BULRIC Model for HFC networks

Descriptive Manual

December 2018

BIPT

AXON

Contents

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 HFC 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 have already been discussed with BIPT and they 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	▶ Hypothetical efficient operator rolling-out modern efficient networks
Assets valuation method	▶ Current Cost Accounting (CCA)
Treatment of civil infrastructure assets	▶ The model considers the exclusion of the CapEx associated to civil infrastructure assets (trenches, ducts, manholes, etc.) that are fully depreciated.
Depreciation method	▶ Economic Depreciation.
Allocation of common network costs	▶ Effective Capacity approach. The allocation of common costs is based on the capacity used by each service, as in the case of the allocation of pure incremental costs
Network Topology	▶ Scorched Node, using the existing locations of operators' network nodes (Local Headends).
Access Technologies	▶ HFC networks
Transmission Technologies	▶ Fibre Links (Ethernet with/without WDM).
Core Technologies	▶ Next Generation Core Network (NGN)
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 and transport

Increments	▶ Access lines vs Conveyance
Costs to be considered	▶ Network CapEx (Depreciation and Cost of Capital), 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 for the Model.
- **Dimensioning Drivers**, examines the conversion of traffic (at service level) to network parameters (for example Erlangs and Mbps) 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.
- **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 annual OpEx and CapEx over the years.
- **Depreciation Module**, presents the calculation of the depreciation methods to distribute CAPEX over the years (annualisation).
- **Cost allocation to services**, includes further explanations about the calculation of costs under the LRIC+ standard and it 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.

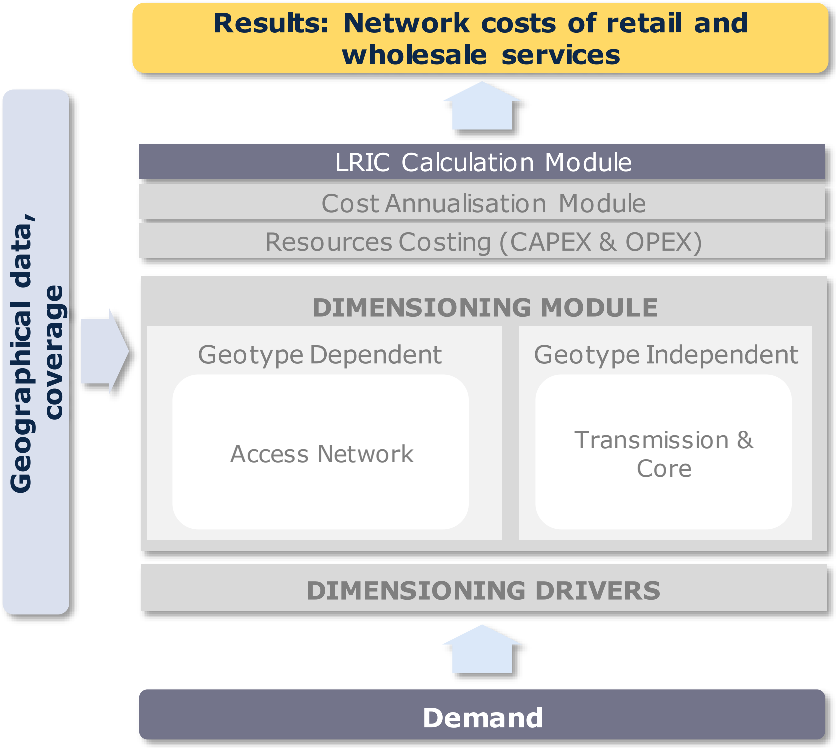


Exhibit 2.1: Structure of the model [Source: Axon Consulting]

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

- **Dimensioning drivers:** Converting traffic 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 network can be geotype-dependent or independent. For example, the dimensioning process corresponding to the access network and the access infrastructure is distinctive and independent for each geo-type.

- **Cost Calculation (CapEx and OpEx):** Calculating cost of resources obtained after network dimensioning, both in terms of CapEx and OpEx.
- **Annualisation module:** Allocating CapEx resources costs over time following the methodology defined. That is, employing an 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

By definition, the main input of a BULRIC model is the demand that should be satisfied by the network to be dimensioned. However, additional data is required. The following list describes the main inputs that are needed for the BULRIC 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.
- **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. Additionally, the characterisation of the core network is needed (e.g. core locations, links). Geographical information is produced by applying the methodology described in section 5.
- **Traffic statistics**: for the dimensioning of the network it is necessary to define certain statistics of the network (e.g. peak consumption per user, TV channel throughput, etc.).
- **Network dimensioning parameters and equipment capacity**: dimensioning algorithms need information about the characteristics of the network equipment in terms of capacity.

4. Dimensioning Drivers

The rationale of the dimensioning drivers is to express traffic and 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.

Dimensioning drivers represent, among others, the following requirements:

- Number of connections for the dimensioning of the access network
- Mbps for transmission through the core network (including for instance broadband and TV services).

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

VARIABLE
DRIV.CABLE.Connections.Total Active connection
DRIV.REGIONAL TRAFFIC.Traffic.Voice traffic
DRIV.REGIONAL TRAFFIC.Traffic.Data traffic
DRIV.CORE TRAFFIC.Traffic.Voice traffic
DRIV.CORE TRAFFIC.Traffic.Data traffic
DRIV.TRANSPORT.Leased Lines.Local
DRIV.TRANSPORT.Leased Lines.Regional
DRIV.TRANSPORT.Leased Lines.National
DRIV.TRANSPORT.Broadband.Local
DRIV.TRANSPORT.Broadband.Regional
DRIV.TRANSPORT.Broadband.National
DRIV.CORE CONNECTIONS.Connections.Total lines
DRIV.CORE CONNECTIONS.Connections.Total Internet lines
DRIV.DIGITAL TV.Traffic.Traffic
DRIV.ANALOGUE TV.Traffic.Traffic
DRIV.VOD.Traffic.Traffic
DRIV.RADIO.Traffic.Traffic

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. Converting traffic units into the corresponding driver units

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. It should be noted that a service is generally assigned to more than one driver as drivers represent traffic in a particular point of the network.

For example, broadband services should be contained in both the drivers used to dimension the transmission network (i.e. the links between local and core nodes) as well as the core equipment.

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

List of relationships	
SERVICE (Variable Name)	**DRIVER (Variable Name)**
Access.Cable.Retail.Access	DRIV.CABLE.Connections.Total Active connection
Access.Cable.Wholesale.Access	DRIV.CABLE.Connections.Total Active connection
Voice.Voice.Retail.Voice traffic	DRIV.REGIONAL TRAFFIC.Traffic.Voice traffic
Europacket Cable.Cable.Wholesale.EPC of equivalent QoS feature	DRIV.REGIONAL TRAFFIC.Traffic.Voice traffic
Voice.Voice.Retail.Voice traffic	DRIV.CORE TRAFFIC.Traffic.Voice traffic
Broadband.Broadband.Retail.25 Mbps	DRIV.REGIONAL TRAFFIC.Traffic.Data traffic
Broadband.Broadband.Retail.50 Mbps	DRIV.REGIONAL TRAFFIC.Traffic.Data traffic

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.

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:

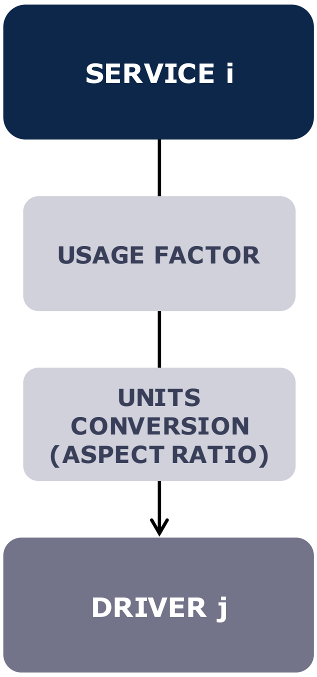


Exhibit 4.3: Conversion Process from Services to Drivers [Source: Axon Consulting]

The conversion factor 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:

$$FC = UF * UCF$$

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 (e.g. voice service in Erlangs) to those used by the driver (e.g. Mbps). These factors are defined in the column I of worksheet `3A MAP SERV TO DRIV´.

It is important to note that, apart from the above two parameters, in the case of broadband services defined for different speed profiles (tiering), the model also considers the average consumption per user in the busy hour (input defined in the worksheet `2A INP NW´) for estimating the total traffic measured in Mbps that should be associated to those broadband services. This calculation is performed in the worksheet `5A CALC ADJUSTED DEMAND ´ of the model.

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 (Optical Nodes mainly) 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 access network and part of the transmission network, 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 3 in order to represent three different types of areas: Urban, Suburban and Rural.

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

- Buildings density (buildings/km^2), 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:

1. Calculating cluster variables. The buildings density and average number of households per building have been calculated at sector level. The source of information employed for this calculation has been the internal database available in BIPT, named "Atlas".
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)[1] is used by default.
4. Assignation of obtained clusters to each sector. Once the three clusters have been calculated, they are assigned to their associated sectors.

The following exhibit shows the results of the geotype characterisation:

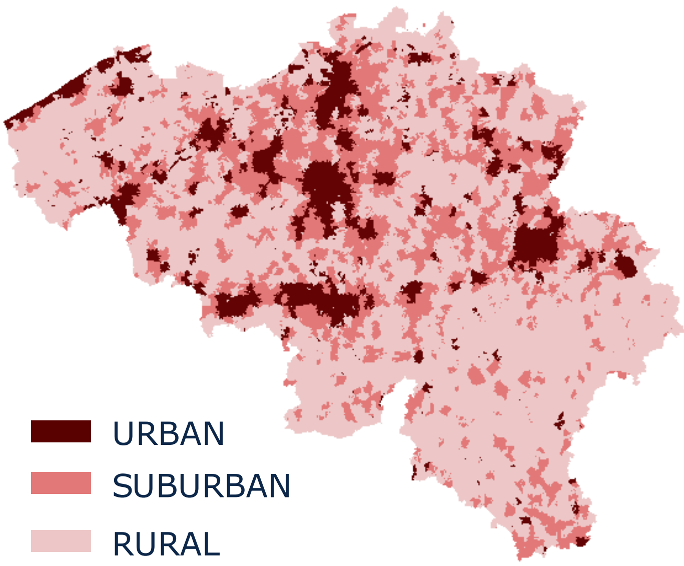


Exhibit 5.1: Classification into geotypes of Belgium sectors for the geographical analysis [Source: Axon Consulting]

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.

[1] "A K-Means Clustering Algorith", by J. A. Hartigan and M. A. Wong. More details in: https://www.labri.fr/perso/bpinaud/userfiles/downloads/hartigan_1979_kmeans.pdf

5.2. Determination of nodes location

The GIS database available in BIPT 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 Optical Nodes. For that purpose, and similar to the geotype characterisation, a k-means algorithm has been implemented.

This algorithm requires an initial definition of the number of k Optical Nodes (obtained from the ratio between the average number of buildings per Optical Node) which are randomly generated within the buildings domain.

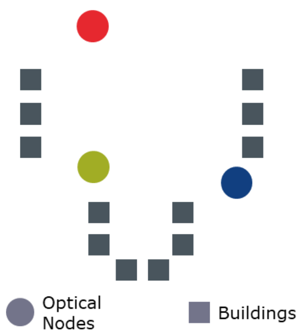
After that, the algorithm proceeds to assign each building to its nearest Optical Node. When no buildings are pending, the first step is completed, and a first aggrupation is done. At this point, k new Optical Nodes need to be re-calculated as the barycentres of the clusters resulting from the previous step. Once the new locations of the Optical Nodes are known, a new binding has to be performed between the same set of buildings and their nearest new Optical Node, generating a loop. As a result of this loop the k Optical Nodes change their location step by step until no more changes are made.

This algorithm aims to minimising an objective function, in this case a squared error function:

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^j - c_j \right\|^2$$

Where $\left\| x_i^j - c_j \right\|^2$ represents the distance between a building x_i^j and a Optical Node c_j.

