average links	1,00	1,00	1,00	1,00	1,00	1,00
Aggregation of 2 links	average links	-	-	-	-	-	-
Aggregation of 4 links	average links	-	-	-	-	-	-
Aggregation of 8 links	average links	-	-	-	-	-	-
Aggregation of 10 links	average links	-	-	-	-	-	-
Aggregation of 12 links	average links	4,46	4,43	4,36	4,36	4,32	3,72
Aggregation of 16 links	average links	-	-	-	-	-	-
Aggregation of 20 links	average links	-	-	-	-	-	-
Aggregation of 24 links	average links	17,44	17,25	17,35	17,14	16,98	16,81
Aggregation of 48 links	average links	-	-	-	-	-	-
Aggregation of 96 links	average links	43,35	38,25	37,35	35,19	33,00	33,31
Aggregation of 192 links	average links	123,82	113,12	114,52	117,54	102,54	-
Aggregation of more than 192 links	average links	260,97	-	-	-	-	-

Exhibit 5.5: Illustrative example of input about distances [Source: Axon Consulting]

Furthermore, the distances of routes that are shared between the secondary network and the primary network are also calculated and included in the model (see worksheet "2C INP GEO NW CHARAC"):

GEOTYPE	% of trenches in the secondary FTTH networks shared with primary FTTH networks
URBAN - DENSE	43,8%
URBAN	35,6%
SUBURBAN - DENSE	33,4%
SUBURBAN	32,2%
RURAL - DENSE	32,7%
RURAL	32,0%
blank	-
blank	-
blank	-
blank	-

Exhibit 5.6: Illustrative example of input about shared routes [Source: Axon Consulting]



6. Dimensioning Module

The Dimensioning Module aims at designing the access network and calculating the number of network resources required to serve the demand and coverage levels of the reference operators. This process is performed in the worksheet '6A CALC DIM ACCESS' of the Model.

In order to better understand this dimensioning procedure, the following exhibits provide an illustrative overview of the network architecture of Proximus, Fiberklaar and Unifiber that are being modelled, together with the nomenclature employed for the different elements of these operators:

Proximus

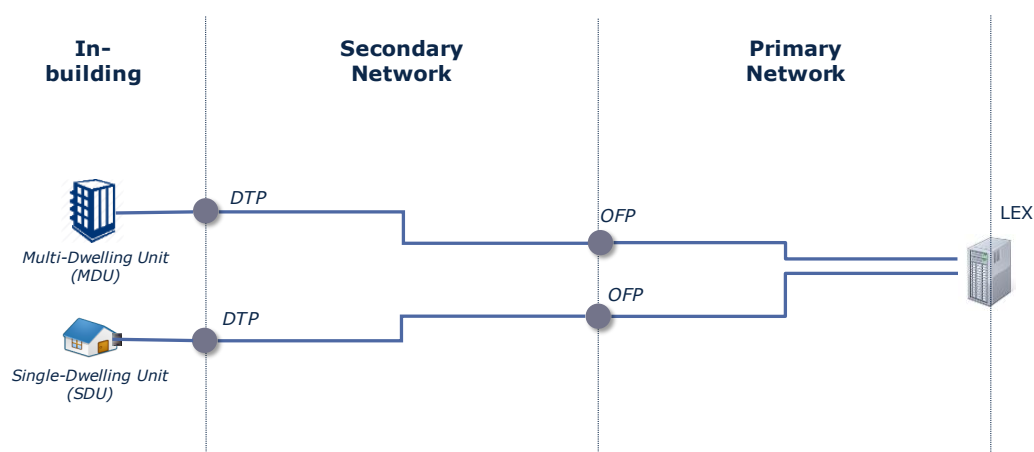


Exhibit 6.1: Architecture of the modelled Access Network of Proximus [Source: Axon Consulting]

The access network for Proximus comprises the network elements ranging from the users' households to the Local Exchanges (LEX). In between, the following network elements may be identified:

- ▶ **In-building, drop cable (lead-in):** Represents the fibre cables generally located inside the building (while sometimes this connection can be done through façade) and connecting the customer household to the first point of connection in the operator's network (DTP in the case of Single Dwelling Units – SDU or Building Entry in the case of Multi Dwelling Units – MDU). Note that this element has been modelled as number of units instead of cable length. In addition to the drop cable, the model also considers an Optical Network Termination Point (ONTP) placed in each terminated household.



- ▶ **Distributed Termination Point (DTP):** Represents the box installed for serving SDU and MDU buildings that contains the first stage splitter, allowing to connect the lead-in cables of the building to the secondary network.
- ▶ **Secondary Network:** Represents the section of the fibre network connecting the DTP and the OFP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Optimized Fiber Point (OFP):** Represents the second stage splitter which combines a certain number of fibre cables by means of the splitting technique. This point separates the secondary and the primary network.
- ▶ **Primary Network:** Represents the section of the fibre network connecting the OFP and the LEX. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Local Exchange (LEX):** Constitutes the central office in the access network. It aggregates OFPs under the same area and contains the Optical Main Distribution Frame (OMDF) and the OLT (Optical Line Terminal).

Based on the above-described network architecture, the signal flows from the building to the DTP and it is directed to the OFP which are eventually aggregated into OMDF (inside the Local Exchange).

Fiberklaar

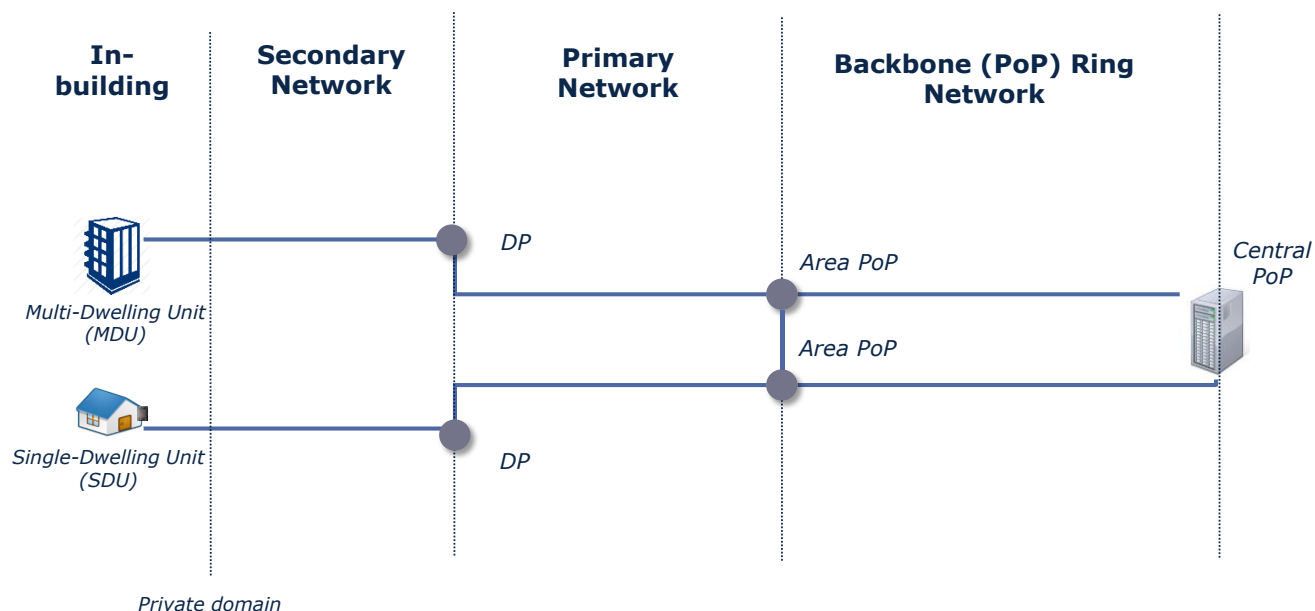


Exhibit 6.2-Architecture of the modelled Access Network of Fiberklaar



The access network for Fiberklaar comprises the network elements ranging from the users' households to the Central PoP. In between, the following network elements may be identified:

- ▶ **In-building, drop cable (lead-in):** Represents the fibre cables generally located inside the building (while sometimes this connection can be done through façade) and going from the customer's household until the end of the private domain in the case of Single Dwelling Units – SDU, or until the Building Entry in the case of Multi Dwelling Units – MDU. Note that this element has been modelled as number of units instead of cable length. In addition to the drop cable, the model also considers a Fiber Termination Point (FTU) placed in each terminated household.
- ▶ **Distributed Point (DP):** Represents the box installed for serving SDU and MDU buildings that contains the first aggregation node, allowing to aggregate the fibre cables of several buildings. This point separates the secondary and the primary network.
- ▶ **Secondary Network:** Represents the section of the fibre network connecting the buildings and the DPs. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Area PoP:** It serves as a point of aggregation for several DPs under the same area and contains the Optical Main Distribution Frame (ODF).
- ▶ **Primary Network:** Represents the section of the fibre network connecting the DPs and the Area PoP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Central PoP:** It serves as a point of aggregation for several Area PoP under the same area and also contains the Optical Main Distribution Frame (ODF).
- ▶ **Backbone (PoP) Ring Network:** Represents the section of the fibre network connecting the Area PoP and the Central PoP. These connections are performed by means of backbone rings aggregating several Area PoP into a Central PoP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).

Based on the above-described network architecture, the signal flows from the building to the Central PoP.