The process performed through this algorithm is outlined in the table below:

	**Step 1.** k initial Optical Nodes (in this case k=3) are randomly generated within the buildings domain (shown in colour).

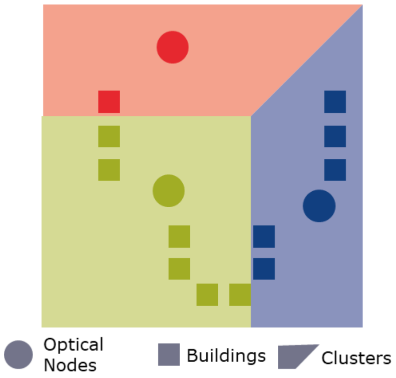
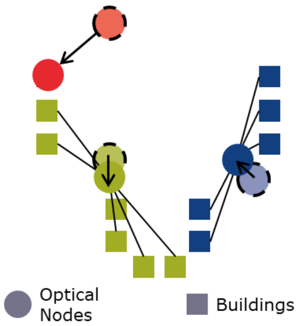
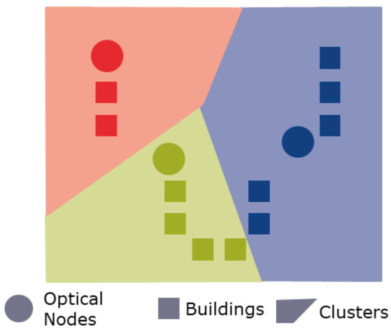
	**Step 2.** k clusters are created by associating every building with its nearest Optical Nodes.
	**Step 3**. The new Optical Node of each of the k clusters is situated in the average location of the premises it aggregates.
	**Step 4**. Steps 2 and 3 are repeated until convergence has been reached.

Exhibit 5.2: Graphical representation of the process followed by the k-means algorithm [Source: Axon Consulting]

As a result of this analysis, the specific location in which the Optical Nodes should be placed are obtained, and at the same time, it also produces the grouping between Optical Nodes and buildings.

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 Optical Nodes and the rest of the circles outline buildings associated to different Optical Nodes.

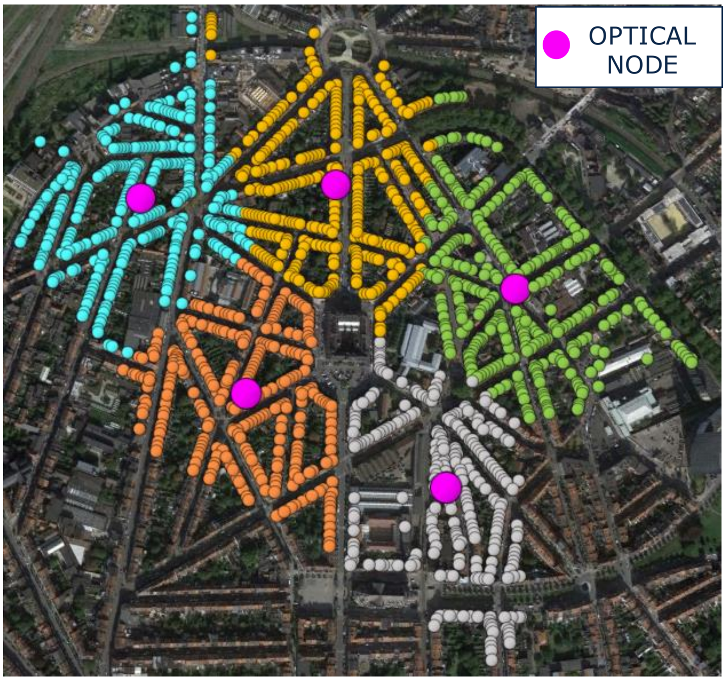


Exhibit 5.3: Optical Nodes that would need to be deployed for an area situated in an URBAN geotype [Source: Axon Consulting]

In the case of the position corresponding to the Local Headends (following point of aggregation after the Optical Nodes), it is worth noting that this information has been gathered during the data request process, in which the operators have provided the exact location of their Local Headends.

Once the location of both the Optical Nodes and the Local Headends is known, the calculation of distances between network elements is performed in the following section.

5.3. Calculation of distances between network elements

The calculation of distances between network elements is performed by the implementation of a Minimum Distance Tree algorithm.

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.

The connections between the different network elements (e.g. from buildings to Optical Nodes and from Optical Nodes to Local Headends) have been designed taking the Minimum Distance Tree topology as a reference. The philosophy of this algorithm is explained below for the connections between buildings and Optical Nodes:

1. The starting building "a_1" is the term that minimizes the following formula

$$\sum_{\forall b} d(a_1, b)$$

   Where d(x,y) represents the distance from building a to building b.

2. To obtain the next building "a_i" (where "i" represents the index of execution), the distances from the not yet connected buildings to the already connected are obtained.
3. The minimum distance from those obtained in step 2 is selected. This distance is related to the link between one already connected building and the new building a_i.
4. If there are buildings that have not been connected, the process is repeated from the step 2.

Once this process is completed for the connections between buildings and Optical Nodes, it is repeated again for the connections between Optical Nodes and Local Headens locations to characterise all the required connections in the access network. As a result of this calculation, the distances between the network elements is obtained for each geotype.

This algorithm has been applied to both the links from buildings to Optical Nodes and from Optical Nodes to Local Headends.

The following illustration provides an overview of the links dimensioned between buildings and Optical Node in an URBAN geotype.

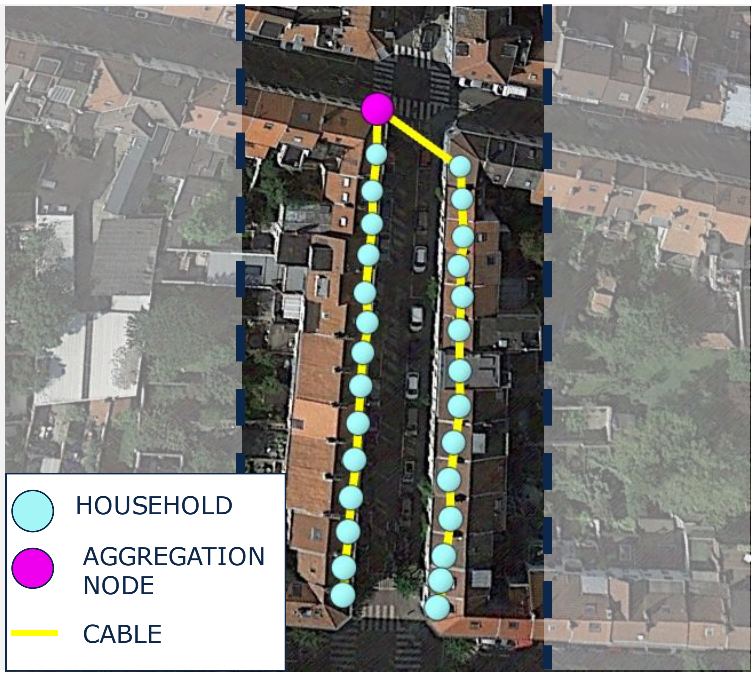


Exhibit 5.4: Illustrative example of the results from the Minimum Tree Algorithm between buildings and their Optical Node in an URBAN geotype [Source: Axon Consulting]

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.

Considering the Minimum Distance Tree topology detailed above, 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:

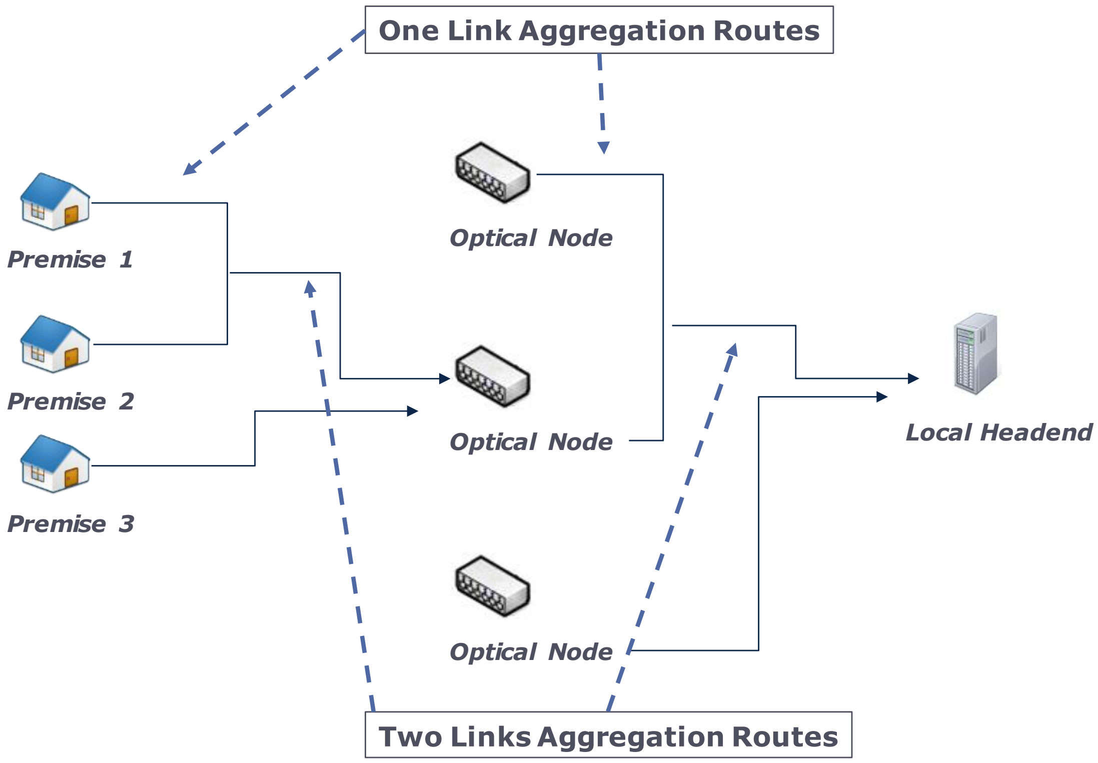


Exhibit 5.5: Illustrative representation of the connection of network elements using a Minimum Distance Tree topology [Source: Axon Consulting]

The implementation of a Minimum Distance Tree topology on the geography of the country in order to calculate the network routes between the different network elements provides the average distance of the links at the different stages of the access network. The following table illustrates an example of results extracted from the geographical analysis which will be taken as inputs in the BULRIC model.

It is also worth noting that for computing purposes, an intermedium step between the buildings and the Optical Nodes has been defined in the case of the BULRIC Model for HFC networks, named as the Distribution Point. However, this physical point may not necessarily exist in the operators' networks. In other cases, it could refer to a splitter or amplifier.

Average distance from TAP/building to Distribution Point (DP)	Average distance per TAP (metres)		
	URBAN	SUBURBAN	RURAL
Aggregation of 1 link	6,77	11,79	20,81
Aggregation of 2 links	7,28	12,49	21,17
Aggregation of 3 links	7,65	13,05	21,26
Aggregation of 4 links	7,77	12,68	20,57
Aggregation of 5 links	7,88	12,20	19,10
Aggregation of 6 links	7,72	11,38	18,64
Aggregation of 7 links	7,72	11,60	17,94
Aggregation of 8 links	7,28	11,00	17,35
Aggregation of 9 links	6,86	10,40	17,37
Aggregation of 10 links	6,45	9,65	15,17
Aggregation of 11 links	6,17	9,17	14,25
Aggregation of 12 links	5,98	8,68	13,05
Aggregation of 13 links	5,43	8,49	12,75
Aggregation of 14 links	4,85	7,84	11,15
Aggregation of more than 14 links	51,48	85,95	145,17
TOTAL	**147,28**	**236,38**	**385,75**

Average distance from Distribution Point (DP) to Optical Node (ON)	Average distance per DP (metres)		
	URBAN	SUBURBAN	RURAL
Aggregation of 1 link	126,30	220,89	427,28
Aggregation of 2 links	95,35	155,93	273,56
Aggregation of 3 links	64,27	122,06	187,26
Aggregation of 4 links	41,34	75,01	129,16
Aggregation of 5 links	28,41	46,75	76,69
Aggregation of 6 links	14,98	34,32	49,21
Aggregation of 7 links	14,53	21,37	34,48
Aggregation of 8 links	7,30	19,80	36,46
Aggregation of 9 links	6,58	7,95	13,61
Aggregation of 10 links	2,27	4,85	10,03
Aggregation of 11 links	1,28	6,74	3,72
Aggregation of 12 links	2,48	10,57	2,89
Aggregation of 13 links	0,17	1,96	-
Aggregation of 14 links	0,59	1,87	2,50
Aggregation of more than 14 links	-	8,11	17,49
TOTAL	**405,85**	**738,18**	**1.264,35**

Average distance from Optical Node (ON) to Local Headend	Average distance per ON (metres)
Aggregation of 1 link	705,35
Aggregation of 2 links	648,10
Aggregation of 3 links	401,00
Aggregation of 4 links	587,61
Aggregation of 5 links	859,59
Aggregation of 6 links	428,12
Aggregation of 7 links	278,47
Aggregation of 8 links	537,70
Aggregation of 9 links	329,89
Aggregation of 10 links	219,75
Aggregation of 11 links	496,07
Aggregation of 12 links	214,56
Aggregation of 13 links	230,76
Aggregation of 14 links	213,50
Aggregation of more than 14 links	3.929,58
TOTAL	**10.080,06**

Exhibit 5.6: Illustrative tables of the results obtained for distances between networks elements considering a Minimum Distance Tree network topology [Source: Axon Consulting]

6. Dimensioning Module

The Dimensioning Module aims at designing the network and calculating the number of network resources required to serve the demand and coverage levels of the reference operator. This section has been divided in three different network sections which are described in detail below:

- Access Network Dimensioning (geotype dependant)
- Transmission Network Dimensioning (geotype independent)
- Core Network Dimensioning (geotype independent)

6.1. Access Network Dimensioning (geotype dependant)

The Access Network Module aims at designing the coaxial cable and optical fibre network and calculating the number of network resources required to serve the demand and coverage levels of the reference operator at geotype level. This process is performed in the worksheet '6A CALC DIM ACCESS´ of the Model.

In order to better understand this dimensioning procedure, the following exhibit provides an illustrative overview of the network architecture that is being modelled, together with the nomenclature employed for the different elements:

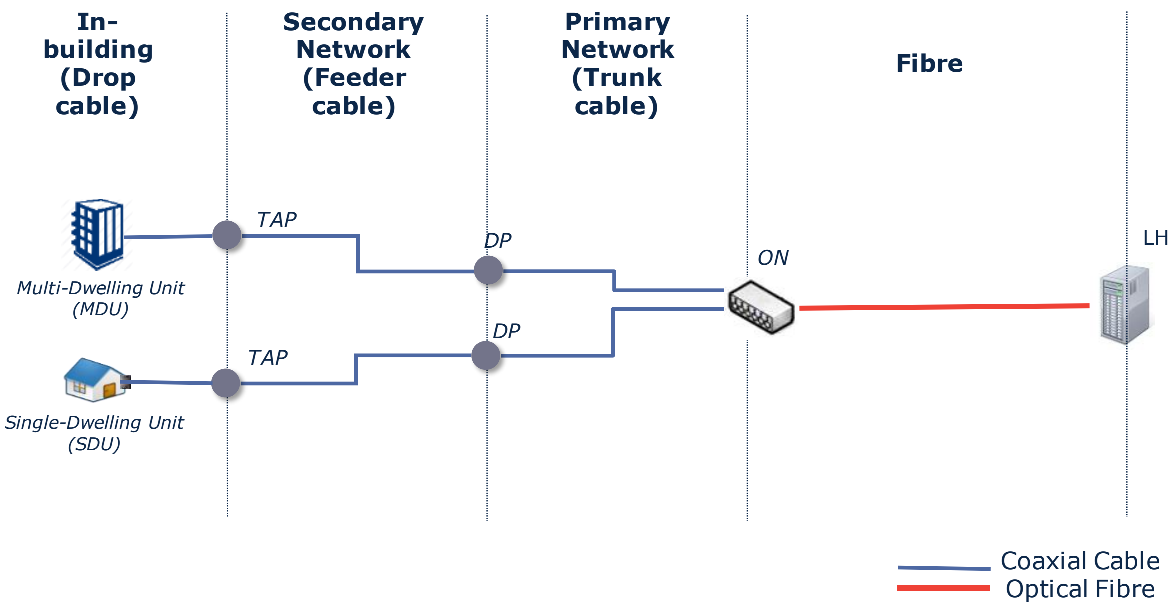


Exhibit 6.1: Architecture of the modelled Access Network [Source: Axon Consulting]

The access network comprises the network elements ranging from the users' premises to the Local Headend (LH). In between, the following network elements may be identified:

- **In-building (Lead-in) or drop cable**: Represents the coaxial cable 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 (TAP in the case of Single Dwelling Units – SDU or Building Unit in the case of Multi Dwelling Units – MDU). Note that this element has been modelled as number of units instead of as cable length (the corresponding drop cable for the HFC network).
- **TAP**: This network element connects the drop and the feeder cable. It is an aggregation point between a number of households, ensuring signal strength to final end-user point. The model has considered three different type of n-ways configurations: 2, 4 and 8 ways.
- **Secondary Network (Feeder cable):** Represents the section of the coaxial network connecting the TAP and the DP, i.e. the feeder cable. This includes the coaxial cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- **Distribution Point (DP)**: Represents an aggregation point which combines a number of feeder cables. The Distribution Points are not costed in the model as they are uniquely employed for network hierarchisation purposes.
- **Primary Network (Trunk cable):** Represents the section of the coaxial network connecting the DP and the ON, i.e. the trunk cable. This includes the coaxial cables as well as the physical infrastructure required for their accommodation (trenches, ducts, manholes, etc.).
- **Optical Node (ON):** Represents the interconnection point between coaxial cable and the fibre cable in the access network. It also considers the active equipment.
- **Local Headend (LH):** Represents an aggregation point for Optical Nodes. It also considers the active equipment.

In addition to the network elements described above, the coaxial cable network counts also with coaxial amplifiers and splitters that power up and multiplex the signal respectively.

Based on the above described network architecture, the signal flows from the households to its nearest street point where the TAP is located and is directed to the Distribution Points (DP) which are eventually aggregated into Optical Nodes (ONs).

The dimensioning of the access network is performed separately 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 two different blocks, namely:

- Dimensioning of the cable and civil infrastructure elements
- Dimensioning of the access network equipment

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

6.1.1. Dimensioning of the cable and civil infrastructure elements

The dimensioning of the cable and civil infrastructure elements are organised into five blocks, as shown in the chart below.

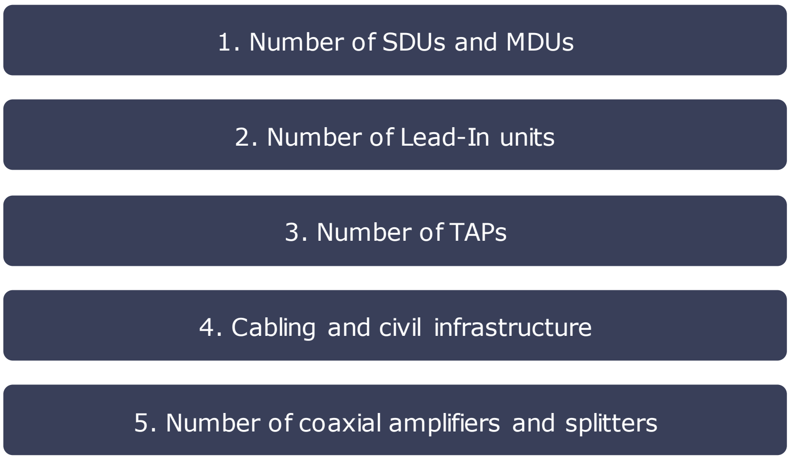


Exhibit 6.2: Schematic steps for the dimensioning of the cable and civil infrastructure elements [Source: Axon Consulting]

1. Number of SDUs and MDUs

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

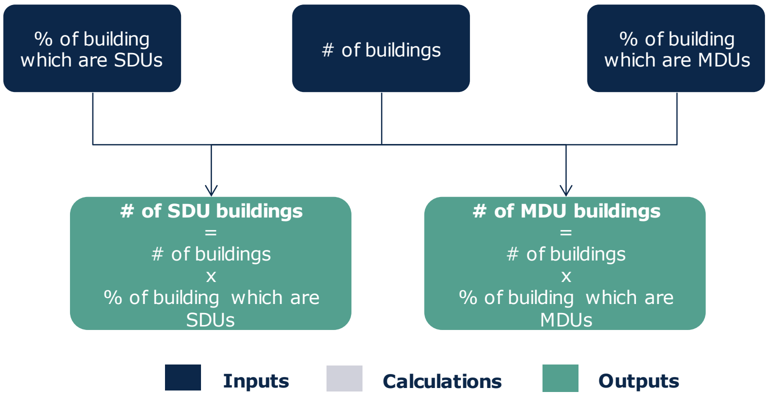


Exhibit 6.3: Algorithm for calculating the number of SDUs and MDUs [Source: Axon Consulting]

The number of covered buildings is multiplied by the percentage of buildings which are SDU and MDU, obtaining the corresponding number of covered SDU and MDU units.

2. Number of Lead-In (Drop cable) units and the NIUs

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

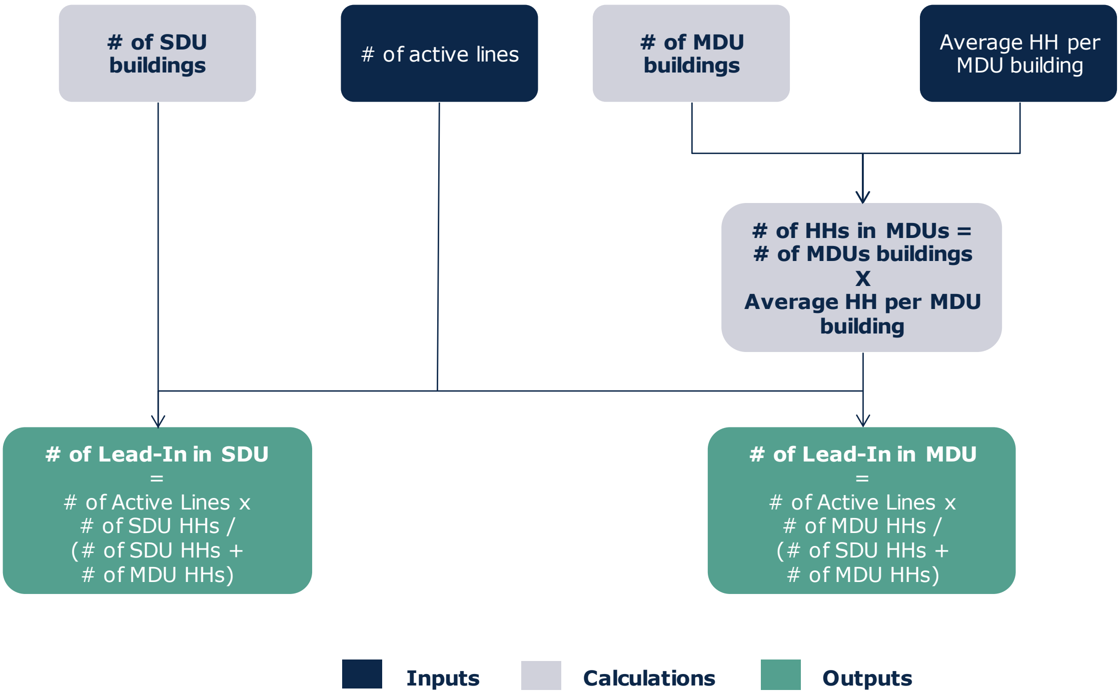


Exhibit 6.4: Algorithm for calculating the number of Lead-In units in SDU and MDU Households [Source: Axon Consulting]

The first step consists of calculating the number of households in MDU buildings covered, multiplying the number of covered MDU buildings by the average number of households per MDU building. By definition, a value of one household is assumed in the case of SDU. After that, the number of active lines are split into the number of Lead-In in SDU and MDU based on the number of households passed in each type (SDU and MDU).