Unifiber

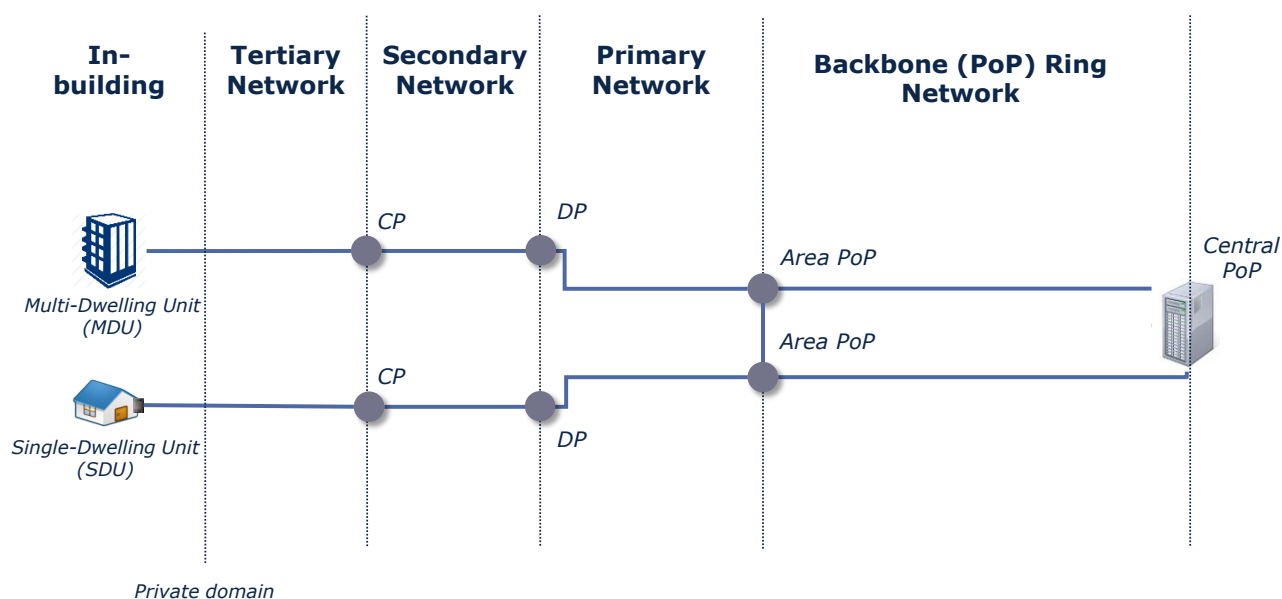


Exhibit 6.3-Architecture of the modelled Access Network of Unifiber

The access network for Unifiber comprises the network elements ranging from the users' households to the Central PoP. In between, the following network elements may be identified:

- ▶ **In-building, drop cable (lead-in):** Represents the fibre cables generally located inside the building (while sometimes this connection can be done through façade) and going from the customer's household until the end of the private domain in the case of Single Dwelling Units – SDU, or until the Building Entry in the case of Multi Dwelling Units – MDU. Note that this element has been modelled as number of units instead of cable length. In addition to the drop cable, the model also considers a Fiber Termination Point (FTU) placed in each terminated household.
- ▶ **Customer Point (CP):** Represents the box installed for serving SDU and MDU buildings that contains the first aggregation node, allowing to aggregate the fibre cables of several buildings. This point separates the tertiary and the secondary network.
- ▶ **Tertiary Network:** Represents the section of the fibre network connecting the buildings and the CP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Distributed Point (DP):** Represents the second aggregation node which combines a certain number of fibre cables from several CPs. This point separates the secondary and the primary network.



- ▶ **Secondary Network:** Represents the section of the fibre network connecting the CP and the DP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Area PoP:** It serves as a point of aggregation for several DPs under the same area and contains the Optical Main Distribution Frame (ODF).
- ▶ **Primary Network:** Represents the section of the fibre network connecting the DP and the Area PoP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- ▶ **Central PoP:** It serves as a point of aggregation for several Area PoP under the same area and also contains the Optical Main Distribution Frame (ODF).
- ▶ **Backbone (PoP) Ring Network:** Represents the section of the fibre network connecting the Area PoP and the Central PoP. These connections are performed by means of backbone rings aggregating several Area PoP into a Central PoP. This includes the fibre cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).

Based on the above-described network architecture, the signal flows from the building to the Central PoP.

The dimensioning of the access networks are performed separately for each modelled operator and for each of the geotypes considered, to accurately reflect the impact of the geographical characteristics in the deployment.

This dimensioning approach has been divided into the following four different blocks, namely:

- ▶ Dimensioning of Proximus own passive network
- ▶ Dimensioning of Fiberklaar's network
- ▶ Dimensioning of Unifiber's network
- ▶ Dimensioning of Proximus' active layer

Each of the following sections provide further details on the technical algorithms employed in each case.



6.1. Dimensioning of Proximus own passive network

The dimensioning of Proximus own passive network is composed of several steps, which can be summarized as illustrated in the chart below.

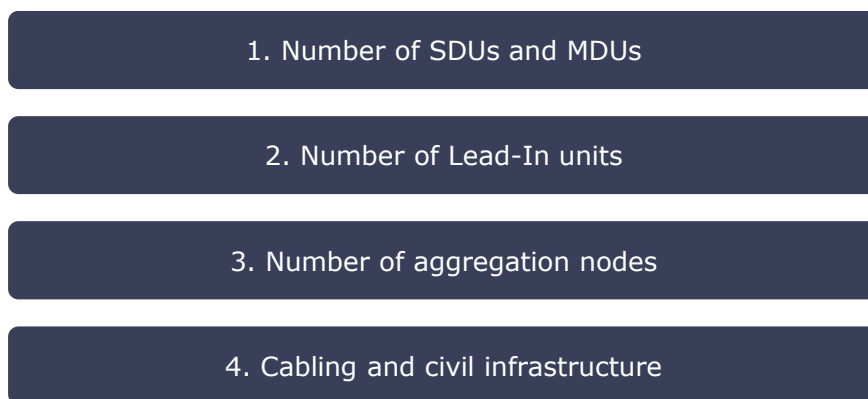


Exhibit 6.4: Schematic steps for the dimensioning of the Proximus own passive network [Source: Axon Consulting]

6.1.1 Number of SDUs and MDUs buildings

The number of such elements is calculated according to the algorithm outlined below:

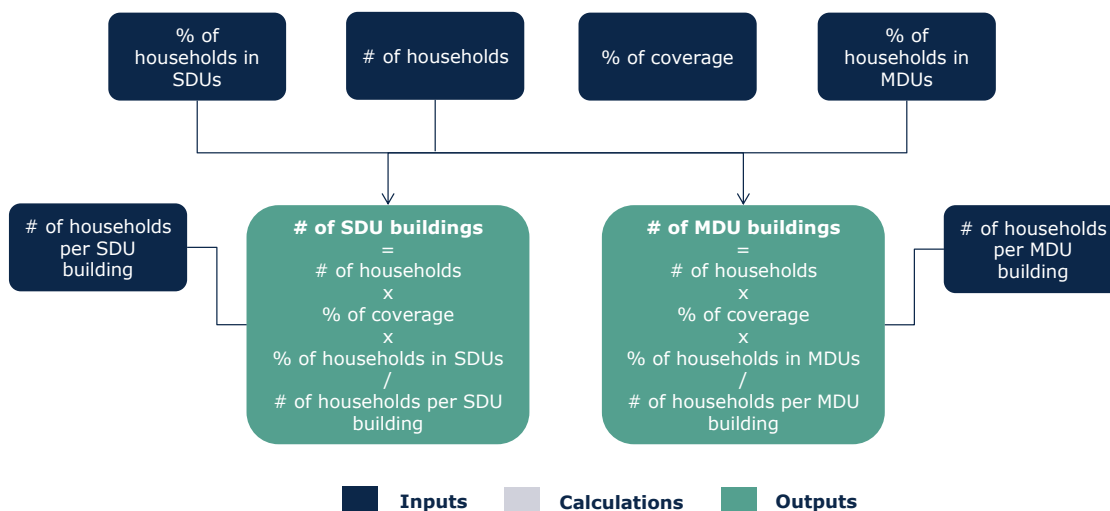


Exhibit 6.5: Algorithm for calculating the number of SDUs and MDUs [Source: Axon Consulting]

The number of covered households is multiplied by the percentage of households which are SDU and MDU, and finally, divided by the corresponding number of households per building, obtaining the corresponding number of covered SDU and MDU building units. By definition, a value of one household per building is assumed in the case of SDU.



6.1.2 Number of Lead-In (Drop cable) units

The number of Lead-In units, corresponding to the drop lines, is calculated as indicated in the following exhibit:

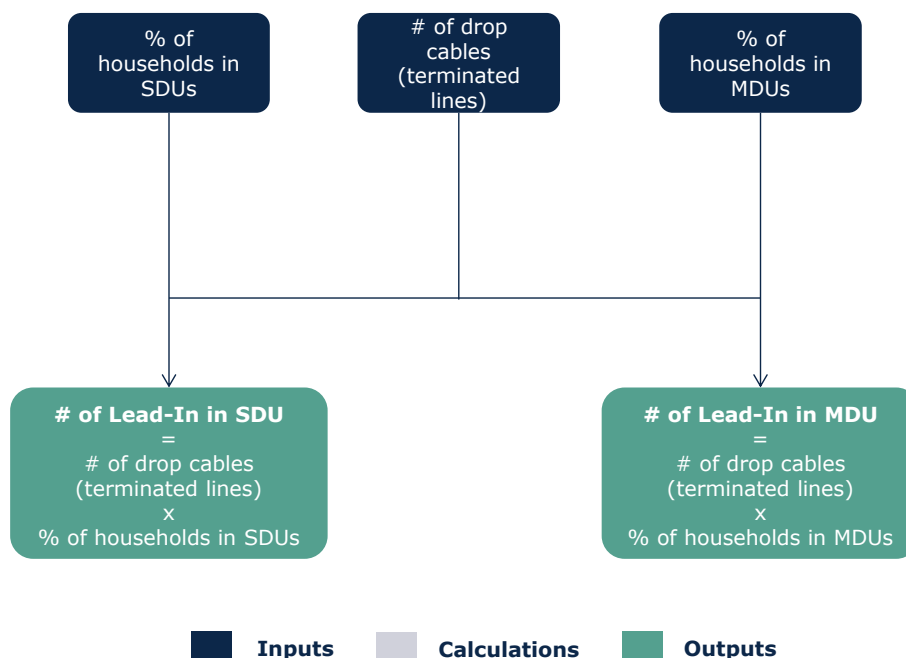


Exhibit 6.6: Algorithm for calculating the number of Lead-In units in SDU and MDU Households
[Source: Axon Consulting]

The number of drop lines is split into the number of Lead-In in SDU and MDU based on the percentage of households passed in each type (SDU and MDU).

In addition to the above, the model also considers that, in the case of Multi Dwelling Units (MDU), the lead-in cable is not directly connected from the customer's household/dwelling to the DTP, but to an intermedium point in the network, named as the building entry, which is generally located in the ground level of the building. The number of these building entries is estimated as equal to number of MDU buildings passed, from previous section.

In the case of building entries of underground type, additionally, the model considers two network elements named as 'Site survey' and 'Technical solution agreement' which correspond to the particular design activities required by Proximus in such case before the pure deployment activities.

Finally, the number of ONTPs is also assumed equivalent to that of Lead-In (Drop cable) units.



6.1.3 Number of aggregation nodes

Proximus' network contains the following aggregation nodes:

- ▶ Distributed Termination Point (DTP)
- ▶ Optimized Fiber Point (OFP), divided between primary and secondary OFPs
- ▶ Superbak, being an intermediate element located between the OFP and the Local Exchange (LEX)

The number of DTPs for SDU and MDU respectively are calculated as indicated in the following exhibit:

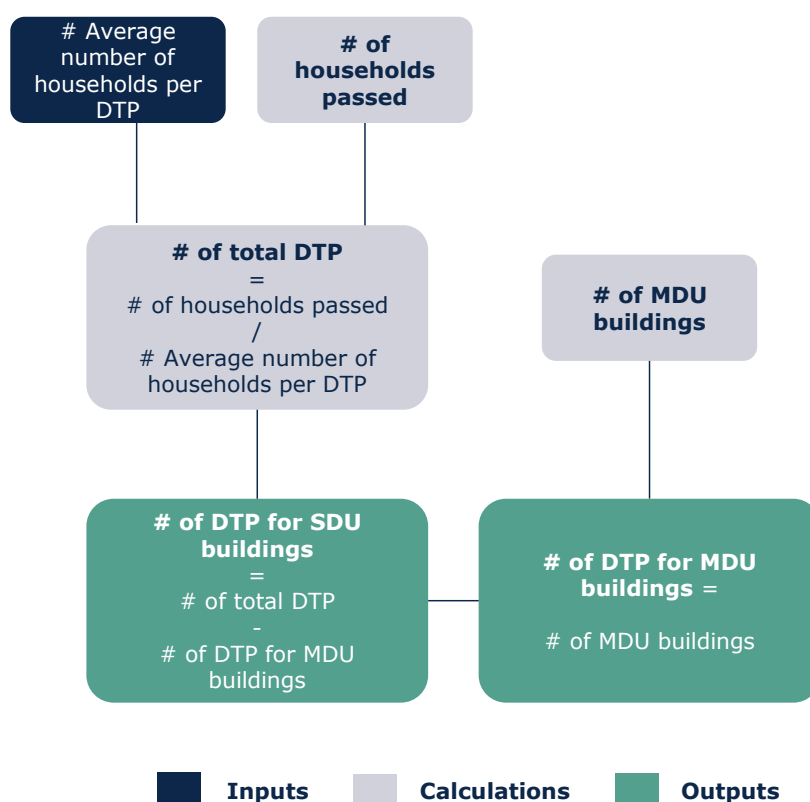


Exhibit 6.7: Algorithm for calculating the number of DTPs [Source: Axon Consulting]

Finally, the DTPs are disaggregated into units installed over façade or underground based on the percentage of DTPs of each case (façade or underground).

On the other hand, the number of OFPs and Superbaks is estimated as indicated in the following exhibit:

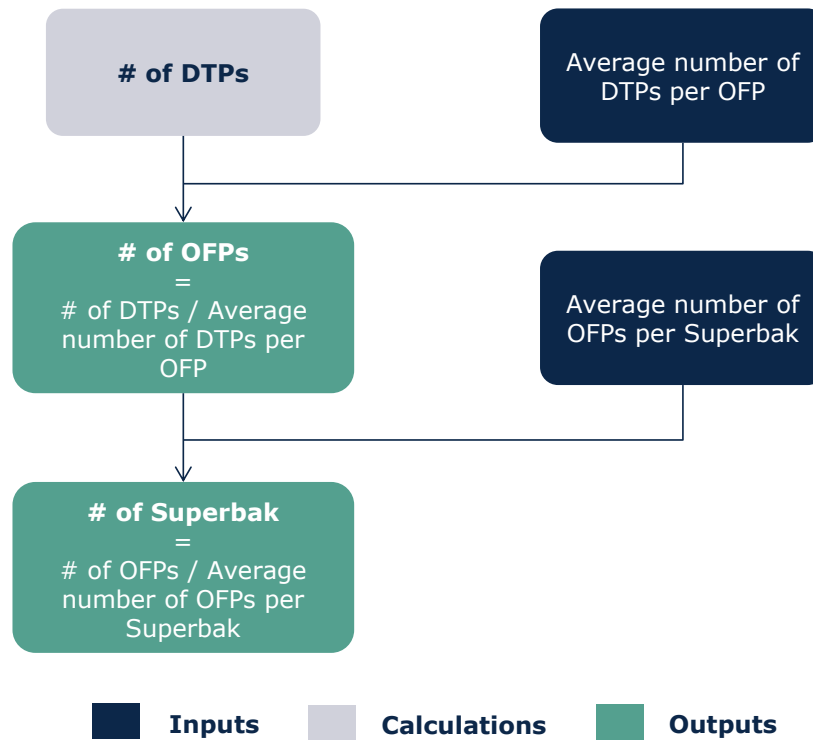


Exhibit 6.8: Algorithm for calculating the number of OFPs and of Superbaks [Source: Axon Consulting]

Finally, in the case of the OFPs, these are disaggregated between primary and secondary OFPs considering an average number of secondary OFPs connected per primary OFP.

6.1.4 Cabling and civil infrastructure

The dimensioning of cabling and civil infrastructure is structured into two steps:

- ▶ Calculation of kilometres of fibre cable in the access network,
- ▶ Calculation of civil infrastructure elements based on the cabling deployed.

Cabling in the access network

The first step consists in calculating the total kilometres of fibre cable needed to cover the access network. These calculations are separated in two physical sections, according to each network segment:

- ▶ Secondary network (DTP-OFP),
- ▶ Primary network (OFP-Local Exchange).



The outputs of the geographical analysis (see section 5) are taken as inputs to calculate the kilometres of fibre in the access network.

Secondary network (DTP-OFD)

The following exhibits illustrates the methodology followed for the fibre cable in the secondary network:

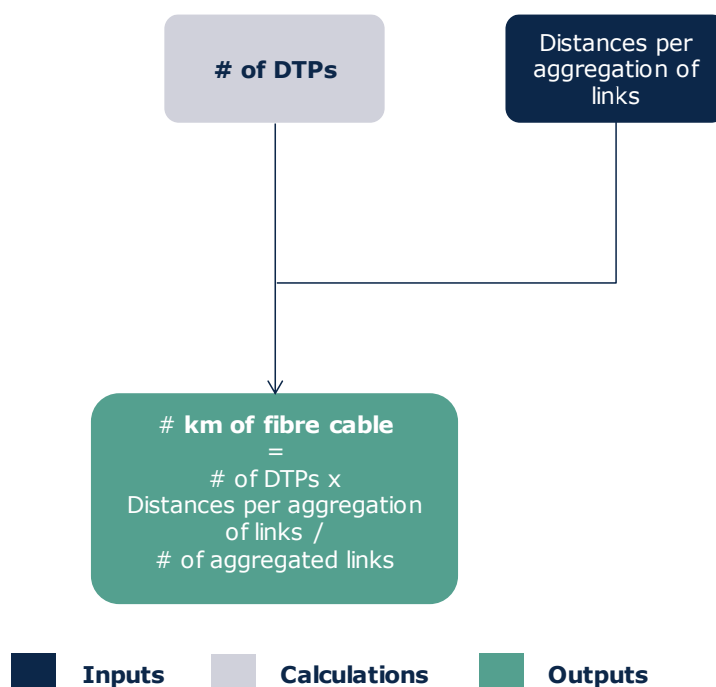


Exhibit 6.9: Algorithm for calculating the kilometres of fibre cable in the secondary network
[Source: Axon Consulting]

The parameter “Distances per aggregation links” comes from the results obtained in the geographical analysis, and it provides information about the distances in the access network section for the different aggregations of links. The following exhibit shows an illustrative example about how the aggregation of links can be performed in the network.