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 TAP, since it passes through an intermedium point in the network, named as the building unit, which is generally located in the ground level of the building. The number of these building units is estimated as equivalent to the number of MDU buildings covered.

Finally, the model calculates the number of NIUs (Network Interface Unit) required equivalent to the number of activated customers.

3. Number of TAPs

The number of TAPs and their different configurations (2-way, 4-way and 8-way) are calculated considering the number of households in each type of building, as indicated in the following exhibit:

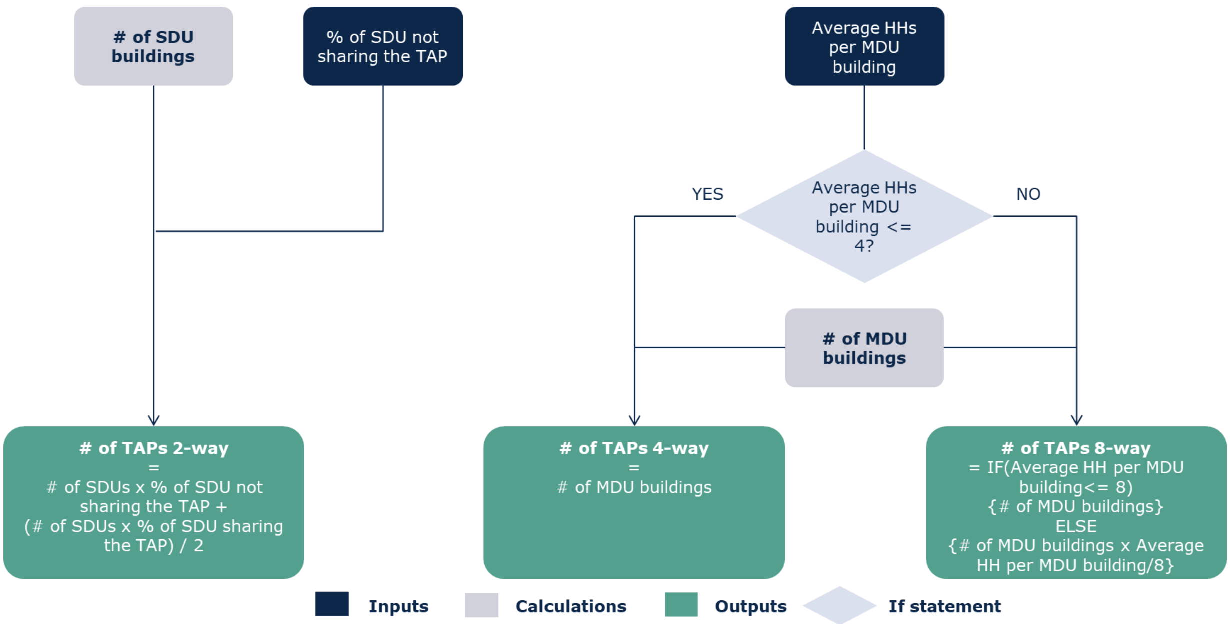


Exhibit 6.5: Algorithm for calculating the number of TAPs by different configurations [Source: Axon Consulting]

In the case of 2-ways TAPs, they are associated to SDU buildings taking into account the percentage of SDUs which share the TAP. That is, it is assumed that by default, two SDU buildings will share one 2-ways TAP.

On the other side, the 4-ways and 8-ways TAPs are reserved for MDU buildings and are calculated depending on the average number of households per MDU building. If this average is lower or equal to 4, each MDU building covered is matched to one 4-ways TAP. In other cases, the MDU buildings are associated to one or various 8-ways TAP (< 9 HHs per building to one 8-ways TAP, 9-16 HHs per building to two 8- ways TAPs, etc).

4. Cabling and civil infrastructure

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

- Calculation of kilometres of coaxial cable and fibre cable in the access network
- Calculation of civil infrastructure elements based on the cabling deployed

4.1 Cabling in the access network

The first step consists in calculating the total kilometres of coaxial cable and feeder fibre needed to cover the access network. These calculations are separated in three physical sections, according to each network segment (see Exhibit 6.1 for the Architecture of the Network):

- Secondary network (TAP-DP) or Feeder Cable
- Primary network (DP-ON) or Trunk Cable
- Feeder fibre network (ON-LH)

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

Secondary network (TAP-DP) or Feeder Cable

The following exhibit illustrates the methodology followed for the coaxial cable in the secondary network (named as feeder cable):

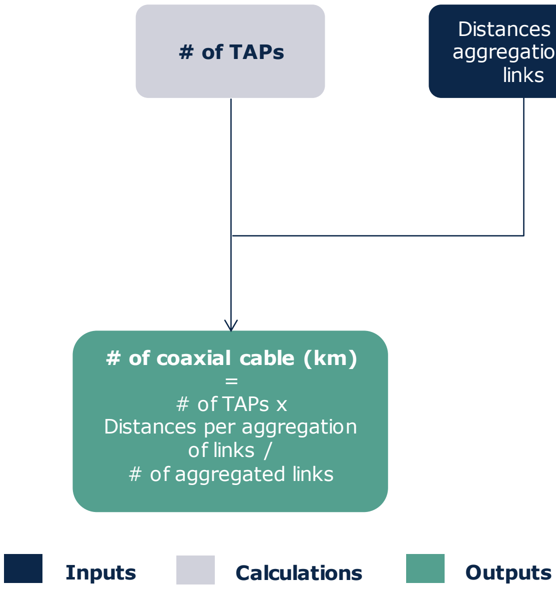


Exhibit 6.6: Algorithm for calculating the kilometres of coaxial cable in the secondary network [Source: Axon Consulting]

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 performed in the network.

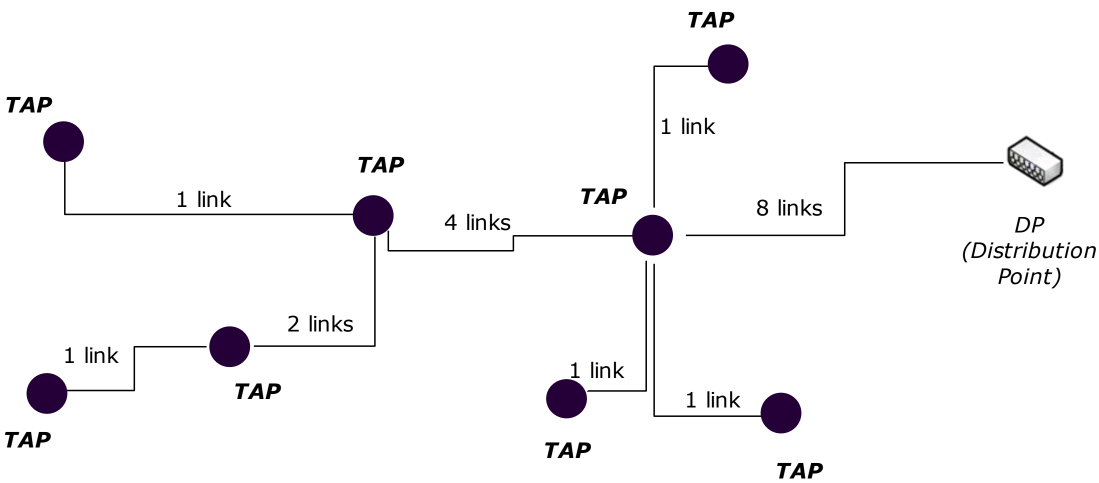


Exhibit 6.7: Illustrative example of aggregation links [Source: Axon Consulting]

This information of distances is then combined with the number of TAPs to calculate the total distance of coaxial 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 coaxial cable associated to each individual TAP

Number of aggregated links between TAP and DP	**Average distance (metres)** [A]	**Number of TAPs aggregated** [B]	**Average distance of coaxial cable associated to each individual TAP (metres)** [A] / [B]
Aggregation of 1 link	6,77	1	6,77
Aggregation of 2 links	7,28	2	3,64
Aggregation of 3 links	7,65	3	2,55
Aggregation of 4 links	7,77	4	1,94
Aggregation of 5 links	7,88	5	1,58
Aggregation of 6 links	7,72	6	1,29
Aggregation of 7 links	7,72	7	1,10
Aggregation of 8 links	7,28	8	0,91
Aggregation of 9 links	6,86	9	0,76
Aggregation of 10 links	6,45	10	0,65
Aggregation of 11 links	6,17	11	0,56
Aggregation of 12 links	5,98	12	0,50
Aggregation of 13 links	5,43	13	0,42
Aggregation of 14 links	4,85	14	0,35
Aggregation of more than 14 links	51,48	15	3,43
TOTAL	**147,29**	**-**	**26,44**

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

Parameter	Value
Number of TAPs [n]	100[2]
Average distance of coaxial cable associated to each individual TAP (metres) [d]	26,44
Total length of coaxial cables (metres) [n] x [d]	**2.644**

Exhibit 6.8: Illustrative example of distance calculation [Source: Axon Consulting]

As it can be extracted from above, the kilometres of coaxial cable associated to an individual TAP are calculated taking into account the number of TAPs aggregated at each stage of the network, which matches with the number of links aggregated. Finally, the multiplication of such individual distance by the total number of TAPs leads to the total number of kilometres of coaxial cable in the secondary network.

Once the total number of kilometres of cable are calculated, the buried and aerial cable is obtained as follows:

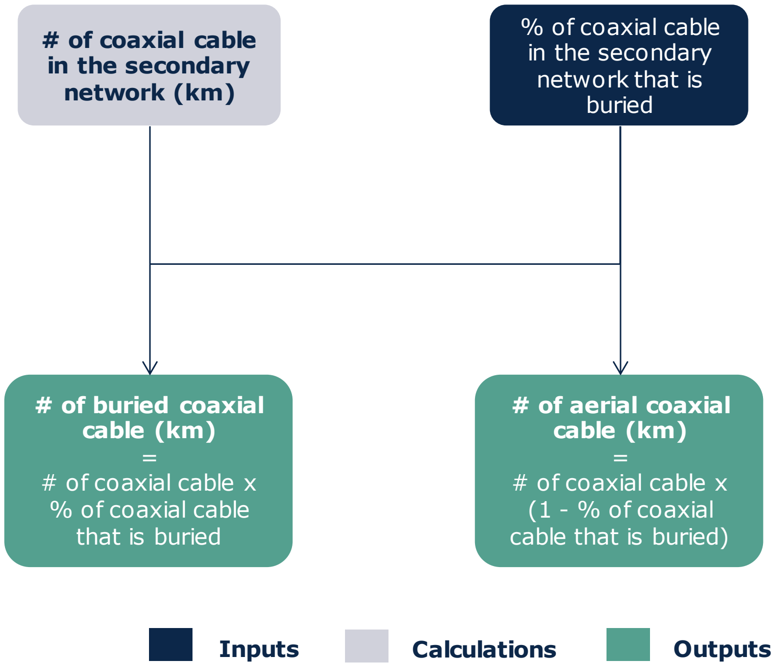


Exhibit 6.9: Algorithm for calculating the kilometres of buried or aerial coaxial cable in the secondary network [Source: Axon Consulting]

[2] Hypothetical value for this example.

Primary network (DP-ON) or Trunk Cable

For the coaxial cable length in the primary network, the calculations are identical to those performed in the secondary network (see above), taking into account that:

- The number of TAPs is now replaced by DPs to reflect the network segment from the DP to the ON. The calculation of DP units is explained detailly in Section 6.1.2.
- The average distances per number of aggregated links are different and specific for this section of the network.