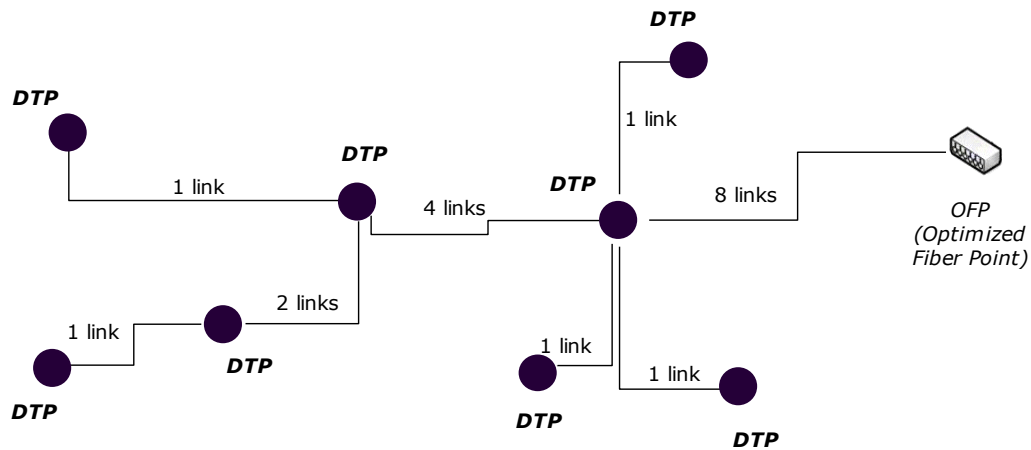


Exhibit 6.10: Illustrative example of aggregation links [Source: Axon Consulting]

This information of distances is then combined with the number of DTPs to calculate the total distance of fibre cable length in the secondary network. An illustrative example of the calculation, step-by-step, is provided below:



Step 1: Calculation of the average distance of fibre cable associated to each individual DTP

Number of aggregated links between DTP and OFP ⁷	Average distance (metres) [A]	Average number of DTPs sharing the aggregated link ⁸ [B]	Cable size employed [C]	Number of cables required [D]	Average distance of fibre cable associated to each individual DTP and the corresponding configuration in number of strands (metres) [A] × [D] / [B]
Aggregation of 1 links	22,01	1,00	1	1	22,01 (of 1 strand)
Aggregation of 2 links	49,89	2,00	2	1	24,95 (of 2 strands)
Aggregation of 4 links	111,17	3,50	4	1	31,74 (of 4 strands)
Aggregation of 8 links	208,67	6,00	8	1	34,79 (of 8 strands)
Aggregation of 10 links	-	-	-	-	-
Aggregation of 12 links	-	-	-	-	-
Aggregation of 16 links	1,74	9,00	16	1	0,19 (of 16 strands)
Aggregation of 20 links	-	-	-	-	-
Aggregation of 24 links	-	-	-	-	-
Aggregation of 48 links	-	-	-	-	-
Aggregation of 96 links	-	-	-	-	-
Aggregation of 192 links	-	-	-	-	-
Aggregation of more than 192 links	-	-	-	-	-
TOTAL	393,49	-	-	-	113,68

Step 2: Calculation of the total length of fibre cables in the secondary network for the geotype under analysis

Parameter	Value
Number of DTPs [n]	100 ⁹
Average distance of fibre cable associated to each individual DTP (metres) [d]	113,68
Total length of fibre cables (metres) [n] × [d]	11.368

Exhibit 6.11: Illustrative example of distance calculation [Source: Axon Consulting]

⁷ The numbers of aggregation of links are aligned with the available fibre configurations (1, 2, 4, 8, etc.), measured in number of fibre strands. However, note that not all fibre configurations may be necessarily used by the modelled operator. In those cases, a value of zero is set in the corresponding row of this table.



As it can be extracted from above, the kilometres of fibre cable associated to an individual DTP are calculated taking into account the number of DTPs aggregated at each stage of the network.

Finally, the multiplication of such individual distance by the total number of DTPs leads to the total number of kilometres of fibre cable in the secondary network. It is important to note that even if in the Step 2 presented above, the total distance of fibre cable (113,68 metres) per DTP has been considered as a whole, this calculation is performed in the model individually for each configuration of cables (in terms of number of strands).

The above calculation is performed four times, for each type of buildings:

- ▶ SDU with DTP on façade,
- ▶ SDU with DTP underground,
- ▶ MDU with DTP on façade,
- ▶ MDU with DTP underground.

Finally, the number of fibre joints is calculated as the total km of fibre cable and multiplied by the parameter 'Average number of fibre joints per km'.

Primary network (OFP-Local Exchange)

For the fibre cable length in the primary network, the calculations are identical to those performed in the Secondary network (DTP-OFP) (see above), taking into account that:

- ▶ The number of DTPs is now replaced by OFPs to reflect the network segment from the OFP to the Local Exchange. The calculation of OFP units is explained in detail in previous section 6.1.3.
- ▶ The average distances per number of aggregated links are different and specific for this section of the network.

⁸ This number must be equal or less than the number of aggregation of links. For instance, in this particular example, the Aggregation of 4 links presents an average value of 3,5 DTPs sharing the aggregated link. This is explained due to the fact that, in certain sections, due to their geographical disposition, only 3 DTPs will share the aggregated link (instead of 4 DTPs), despite the fibre cable in such sections will have 4 fibre strands, thus presenting 1 unused fibre strand.

⁹ Hypothetical value for this example.



- ▶ Only one calculation is needed (instead of four) since the same configuration of OFP is employed for aggregating all types of buildings.

Civil infrastructure in the access network

The calculation of the civil infrastructure elements is highly conditioned by the type of cable installed (buried or aerial – on façade or on poles -). The kilometres of trenches and ducts are calculated as indicated in the following scheme:

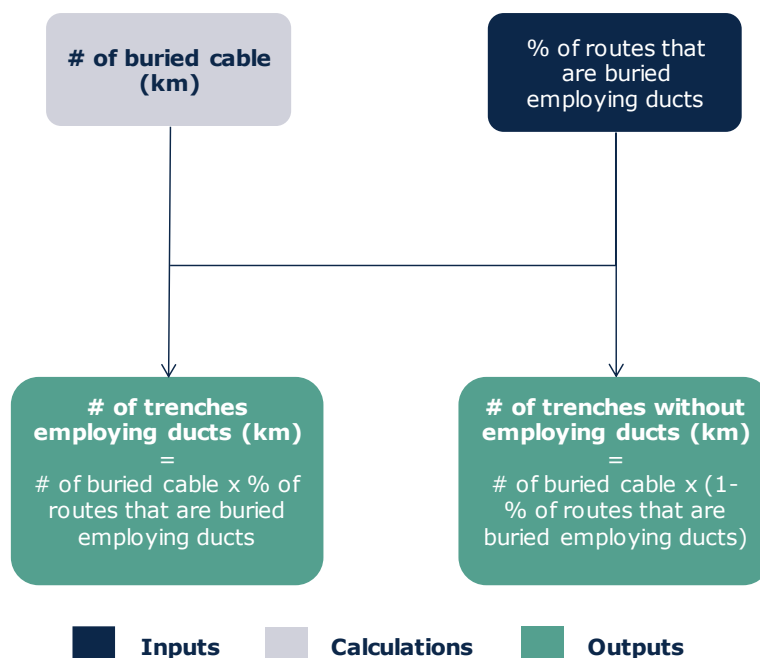


Exhibit 6.12: Algorithm for calculating the kilometres of trenches employing or not ducts in the access network [Source: Axon Consulting]

The kilometres of buried cable are disaggregated between trenches employing or not ducts. The percentage of routes that are buried employing ducts is different for each network section.

In addition to the above, the model also considers that in the primary network, there is the possibility of the reuse of the existing civil infrastructure assets previously employed for xDSL services also for the accommodation of the new FTTH cables. To take this aspect into account, the model assumes that a percentage of trenches/ducts can be shared



between xDSL and FTTH services¹⁰, and it assumes that where practicable, the cost associated to these assets should be split 50%-50% between both group of services. In an equivalent manner, the model also excludes the portion of trenches/ducts that are shared with other networks (the operator's transmission network, other operators' networks and utilities companies).

The manholes and poles take also into account the type of cable installed, as follows:

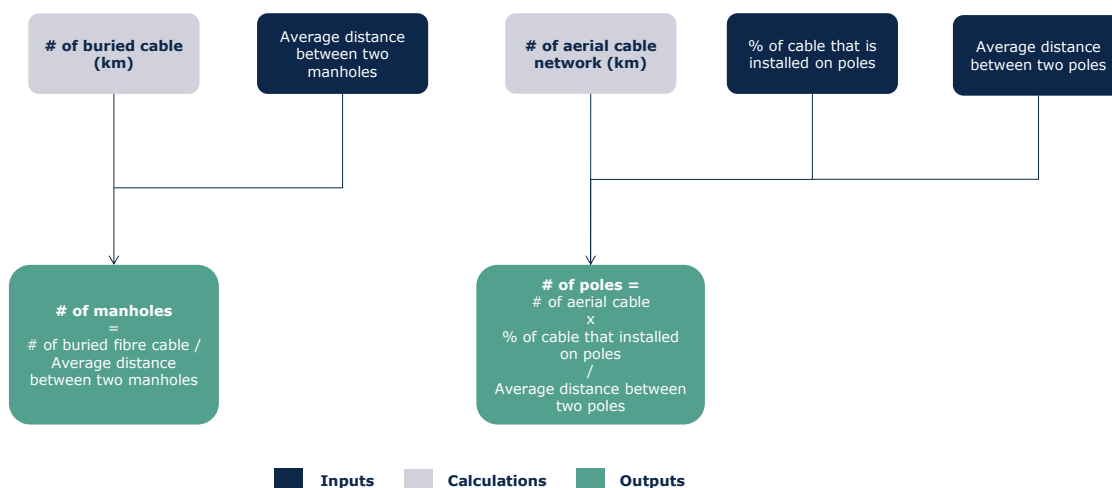


Exhibit 6.13: Algorithm for calculating the number of manholes and poles in the secondary network
[Source: Axon Consulting]

The average distance between manholes and poles are used to divide the total fibre cable length per network section, resulting in the number of manholes and poles in each section.

Finally, the model also calculates the number of transitions elements required for moving from façade to underground (in trenches) deployments, as the km of trenches divided by a ratio representing the 'Average number of transitions from façade to trench per km of trench'.

6.2. Dimensioning of Fiberklaar's network

The dimensioning of Fiberklaar's network is composed of several steps, equivalent to those of Proximus, which can be summarized as illustrated in the chart below.

¹⁰ We note that this only applies to Proximus, since Unifiber and Fiberklaar do not own a previously existing xDSL network.

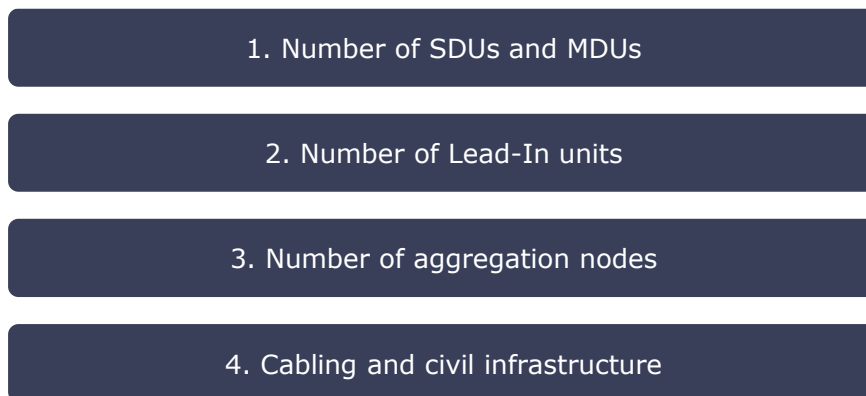


Exhibit 6.14: Schematic steps for the dimensioning of the Fiberklaar’s network [Source: Axon Consulting]

6.2.1 Number of SDUs and MDUs buildings

The dimensioning of the SDUs and MDUs buildings is equivalent to that previously described in section 6.1.1 for Proximus.

6.2.2 Number of Lead-In (Drop cable) units

The dimensioning of Lead-In (Drop cable) units is equivalent to that previously described in section 6.1.2 for Proximus.

However, in this particular case, it must be noted that the Fiber Termination Point (FTU) equipment is the equivalent element to the ONTP in the case of Proximus.

6.2.3 Number of aggregation nodes

Fiberklaar’ network contains the following aggregation nodes:

- ▶ Distributed Point (DP)
- ▶ Area PoP
- ▶ Central PoP

The number of these elements is calculated as indicated in the following exhibit:

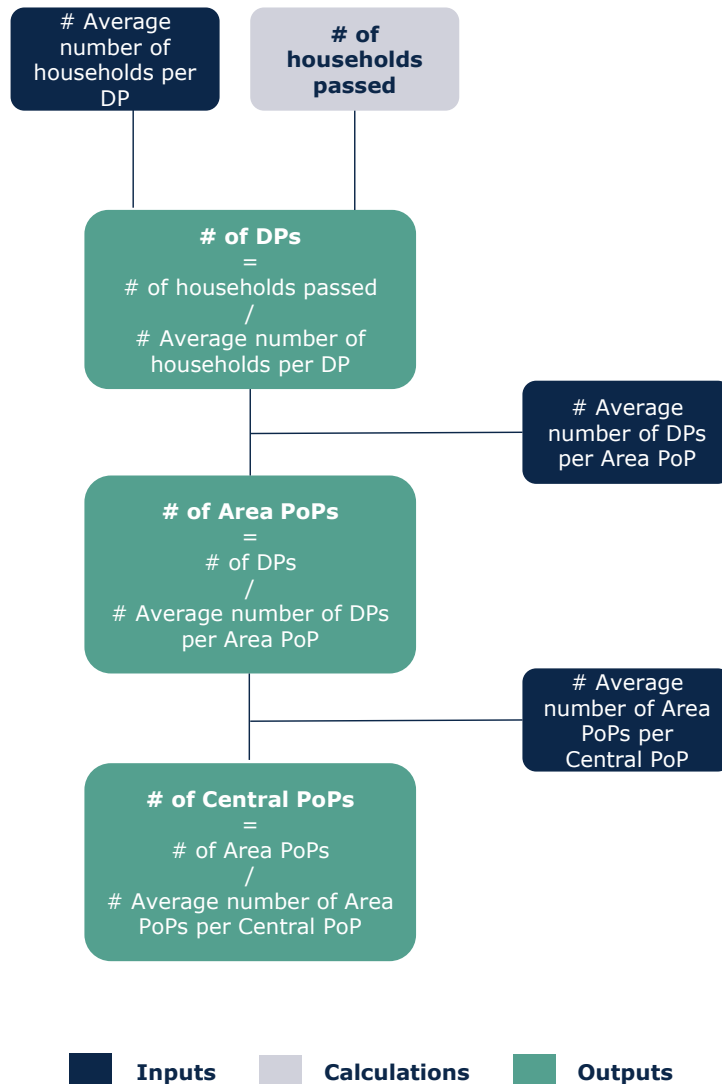


Exhibit 6.15: Algorithm for calculating the number of aggregation nodes [Source: Axon Consulting]

As it can be observed in the chart, the calculation follows a cascade flow in which each access network element is obtained from the number of elements in the previous aggregation level.

Finally, the model also installs one Optical Distribution Frame (ODF) and two handholes in each Area PoP and Central PoP.

6.2.4 Cabling and civil infrastructure

The dimensioning of the cabling and civil infrastructure is equivalent to that previously described in section 6.1.4 for Proximus.



However, the following particularities of Fiberklaar's network must be considered:

- ▶ While the secondary network of Proximus represents the connection DTP-OFP, in the case of Fiberklaar, this secondary network represents the connection Building-DP. For this reason, the number of DTPs must be replaced by the number of buildings in the required calculations.
- ▶ While the primary network of Proximus represents the connection OFP-Local Exchange, in the case of Fiberklaar, this primary network represents the connection DP-Area PoP. For this reason, the number of OFPs must be replaced by the number of DPs in the required calculations.
- ▶ As previously introduced, Fiberklaar's network requires an additional backbone (PoP) ring for connecting the Area PoPs to the Central PoP. For the estimation of the required km of trenches, the model multiplies the average route distance per ring by the number of Central PoPs. In the particular case of the required km of fibre cables, an additional multiplying factor is taken into account to recognise the needed redundancy of fibre cables.

6.3. Dimensioning of Unifiber's network

The dimensioning of Unifiber's network is equivalent to that previously described in section 6.2 for Fiberklaar, with the following differences:

- ▶ Unifiber installs an additional aggregation node named as Customer Point (CP), located between the building and the Distributed Point (DP). The number of Customer Points is obtained as the division between the number of passed households and the average number of households per CP. As a result of this, Unifiber requires an additional network segment, the tertiary network, connecting the buildings to the CPs.
- ▶ In a different manner to Fiberklaar, Unifiber is responsible for the installation of optical splitters in its network. This number of splitters is obtained according to the following calculation:

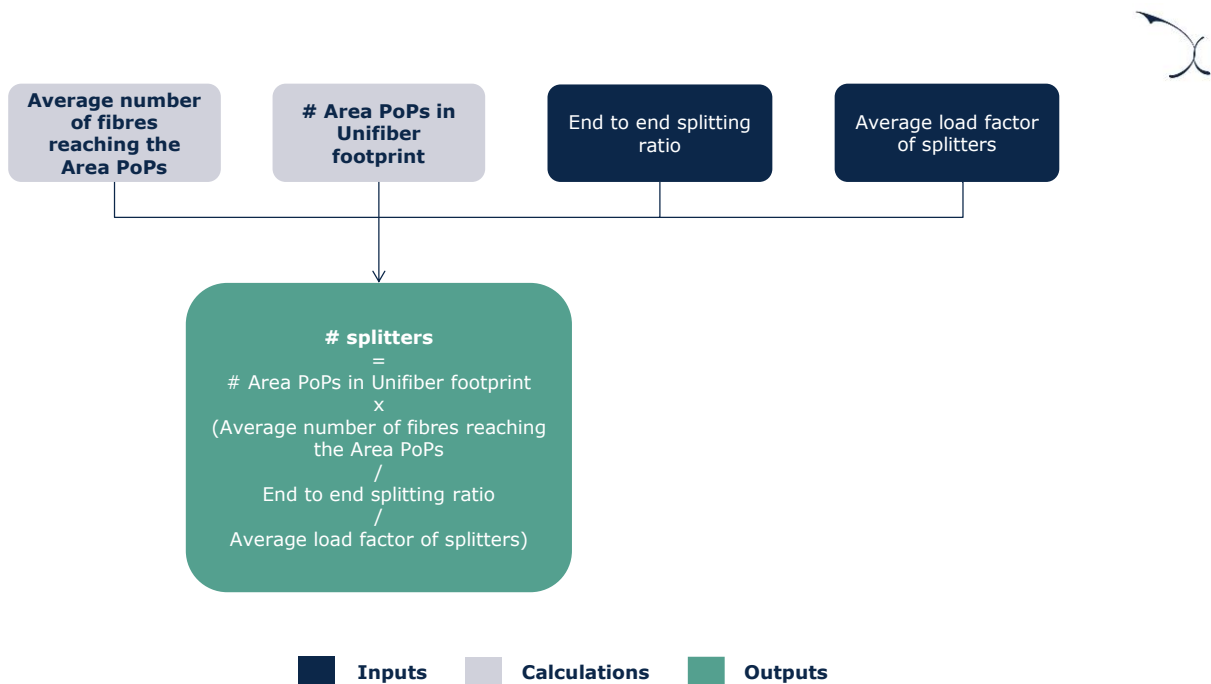


Exhibit 6.16: Algorithm for calculating the number of splitters [Source: Axon Consulting]

6.4. Dimensioning of Proximus' active layer

The dimensioning of Proximus' active layer refers to the estimation of the number of resources¹¹ that need to be placed by Proximus on top of the rented passive networks from Fiberklaar and Unifiber, or on top of its own passive network, and which are required for the service provision to the end customer.