Feeder fibre network (ON-LH)

For the cable length in the feeder fibre network, the calculations are identical to those performed in the secondary network, taking into account that:

- The number of TAPs is now replaced by ONs to reflect the network section from the ON to the LH. The calculation of ON units is explained detailly in Section 6.1.2.
- The average distances per number of aggregated links are different and specific for this section of the network.

4.2 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). The kilometres of trenches and ducts are calculated as indicated in the following scheme:

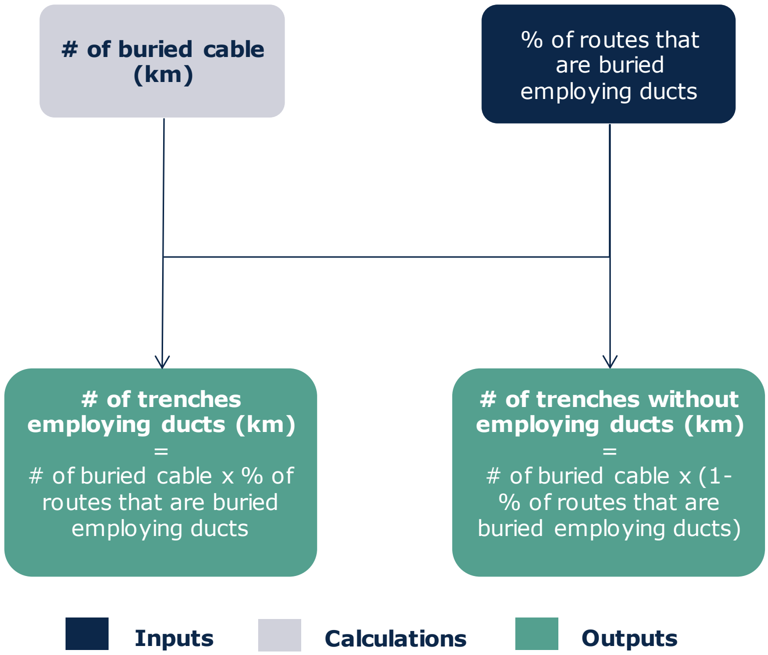


Exhibit 6.10: Algorithm for calculating the kilometres of trenches employing or not ducts in the access network [Source: Axon Consulting]

The kilometres of buried cable are equal to the kilometres of trenches, being eventually disaggregated between trenches employing or not ducts. The percentage of routes that are buried employing ducts is different for each network section.

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

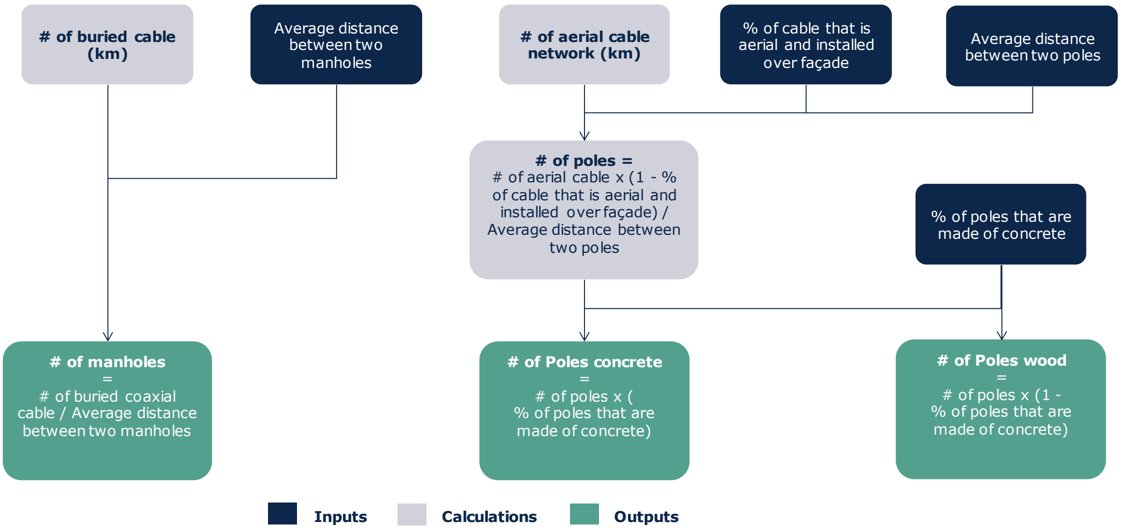


Exhibit 6.11: Algorithm for calculating the number of manholes and poles in the secondary network [Source: Axon Consulting]

Similar to the trenches and ducts, the parameters employed to calculate the manholes and poles are specific for each network section. The average distance between manholes and poles are used to divide the total cable length per network section, resulting in the number of manholes and poles in each section. Finally, the poles are disaggregated between concrete and wood poles.

5. Number of coaxial amplifiers and splitters

The total kilometres of coaxial cable (secondary and primary) are used in order to obtain the number of coaxial amplifiers and splitters:

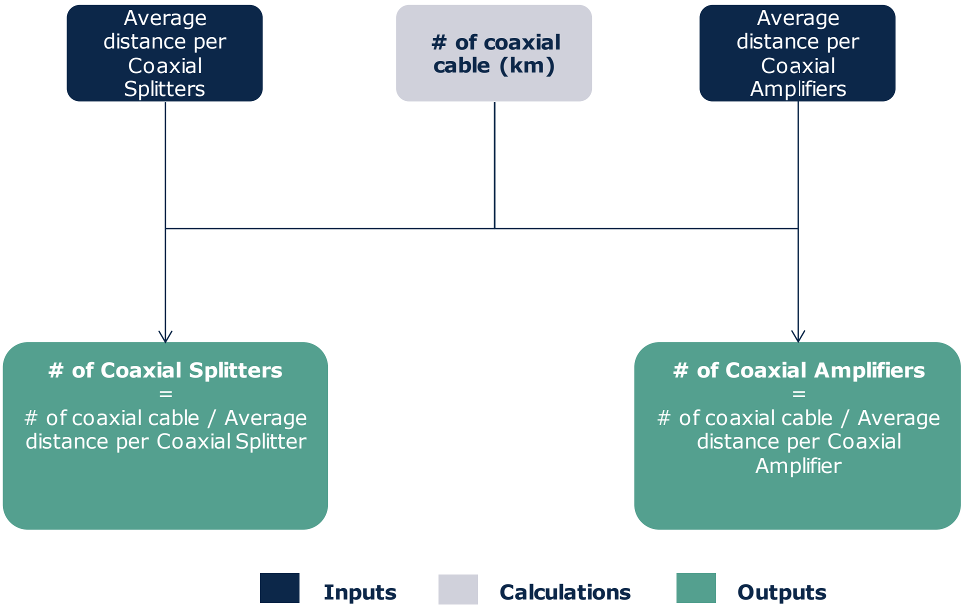


Exhibit 6.12: Algorithm for calculating the number of coaxial amplifiers and splitters in the network [Source: Axon Consulting]

The total number of coaxial splitters and amplifiers is calculated by dividing the total kilometres of coaxial cable by the average distance between two same elements of each specific component.

6.1.2. **Dimensioning of the access network equipment**

The access network elements comprise the network components found in a coaxial cable network:

- Distribution Points (DPs).
- Optical Nodes (ONs).
- Local Headends (LHs), which contains the CMTS and QAM equipment.

The calculation of access network elements is performed as indicated in the following chart:

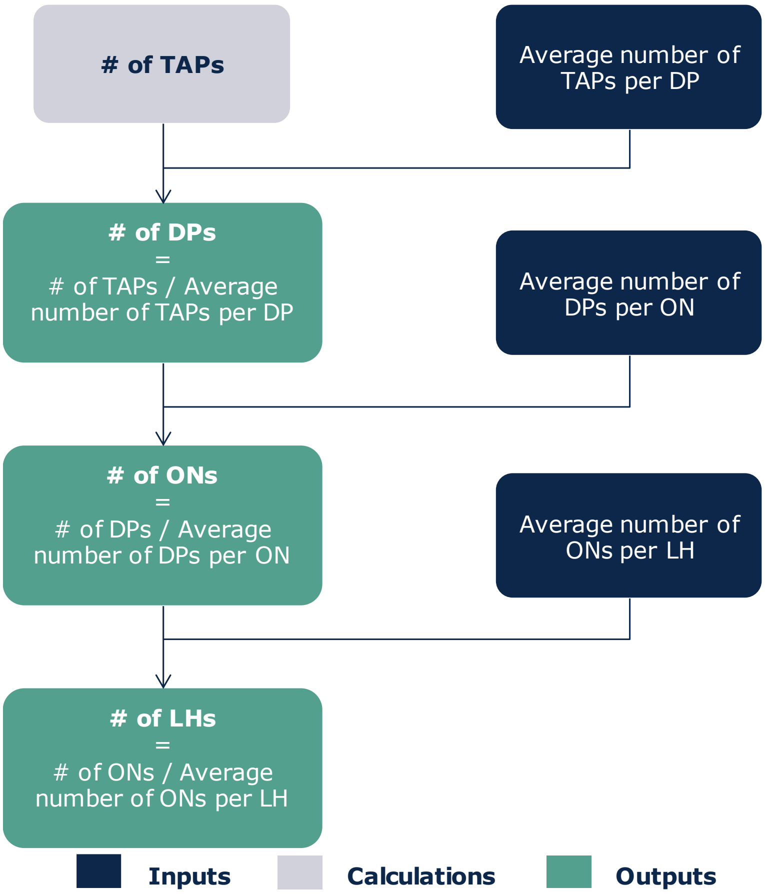


Exhibit 6.13: Algorithm for calculating number of access network elements [Source: Axon Consulting]

As it can be observed in the previous 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 number of CMTS and QAM (active equipment) components are calculated considering their typical configurations in terms of line cards:

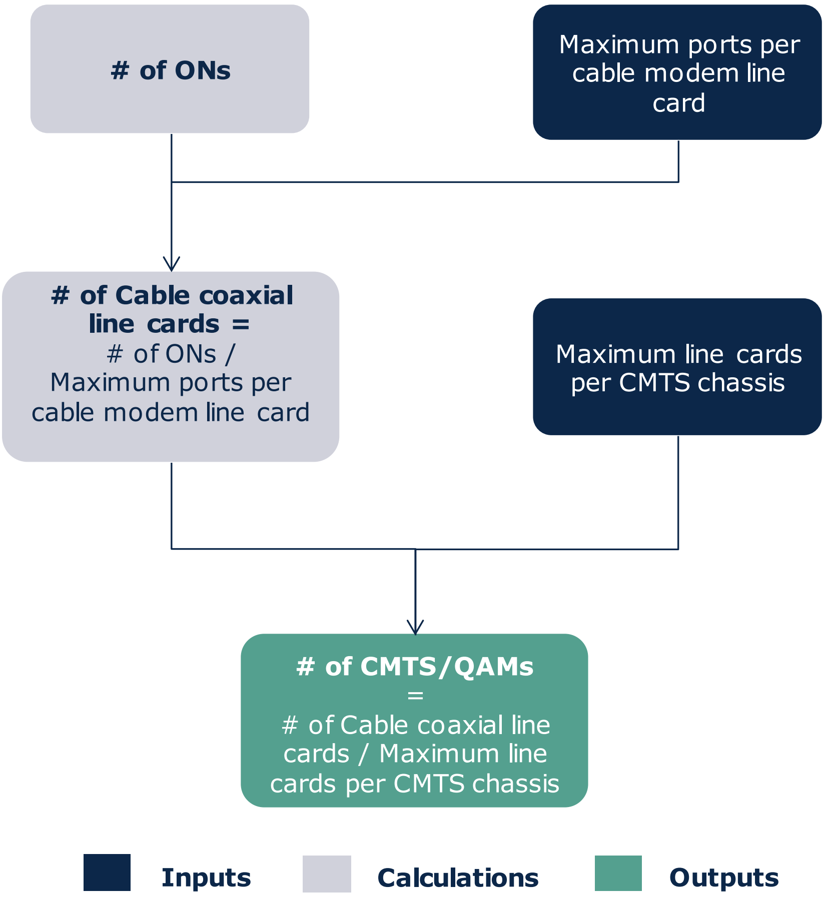


Exhibit 6.14: Algorithm for calculating the number of CMTS and QAMs [Source: Axon Consulting]

The number of CMTS is equal to the number of QAMs (it is assumed that one unique device includes both functionalities).

6.2. **Transmission Network Dimensioning (geotype independent)**

The Transmission module is responsible for dimensioning the required interconnections of equipment that occur between the access and core network. This module dimensions all the links from the Local Nodes (located in the Local Headends) to the Core Nodes, as well as the connections in between these. This process is performed at the beginning (block 1) of the worksheet '7A CALC DIM CORE´ of the Model.

The transmission network modelled may be divided in two different steps, depending on the network elements that are linked, as described below:

- *Local Node – Core Node*: This part of the network connects the Local Nodes with the Core Nodes of the operators.
- *Core Node – Core Node*: Represents the connections in between the Core Locations of the operators.

According to the reality of Belgian operators, ring topologies have been considered for the network connections. An illustrative representation of the transmission network considered is provided in the exhibit below:

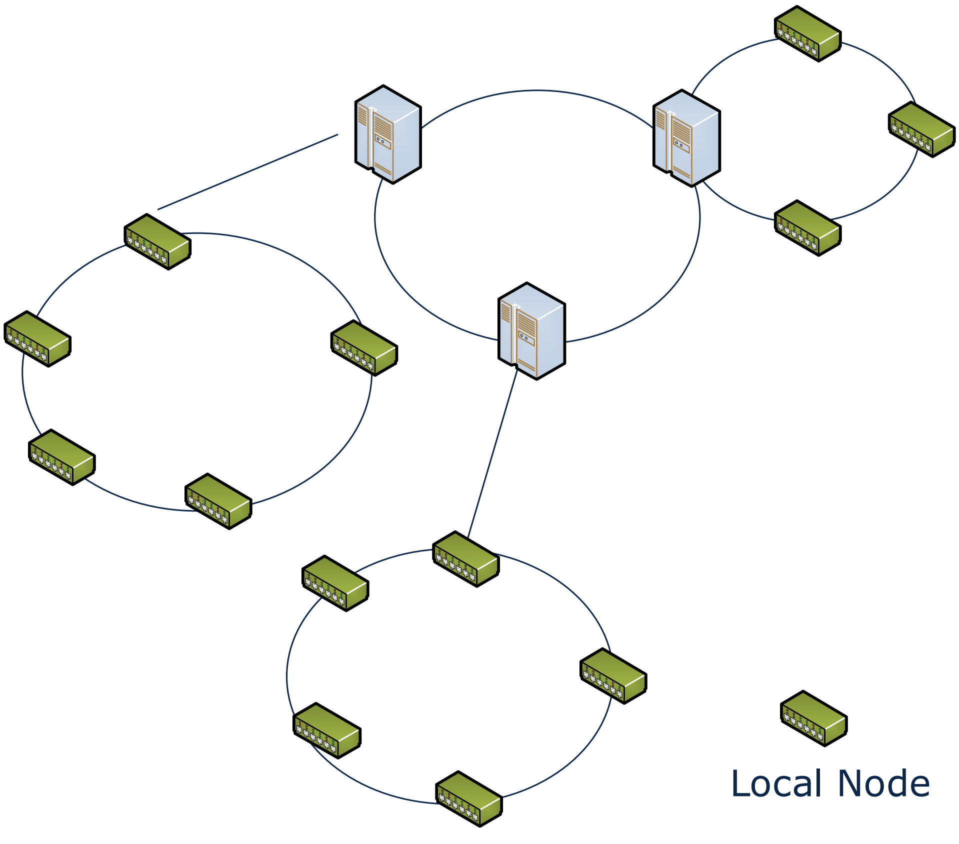


Exhibit 6.15: Overview of the general architecture considered in the transmission network [Source: Axon Consulting]

The dimension of the transmission links has been optimised taking into consideration the position of the operators' network elements. Specifically, information provided by operators have been taken to determine the different rings in the country in terms of length.

The dimensioning of the transmission links considers three different technologies (Fibre DWDM, Fibre Ethernet and Microwaves), and selects the cheapest alternative available that is able to handle the link's traffic. It is also worth noting that at the present time, no Microwaves links are being employed by Belgian operators, reason why the availability of this type of links in the Model has been set to zero.

The percentage of traffic that will circulate through each link is introduced based on the percentage of active premises for which the associated traffic will need to circulate through that link.

The dimensioning algorithm that has been followed in the dimensioning of the transmission network is organised into four steps as shown below:

Step 1. Calculation of Local Nodes– Core Nodes links

Step 2. Calculation of Core Nodes– Core Nodes links

Step 3. Determination of the number of Routers required

Step 4. Calculation of additional trenches for the transmission network

Exhibit 6.16: Steps for Transmission Network Dimensioning [Source: Axon Consulting]

6.2.1. **Step 1. Calculation of Local Nodes - Core Nodes links**

As a first step, the Model calculates the number of links that would be required under each technology, based on their bitrate. Knowing the number of links required, the Model then calculates their associated costs, and selects the most cost-efficient alternative among those available, as shown in the illustration below:

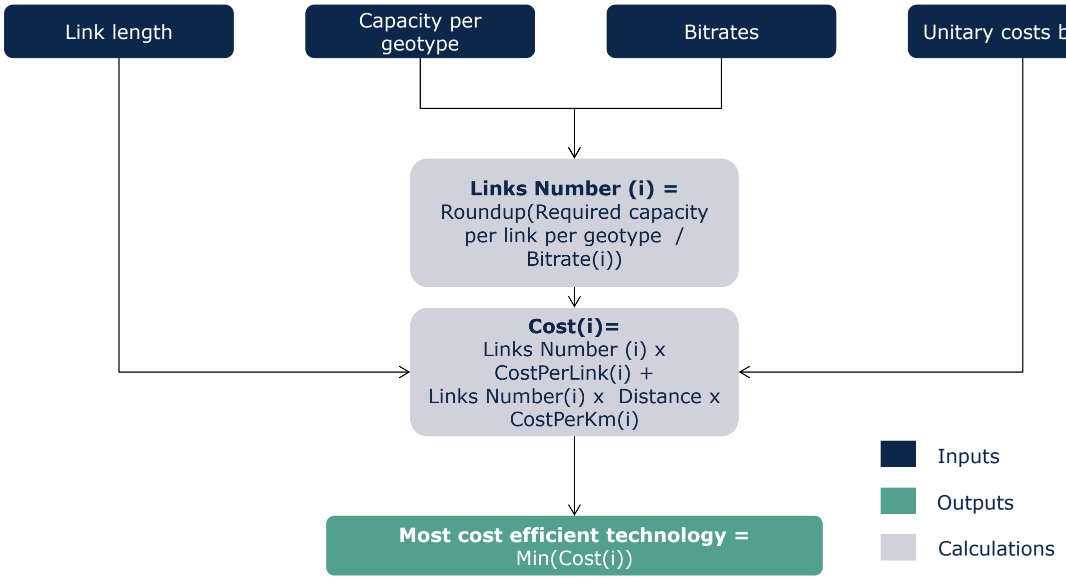


Exhibit 6.17: Calculation of the optimum configuration of links. [Source: Axon Consulting]

Please note that the technology selected in the algorithm presented above may not be possible to use it for all the sites due to technical issues. These conditions are taken into account as per operators' indications in the data gathering process.

For that reason, the cheapest technology in each link is chosen and, applying the availability factor for that technology, the percentage of links of each type that will be possible to use is determined. The procedure is then repeated for each technology, in order of economic efficiency until all links are covered.

The figure below illustrates the calculation algorithm:

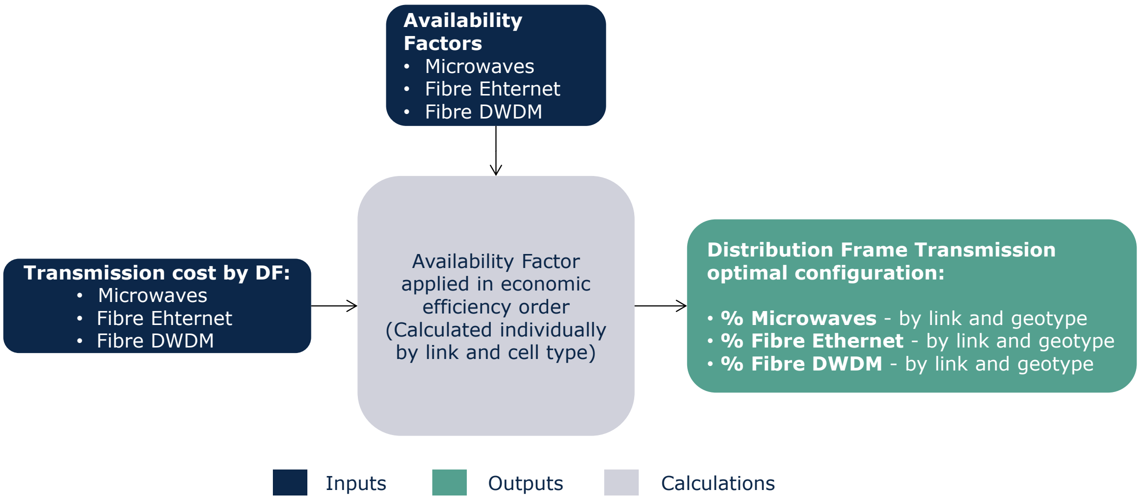


Exhibit 6.18: Optimal Transmission Network Determination [Source: Axon Consulting]

6.2.2. **Step 2. Calculation of Core Nodes– Core Nodes links**

Step 2 calculates the transmission links required to interconnect Core Nodes with Core Nodes.

The calculations performed in this step are equivalent to those underlined in Step 1, except that the taken inputs correspond to the Core Nodes to Core Nodes links.

6.2.3. **Step 3. Determination of the number of Routers required**

This step calculates the number of routers required in the transmission and core networks. This number of routers is highly dependent on the number of links calculated in the previous steps, specifically the number of ports required in each transmission section.

Firstly, the number of Core Routers is calculated using the number of facing and exit ports employed in the Core to Core Nodes links.

The number of facing and exit ports of the core nodes is obtained in the previous steps.