The list of resources required for this purpose are:

- ▶ Local Exchange (LEX),
- ▶ OLT and OMDFs,
- ▶ Backhaul lines to connect with PoPs of Fiberklaar and Unifiber's passive networks,
- ▶ Optical splitters in the case of Fiberklaar's network.

The calculation process for these elements is detailed in the following sections:

¹¹ Please note that not all of these network resources correspond to active elements as they also contain passive elements.



Local Exchange (LEX)

The number of Local Exchanges (LEX) is calculated according to the algorithm outlined below:

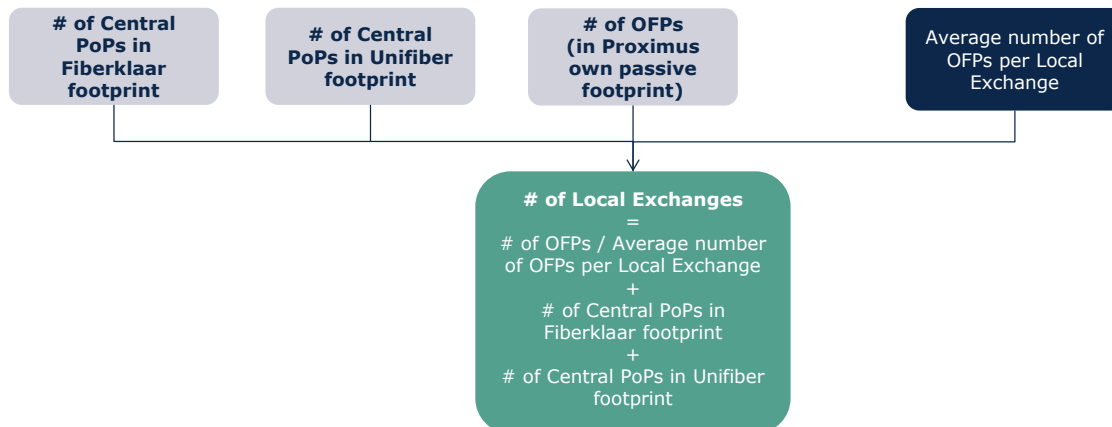


Exhibit 6.17: Algorithm for calculating number of Local Exchanges [Source: Axon Consulting]

As it can be observed, in addition to the Local Exchanges required by Proximus in its own passive footprint, it also needs one additional Local Exchange for each of the Central PoPs of both Fiberklaar and Unifiber.

OLT and OMDFs

The number of OLTs and OMDFs is calculated considering the following algorithm:

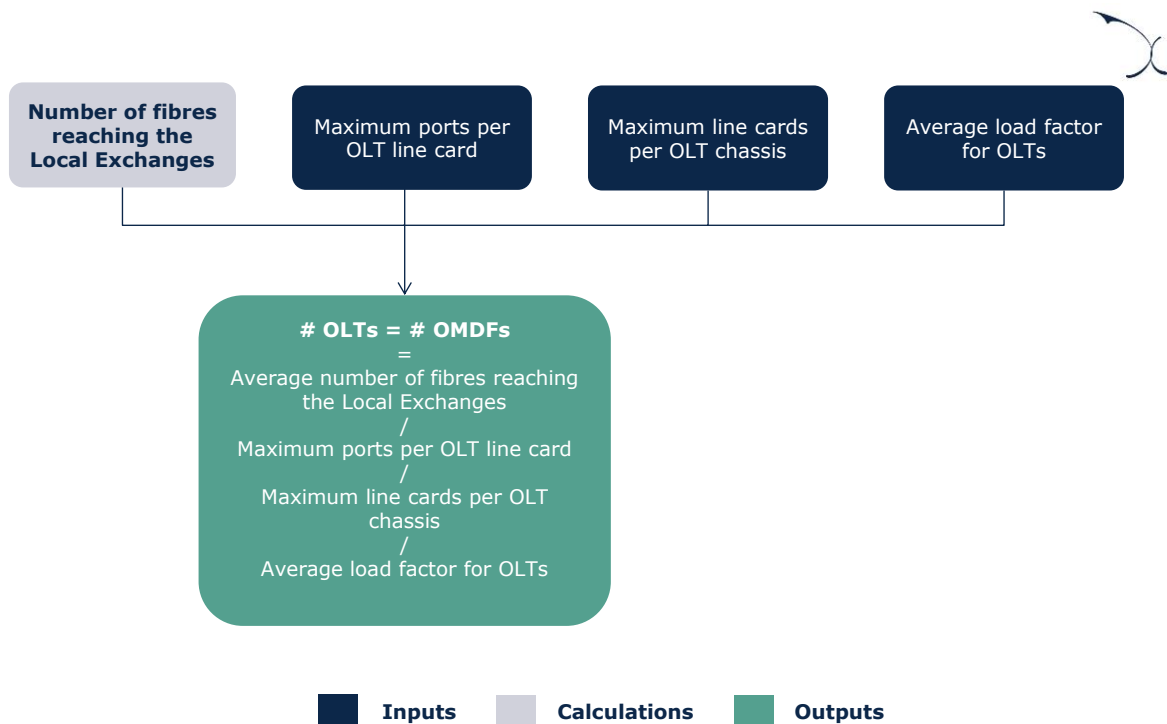


Exhibit 6.18: Algorithm for calculating the number of OLTs and OMDFs [Source: Axon Consulting]

The number of OLTs and OMDFs is obtained considering the maximum ports per line card (assuming that each fibre cable reaching the Local Exchange will be connected to one port) and the maximum line cards per OLT chassis.

In addition to the above, the model also assumes that, in the case of the footprint of Fiberklaar and Unifiber, at least one OLT will be placed by Proximus for each Central PoP of Fiberklaar or Unifiber.

In order to differentiate the number of OLTs as “OLTs that support both XGS-PON and GPON” and “OLTs that support only GPON”, the total number of OLTs is multiplied by the input “Percentage of OLTs that support XGS-PON”. The remaining are the OLTs that only support GPON.

It is also worth noting that the number of OMDFs in Proximus’ network is equivalent to that of OLTs.

Backhaul lines to connect with PoPs of Fiberklaar and Unifiber’s passive networks

The km of backhaul lines to connect with PoPs of Fiberklaar and Unifiber’s passive networks are calculated considering the following algorithm:

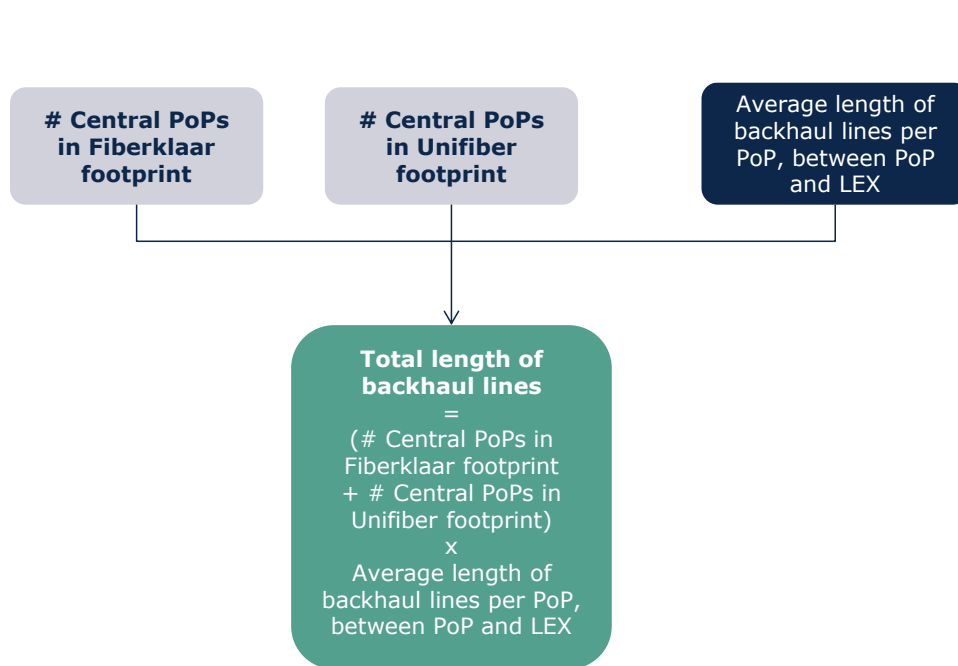


Exhibit 6.19-Algorithm for calculating total length of Backhaul lines to connect with PoPs of Fiberklaar and Unifiber’s passive networks [Source: Axon Consulting]

Optical splitters in the case of Fiberklaar’s network

In the case of the Fiberklaar’s footprint, the wholesale customer should be the responsible for the installation of the optical splitters. In the case of Proximus active services, this number of splitters is obtained assuming an equivalent approach to that employed for the calculation of splitters in Unifiber’s network, previously explained in section 6.3.