The exhibit below provides the calculation algorithm that has been employed for calculating the number of core routers required:

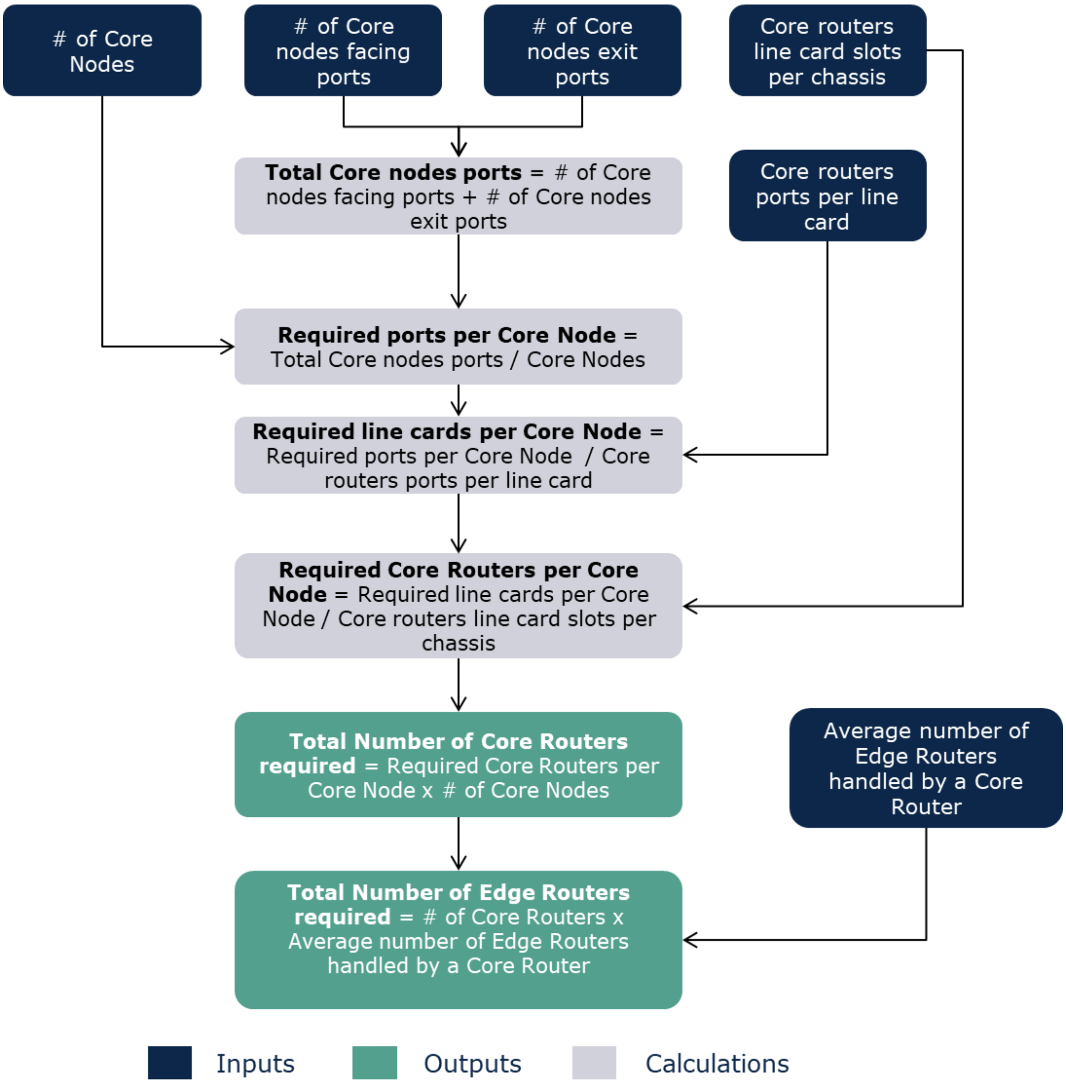


Exhibit 6.19: Algorithm employed to calculate the number of Core Routers required [Source: Axon Consulting]

As can be observed, from the number of core ports, the number of line cards is obtained that results in a total number of core routers (chassis). Finally, the capacity of core routers is used to calculate the number of edge routers.

6.2.4. Step 4. Calculation of additional trenches for the transmission network

This step presents the calculation of the additional kilometres of trenches that are required in the transmission network. The calculation performed considers each of the two different network sections considered in the transmission network:

- Links from the Local Node to the Core Node
- Links from Core Node to Core Node

The exhibit below illustrates the algorithm used to calculate these additional trenches that need to be deployed.

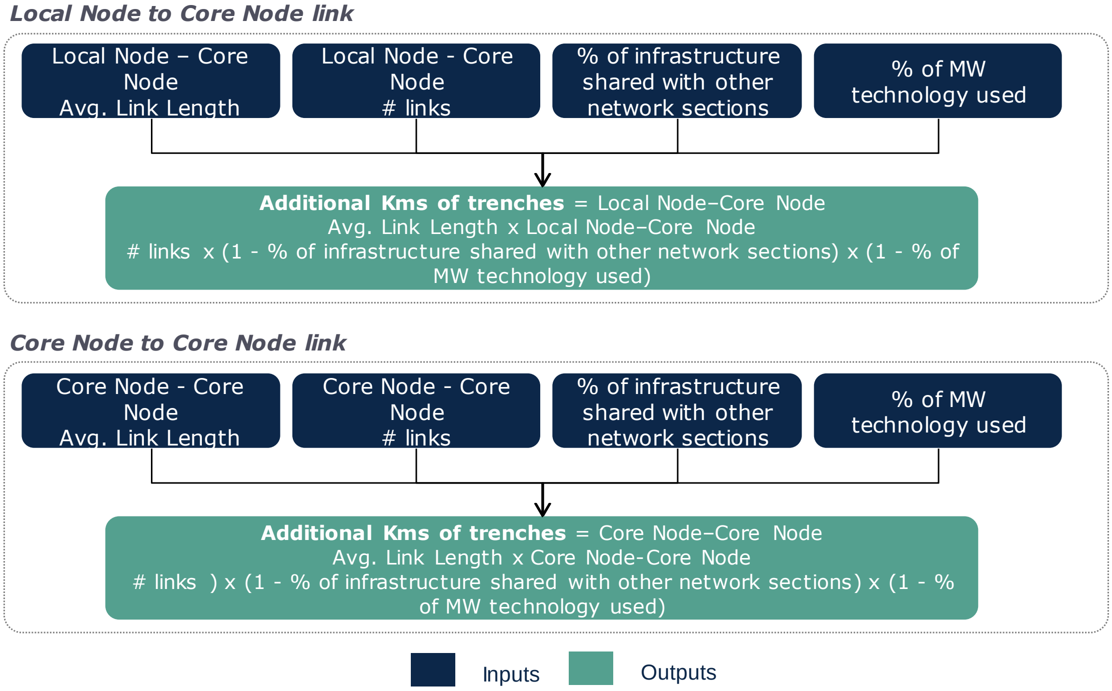


Exhibit 6.20 Calculation of additional trenches to be deployed per link type [Source: Axon Consulting]

6.3. Core Network Dimensioning (geotype independent)

The Core Network Dimensioning module is responsible for the dimensioning of the Core Equipment, dealing with the central network management. This process is performed at the end (block 2) of the worksheet '7A CALC DIM CORE´ of the Model.

The model considers an NGN core network, which represents the MEA of traditional fixed networks. In that context, NGN core network is able to provide all retail and wholesale services currently sold by operators. However, it is important to note that specific voice platforms, not being the results of voice services under the scope of this Model, have not been modelled. The following network elements have been modelled:

- **HSS (Home Subscriber Server)**: Responsible for storage of various kinds of subscriber-related data, including authentication credentials, details of services subscribed. The number of units has been limited by the nominal capacity in terms of subscribers:

$$HSS\ Number \geq \frac{Total\ Connections\ (Subs))}{Technical\ Constraint\ (Subs)}$$

- **BRAS (Broadband Remote Access Server)**: Responsible for aggregating user sessions from the access network to Internet. The number of units has been limited by the nominal capacity in terms of broadband users connected simultaneously:

$$BRAS\ Number \geq \frac{Total\ \text{Simulaneous}\ Connections\ (Subs))}{Technical\ Constraint\ (Subs)}$$

- **RADIUS (Remote Authentication Dial-In User Service):** Provides authentication and authorization remote services to handle the usage of a network resource by the users. The number of units has been limited by the nominal capacity in terms of broadband users connected simultaneously:

$$RADIUS\ Number \geq \frac{Total\ \text{Simulaneous}\ Connections\ (Subs))}{Technical\ Constraint\ (Subs)}$$

- **DNS (Domain Name System):** Responsible for translating domain names to numerical IP addresses. The number of units has been limited by the nominal capacity in terms of broadband users connected simultaneously:

$$DNS\ Number \geq \frac{Total\ \text{Simulaneous}\ Connections\ (Subs))}{Technical\ Constraint\ (Subs)}$$

- **VoD Server (Video On-demand Server):** Provides customized video contents under user requests. One VoD Server unit has been modelled provided that the number of core connections are not zero.
- **Analog TV Platform:** Responsible for processing, modulating and coding the TV analogue signal before its transmission. One Analogue TV Platform unit has been modelled provided that the number of Analogue TV connections is not zero.
- **Digital TV Platform:** Responsible for processing, modulating and coding the TV digital signal before its transmission. One Digital TV Platform unit has been modelled provided that the number of Digital TV connections is not zero.

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.

Step 1. Determination of unit costs of Resources and application of trends

Step 2. Calculation of Resources acquisition

Step 3. Calculation of annual CAPEX and OPEX

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 current year. This information is introduced in the worksheet `1E 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 `1F 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.

$$Unit\ Cost\ (year) = Unit\ Cost\ (year - 1) * \left(1 + Trend\ (year)\right)$$

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 they will be excluded from the model's results. This calculation is performed in the worksheet `4A CALC UNIT CAPEX CONSOL´ of 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:

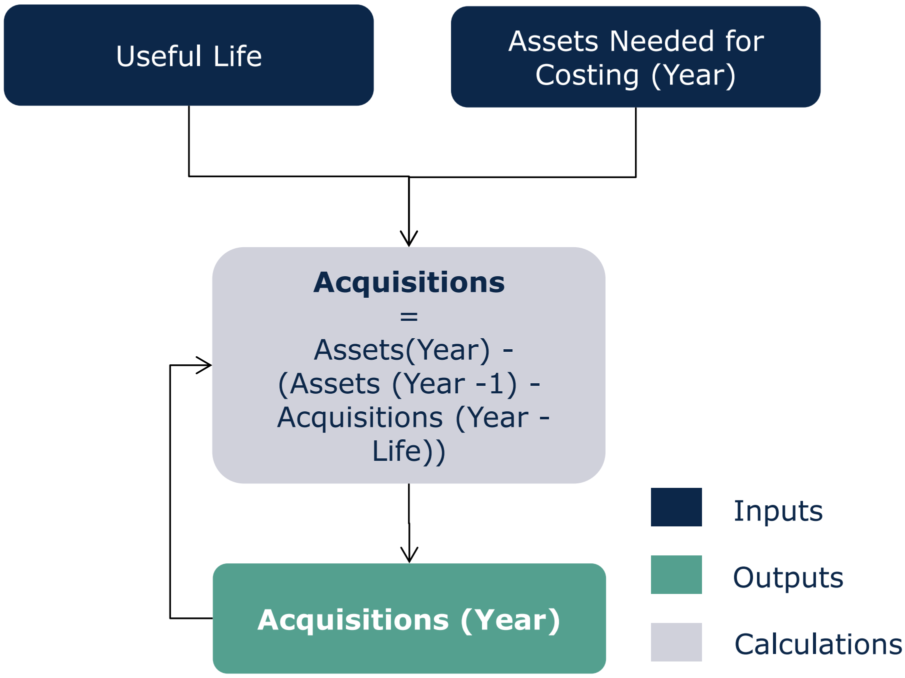


Exhibit 7.2: Algorithm for the Calculation of New Acquisitions [Source: Axon Consulting]

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

- **Network deployment:** The roll-out of new or existing technologies, or the acquisition of new equipment for increasing the capacity, 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 Annual 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 annual CAPEX (before annualized) and OPEX follows the algorithm:

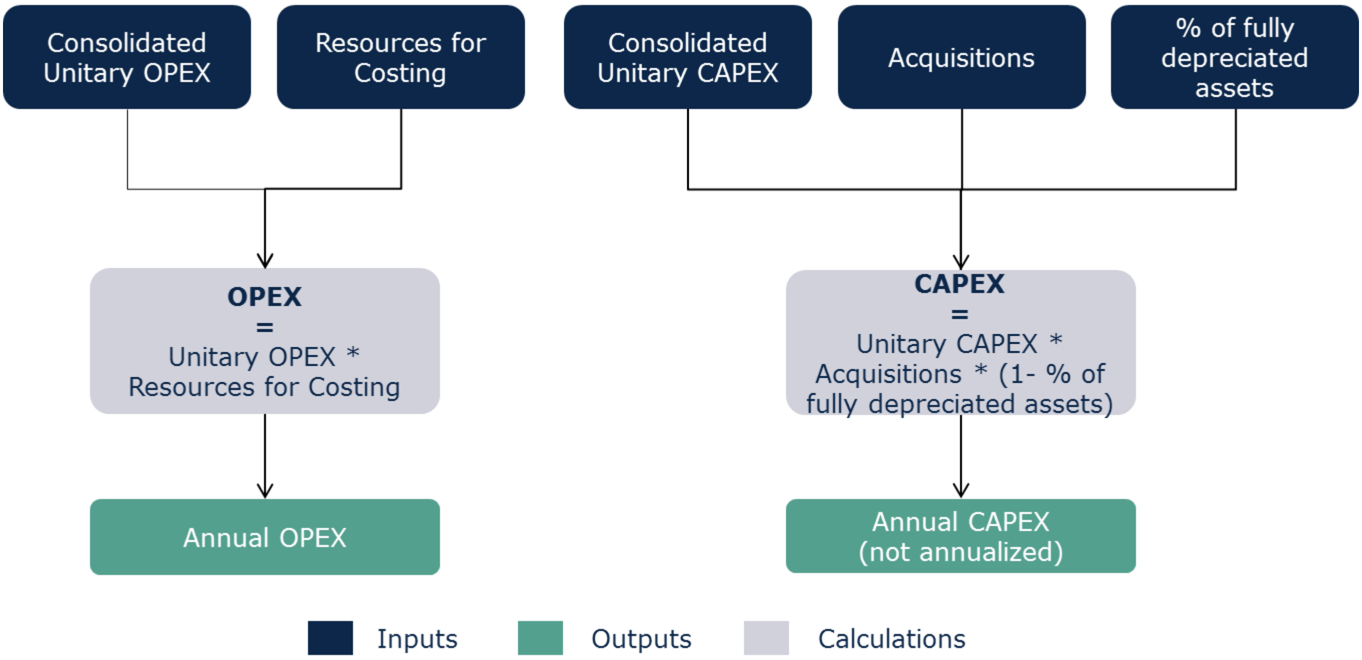


Exhibit 7.3: Algorithm for the Calculation of the Annual CAPEX and OPEX [Source: Axon Consulting]

8. Depreciation Module

The Depreciation Module aims at distributing CAPEX over the years (annualisation). The Economic Depreciation method is considered in the model.