7. CapEx & OpEx Costs Module

The purpose of the CapEx & OpEx Costs Module is to calculate the expenditures (CapEx and OpEx) associated with the required network resources coming from the Dimensioning Module. This section presents the steps to obtain these expenses, as illustrated in the following figure.

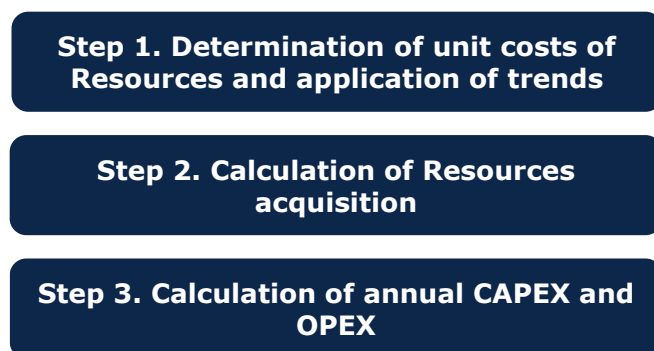


Exhibit 7.1: Resources Costing [Source: Axon Consulting]

The following sections explain each step in detail.

7.1. Step 1. Determination of Resources' Unit Costs and Cost Trends

For the definition of the unitary costs of the resources considered in the Model, two inputs are needed:

- ▶ **Unitary cost:** Separated in CAPEX and OPEX (for those resources where applicable) in the historical period. This information is introduced in the worksheet '1D INP UNITARY COSTS'.
- ▶ **Cost trends:** For each resource, a cost trend can be introduced, outlining the expected evolution of its prices (both CapEx and OpEx separately) in the future period. This information is introduced in the worksheet '1E INP COST TRENDS'.

Once historic unit costs and cost trends have been introduced, the Model will apply the trend where unit cost have not been introduced (i.e. usually in future years). The formula used for the application of cost trends is the following.

$$\text{Unit Cost (year)} = \text{Unit Cost (year - 1)} * (1 + \text{Trend (year)})$$



In the case of the CAPEX, additionally, the exclusion of the cost associated to fully depreciated assets is performed. Given that these assets have already attained their entire useful life, they no longer represent a cost for the operator, and then, they are excluded from the model's results. This calculation is performed in the worksheet '4A CALC UNIT CAPEX CONSOL' of the model, for those resources that have been previously indicated in worksheet '1D INP UNITARY COSTS', in table 'Percentage of assets fully depreciated'.

Finally, we also note that the impact of the inflation is already reflected in both CAPEX and OPEX trends assumed in the model.

7.2. Step 2. Calculation of Resources Acquisition

In Step 2, the calculation of Capital Expenditures (CAPEX) that is needed to obtain new acquisitions is produced for each year. The following algorithm is used:

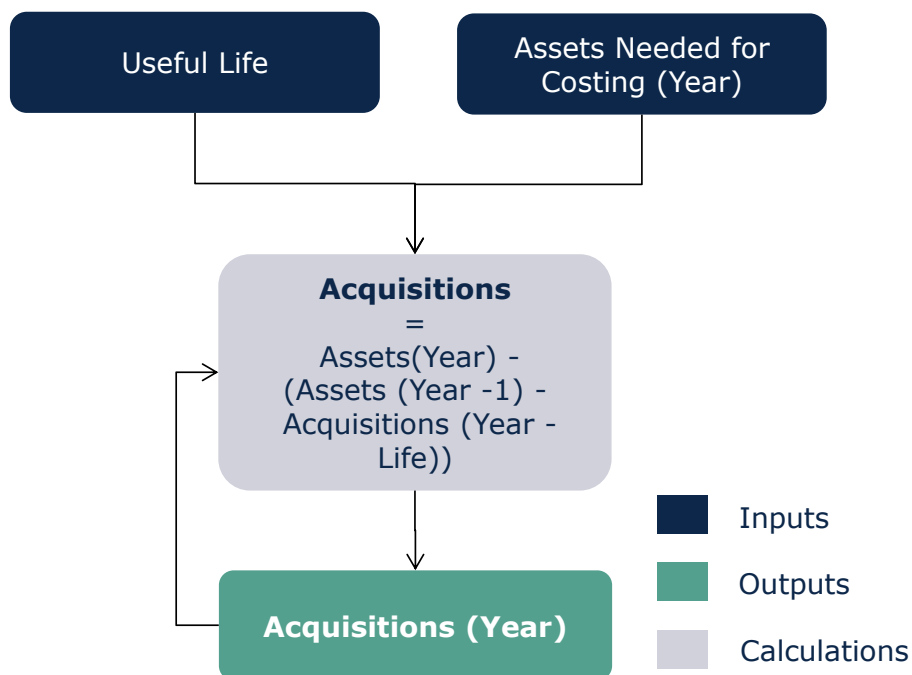


Exhibit 7.2: Algorithm for the Calculation of New Acquisitions [Source: Axon Consulting]

New acquisitions can be driven by two factors, network deployment or equipment's replacement, as follows:

- ▶ **Network deployment:** The roll-out of new equipment for increasing the coverage or capacity levels, which will be determined by additional network requirements to meet the demand.



- ▶ **Equipment replacement:** Once the equipment's useful life is expired, and when this resource is still necessary due to network requirements, the resource is replaced. In some cases, when the equipment is not required anymore, the equipment is just dismantled but not replaced.

7.3. Step 3. Calculation of CAPEX and OPEX

Once the unit cost and the new acquisitions for each resource and year are determined, a P*Q system will be used to obtain the expenditures. The calculation of CAPEX (before annualization) and OPEX (before annualization) follows the algorithm:

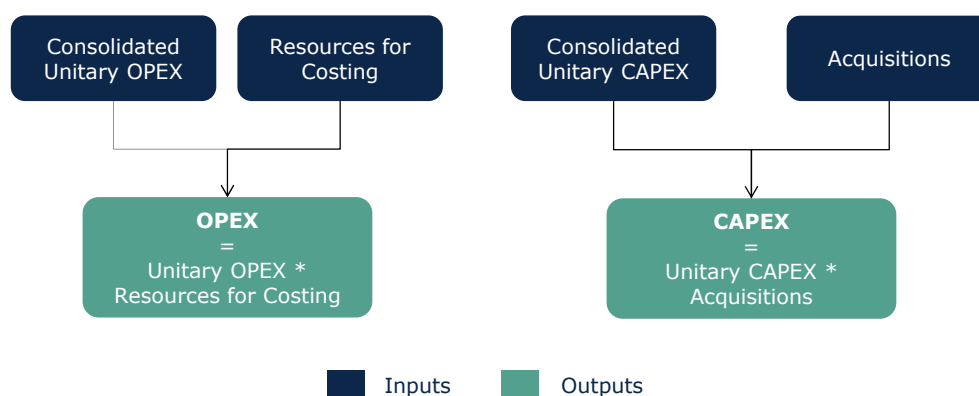


Exhibit 7.3: Algorithm for the Calculation of the CAPEX and OPEX [Source: Axon Consulting]



8. Depreciation Module

The Depreciation Module aims at calculating the annualisation method to distribute CAPEX and OPEX over the years (annualisation). Therefore, this section presents the economic depreciation method, whose objective is to adjust the recovery of the asset value to the economic value it produces.

In particular, economic depreciation adjusts the annuities of the investment by means of a production factor defined from the performance that is extracted from the asset. For instance, if an asset is expected to be used more exhaustively in the future (e.g. due to an increase of adoption), the application of the economic depreciation results in higher annuities in the future than in the present (and relatively constant unitary costs).

Particularly, the formula used in the calculation for the economic depreciation is as follows:

$$c_i = I \cdot \frac{p_i \cdot f_i}{\sum_{n=i_0}^{i_0+UL-1} (p_n \cdot \alpha_n \cdot f_n)}$$

Where:

- ▶ I is the yearly investment associated to the asset. This figure shall include the OpEx that would be incurred in order to operate and maintain the asset throughout its lifetime.
- ▶ c_i is the annualised costs at year i (within the useful life)
- ▶ f_i is the production factor that can be associated with the asset in year i , in terms of average demand per asset
- ▶ p_i is the reference price of the asset for the year i
- ▶ UL is the useful life of the asset
- ▶ i_0 is the year when the asset was purchased
- ▶ α_i represents the cost of capital factor and responds to the following formula:

$$\alpha_i = (1 + WACC)^{-(i-i_0+1)}$$



9. Cost allocation to services

This section presents the methodology followed to calculate the incremental and common costs of the resources, and how these costs will be allocated to the services in order to obtain unit costs under the LRIC+ standard.

9.1. Incremental and common costs calculation

The incremental cost associated to each increment is the reduction in the costs calculated by the Model due to ceasing the provision of the services included in that increment. This cost is expressed mathematically as the difference between the cost of total demand and the cost obtained when the level of demand for the services included in the increment are set to zero, leaving all others unchanged:

$$INCREMENTAL\ COST(increment1) = F(v1, v2, v3, vN, C) - F(0, v2, v3, vN, C)$$

Where F is the formula that represents the LRIC+ model (which calculates the cost according to demand and coverage), v_i represents the demand volume of increment i , and C represents the coverage.

To calculate the incremental costs, increments are defined as groups of services. Therefore, services have to be assigned to increments. In the model (sheet '0D PAR OTHER'), an increment has been defined: Access. Services are then assigned to this increment in Sheet '0A PAR SERVICES'.

Once incremental costs are calculated for this increment as described previously, common costs by resource are obtained as the difference between the total cost base obtained under Fully Allocated Costs standard (considering all the demand) and the incremental costs. The following formula shows this calculation:

$$COMMON\ COST = TOTAL\ COSTS\ (Fully\ Allocated\ Costs) \\ -\ INCREMENTAL\ COST(Access\ increment)$$

In the model, resources' incremental costs are calculated in sheet '8C CALC RES COST CONSOL' while common costs are shown in sheet '10A CALC RES COMMON COST'.

The following section presents the methodology employed for the allocation of resources' costs to services in the Model.



9.2. Resources' costs imputation to services

Incremental costs are allocated to services using Routing Factors. This methodology allocates costs to products based on the use made of each equipment. The Routing Factor is a measure of how many times a resource is used by a specific service during its provision. Once annual costs incurred per resource are available, these have to be distributed to the final services.

The cost imputation process is done in two main steps (see the Figure below):

- ▶ Step 1. Combination of Routing Factors and Services' demand
- ▶ Step 2. Cost allocation to services based on such combination

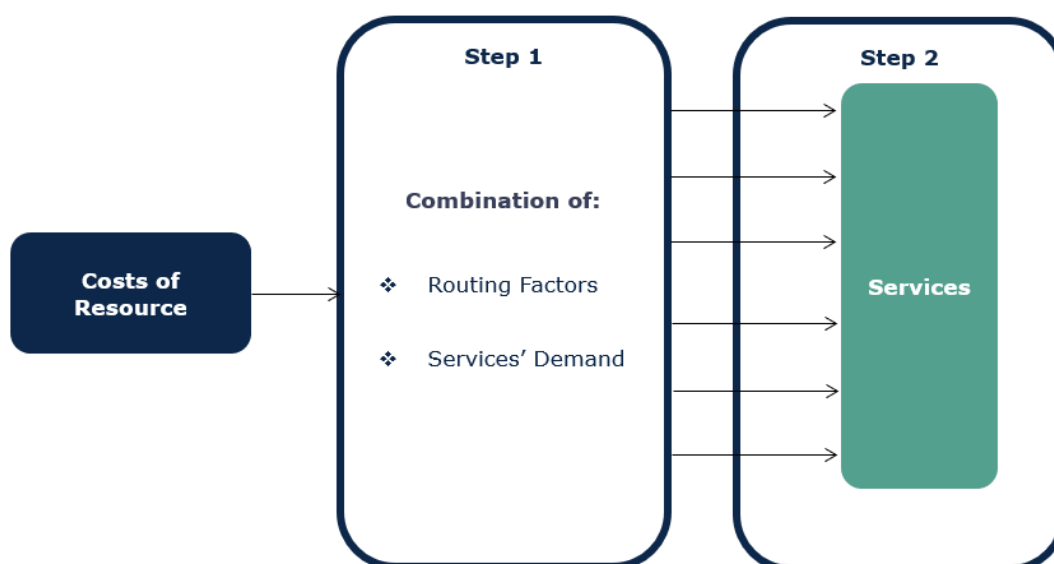


Exhibit 9.1: Cost Imputation Process using Routing Factors [Source: Axon Consulting]

Once incremental costs have been allocated, the allocation of common costs is based on an Effective Capacity approach. This methodology allocates common costs also through the Routing Factors, following the same philosophy as the incremental costs.

Finally, once network costs have been allocated, general and administrative expenditures (G&A) and IT Costs are allocated to all services following a separate mark-up on top of services costs.

More details about Steps 1 and 2 are provided in following paragraphs.



9.2.1 Step 1: Combination of Routing Factors and Services' Demand

The methodology used to allocate resources' costs to services is based on the idea that the cost of a resource has to be imputed to services proportionally to the amount of demand volume, and to a "factor of use", the Routing Factor. Hence, the more demand a service generates, the higher the cost will be charged from the asset considered; and the higher utilisation of the asset, the higher cost taken.

Below there is an illustrative excerpt showing some examples of Routing Factor associations between Services and Resources.

EQUIVALENT EQUIPMENT (Group of resources)	Relevance to operator	Service CATEGORY	Service SUBCATEGORY	Service SEGMENT	Service DESCRIPTION	Routing Factor
Passive Network Building Unit - Proximus own deployment	Proximus passive access	Access	Fibre	Retail and Wholesale	Passive access (Point-to-Multipoint)	1,00
Access Fibre Cabling - Proximus own deployment	Proximus passive access	Access	Fibre	Retail and Wholesale	Passive access (Point-to-Multipoint)	1,00
Civil Infrastructure - Proximus own deployment	Proximus passive access	Access	Fibre	Retail and Wholesale	Passive access (Point-to-Multipoint)	1,00
DFP - Proximus own deployment	Proximus passive access	Access	Fibre	Retail and Wholesale	Passive access (Point-to-Multipoint)	1,00
Superbak - Proximus own deployment	Proximus passive access	Access	Fibre	Retail and Wholesale	Passive access (Point-to-Multipoint)	1,00

Exhibit 9.2: Illustrative extract of Routing Factor Correlation to Services and Resources (Sheet '3C MAP ROUTING FACTORS') [Source: Axon Consulting]

9.2.2 Step 2: Cost Allocation to Services

Once the weight of a single service in relation to each different asset has been established, it is possible to distribute all costs to all services.

The basic relation is the following:

$$ServiceCost(i, year) = \sum_n \frac{Asset(n, year) \cdot Demand(i, year) \cdot RF(i, n)}{\sum_i Demand(i, year) \cdot RF(i, n)}$$

Where:

- ▶ ServiceCost (i, year) is the cost of service i in an established year.
- ▶ Asset (n, year) is the cost of resource n in that year.
- ▶ Demand (i, year) is the volume making use of the service i in the selected year.
- ▶ RF (i, n) is the Routing Factor that relates the resource n with the service i

The allocation of resources' cost to services is presented in the sheet '9B CALC SERV INCR COST', where the formula used allows the implementation of steps described under this section 9.2.



Annex A. Services' descriptions

This annex contains a description of the services (see worksheet "0A PAR SERVICES") that have been included in the BULRIC Model for FTTH networks.

▶ Proximus (passive layer)

- **Access Fibre - Passive access (Point-to-Multipoint).** Provision of a FTTH line to an activated end customer. Its unit cost is comprised of the cost of the passive access network, from the customer premise up to the Local Exchange (exclusive), and excluding the cost of the drop cable and the ONTP (contained in the following service).
- **Access Fibre - Access to drop cable.** Provision of a FTTH line to an activated end customer. Its unit cost is only comprised of the cost of the drop cable and ONTP.
- **Ducts - Access Duct.** This service includes the cost of providing duct infrastructure, rented to third parties.
- **Access Fibre - Terminated lines (support service, no results applicable).** This service is included in the model exclusively for calculation purposes, as no result is applicable for it. It represents the number of households in the operator's network that present a drop cable connection to the customer's household (i.e., that are terminated and ready for activation if requested).

▶ Fiberklaar and Unifiber

- **Access Fibre - Passive access from user's premise to Area PoP.** Provision of a FTTH line to an activated end customer, sold on a wholesale basis, and when the connection by the Requesting Party is performed in the Area PoP. Its unit cost is comprised of the cost of the passive access network, from the customer premise up to the Area PoP (inclusive), and excluding the cost of the drop cable and the FTU, contained in the service below 'Access to drop cable'.
- **Access Fibre - Passive access from user's premise to Central PoP.** Provision of a FTTH line to an activated end customer, sold on a wholesale basis, and when the connection by the Requesting Party is performed in the Central PoP. Its unit cost is comprised of the cost of the passive access network, from the customer premise up to the Area PoP (inclusive), and excluding the cost of the drop cable and the FTU, contained in the service below 'Access to drop cable'.



- **Access Fibre - Access to drop cable.** Provision of a FTTH line to an activated end customer, sold on a wholesale basis. Its unit cost is only comprised of the cost of the drop cable and FTU.
- **Ducts - Access Duct.** This service includes the cost of providing duct infrastructure, rented to third parties.
- **Access Fibre - Terminated lines (*support service, no results applicable*).** This service is included in the model exclusively for calculation purposes, as no result is applicable for it. It represents the number of households in the operator's network that present a drop cable connection to the customer's household (i.e., that are terminated and ready for activation if requested).

▶ **Proximus (active layer)**

- **Access Fibre - Active access on Fiberklaar passive access network.** Provision of a FTTH line to an activated end customer. Its unit cost is comprised of the cost of the layer that needs to be placed by Proximus on top of the rented passive layer to Fiberklaar, required for the service provision to the end customer. It includes the cost of the Local Exchange, OMDF, OLT, the backhaul connection between Fiberklaar's PoP and Proximus' Local Exchange, and the optical splitters.
- **Access Fibre - Active access on Unifiber passive access network.** Provision of a FTTH line to an activated end customer. Its unit cost is comprised of the cost of the layer that needs to be placed by Proximus on top of the rented passive layer to Unifiber, required for the service provision to the end customer. It includes the cost of the Local Exchange, OMDF, OLT and the backhaul connection between Unifiber's PoP and Proximus' Local Exchange.
- **Access Fibre - Active access on Proximus' P2MP access network.** Provision of a FTTH line to an activated end customer. Its unit cost is comprised of the cost of the Local Exchange, OMDF and OLT.