The objective of economic depreciation 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 in 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 investment associated to the asset
- 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
- $\boldsymbol{\alpha_i}$ 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), vi 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'), two increments have been defined: Access and Conveyance. Services are then assigned to this increment in Sheet '0A PAR SERVICES'.

Once incremental costs are calculated for these two increments 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:

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

In the model, resources' incremental costs are calculated in sheet '9C CALC RES COST CONSOL' while common costs are shown in sheet '11A 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' Traffic
- Step 2. Cost allocation to services based on such combination

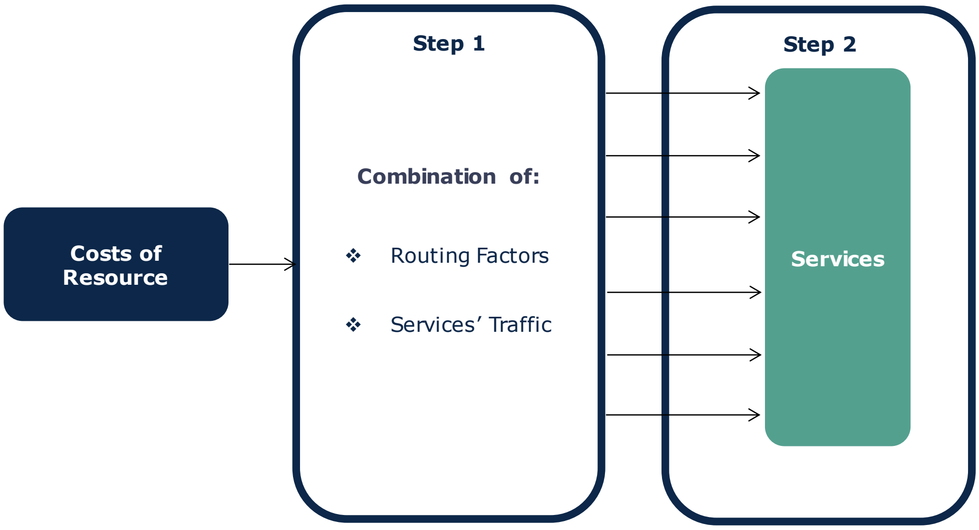


Exhibit 9.1: Cost Imputation Process using Routing Factors [Source: Axon Consulting]

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' Traffic

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 traffic generated by the service itself, and to a "factor of use", the Routing Factor. Hence, the more traffic 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)	Service CATEGORY	Service SUBCATEGORY	Service SEGMENT	Service DESCRIPTION	Routing Factor
Network Building Unit	Access	Cable	Retail	Access	1.00
Network Building Unit	Access	Cable	Wholesale	Access	1.00
Access Cable Cabling	Access	Cable	Retail	Access	1.00
Access Cable Cabling	Access	Cable	Wholesale	Access	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:

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

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
- Traffic (i, year) is the traffic 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 `10B CALC SERV INCR COST´ and, 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 that have been included in the BULRIC Model for HFC networks.

- **Access services**: These services provide access to the customers from their households/dwellings to the operator's Local Headend.
  - **'Access.Cable.Retail.Access':** Provision of a coaxial cable line to an end customer. Its unit cost is comprised of the cost of the access network, from the customer premise up to the access nodes (until the Local Headend, and including the cost of the CMTS). Please note that the conveyance of the traffic generated by the subscriber is included in other services such as broadband, TV or leased lines services.
  - **'Access.Cable.Wholesale.Access':** Wholesale service which is in terms of network costs equivalent to its analogous retail service (excluding the cost related to the HSS platform) and will be resold by a Requesting Party.
- **Broadband services**: Services that include the costs of providing broadband services. These services include the costs of the transmission and applicable core equipment. Please note that these services are not including access network related costs (described above) but only the costs for conveying data traffic. These services are disaggregated by type of service and maximum download throughput as follows:
  - **Retail Services:** Including the costs associated to the transmission of the broadband traffic of a retail customer from the access nodes (Local Headends) up to the Internet[3]:
    - **'Broadband.Broadband.Retail.25 Mbps'**
    - **'Broadband.Broadband.Retail.50 Mbps'**
    - **'Broadband.Broadband.Retail.75 Mbps'**
    - **'Broadband.Broadband.Retail.100 Mbps'**
    - **'Broadband.Broadband.Retail.125 Mbps'**
    - **'Broadband.Broadband.Retail.150 Mbps'**
    - **'Broadband.Broadband.Retail.200 Mbps'**
    - **'Broadband.Broadband.Retail.300 Mbps'**
    - **'Broadband.Broadband.Retail.500 Mbps'**

[3] It is worth noting that the cost of the international connectivity to Internet is not included.

- **Wholesale Services (Bitstream):** Including the costs associated to the transmission of the broadband traffic associated to a Requesting Party's customer from the access node (Local Headend) up to the point where the traffic is interconnected to the Requesting Party:
  - **'Broadband.Broadband.Wholesale.Bitstream 25 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 50 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 75 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 100 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 125 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 150 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 200 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 300 Mbps'**
  - **'Broadband.Broadband.Wholesale.Bitstream 500 Mbps'**
- **'Broadband.Broadband.Wholesale.Local Ethernet Transport'.** Broadband service provided with an uncontended (dedicated) capacity in the network through an Ethernet connection at local level. The cost only includes the network cost associated to the transmission network.
- **'Broadband.Broadband.Wholesale.Regional Ethernet Transport'.** Broadband service provided with an uncontended (dedicated) capacity in the network through an Ethernet connection at regional level. The cost only includes the network cost associated to the transmission/core networks.
- **'Broadband.Broadband.Wholesale.National Ethernet Transport'.** Broadband service provided with an uncontended (dedicated) capacity in the network through an Ethernet connection at national level. The cost only includes the network cost associated to the transmission /core networks.

- **'Voice.Voice.Retail.Voice traffic'.** This service includes the cost of conveying voice traffic through the fixed network. The cost is associated to the conveyance of the voice traffic in the transmission/core network, without including the access service (see above) which is required to be able to provide this service.

- **Europacket Cable.Cable.Wholesale.EPC of equivalent QoS feature.** This service includes the cost of conveying voice traffic by means of a dedicated channel according to the protocol Europacket cable. The cost is associated to the conveyance of the voice traffic in the transmission/core network, without including the access service (see above) which is required to be able to provide this service.

- **TV services:** These services include costs of conveying TV traffic.

- **'TV.TV.Retail.TV - SD channel'.** This service represents the cost of transmitting one SD channel through the network. The cost is associated to the transmission of TV traffic and the usage of TV platforms in the transmission/core networks.
- **'TV.TV.Retail.TV - HD channel'.** This service represents the cost of transmitting one HD channel through the network. The cost is associated to the transmission of TV traffic and the usage of TV platforms in the transmission/core networks.
- **'TV.TV.Retail.Analogue TV - Channel'**. This service represents the cost of transmitting one analogue channel through the network. The cost is associated to the transmission of TV traffic and the usage of TV platforms in the transmission/core networks.
- **'TV.TV.Retail.Radio - Channel'.** This service represents the cost of transmitting one radio channel through the network. The cost is associated to the transmission of TV traffic and the usage of TV platforms in the transmission/core networks.
- **'TV.TV.Retail.VoD - Channel'.** This service represents the cost of transmitting VoD channels through the network. The cost is associated to the transmission of TV traffic and the usage of TV platforms in the transmission/core networks.
- **'TV.TV.Wholesale.TV - SD channel'.** Analogous service to the retail one in terms of unit cost. This service is sold to other operator or company.
- **'TV.TV.Wholesale.TV - HD channel'.** Analogous service to the retail one in terms of unit cost. This service is sold to other operator or company.
- **'TV.TV.Wholesale.Analogue TV - Channel'.** Analogous service to the retail one in terms of unit cost. This service is sold to other operator or company.
- **'TV.TV.Wholesale.Radio - Channel'.** Analogous service to the retail one in terms of unit cost. This service is sold to other operator or company.
- **'TV.TV.Wholesale.VoD - Channel'.** Analogous service to the retail one in terms of unit cost. This service is sold to other operator or company.
- **'TV.TV.Retail.TV Line - Analogue'.** KPI that represents the cost per customer of transmitting TV analogue traffic.
- **'TV.TV.Retail.TV Line - Digital'.** KPI that represents the cost per customer of transmitting TV digital traffic (including both SD and HD channels).
- **'TV.TV.Wholesale.TV Line - Analogue'.** Analogous service to the retail one in terms of unit cost. The same network cost is applicable.

- **'TV.TV.Wholesale.TV Line - Digital'.** Analogous service to the retail one in terms of unit cost. The same network cost is applicable.

- **Leased lines**: Services offered to companies or other network operators which provide them with an uncontended (dedicated) capacity in the network:
  - **'Leased Lines.Leased Lines.Retail.Local Ethernet Transport'.** Leased line service provided with an uncontended (dedicated) capacity in the network through an Ethernet connection at local level. The cost only includes the network cost associated to the transmission network.
  - **'Leased Lines.Leased Lines.Retail.Regional Ethernet Transport'.** Leased line service provided with an uncontended (dedicated) capacity in the network through an Ethernet connection at regional level. The cost only includes the network cost associated to the transmission /core networks.
  - **'Leased Lines.Leased Lines.Retail.National Ethernet Transport'.** Leased line service provided with an uncontended (dedicated) capacity in the network through an Ethernet connection at national level. The cost only includes the network cost associated to the transmission /core networks.
  - **'Leased Lines.Leased Lines.Wholesale.Local Ethernet Transport'.** Analogous service to the retail local leased lines in terms of unit cost. The service is offered to other network operators.
  - **'Leased Lines.Leased Lines.Wholesale.Regional Ethernet Transport'.** Analogous service to the retail regional leased lines in terms of unit cost. The service is offered to other network operators.
  - **'Leased Lines.Leased Lines.Wholesale.National Ethernet Transport'.** Analogous service to the retail national leased lines in terms of unit cost. The service is offered to other network operators.

- **Ancillary services and other services.**
  - **'Ancillary.Ancillary.Retail.Consumption fee for exceeding monthly basic volume'.** The service includes the extra cost incurred by the retail customers for exceeding the monthly consumption limit. In terms of unit cost, it represents the cost associated to the transmission /core networks.
  - **'Ancillary.Ancillary.Wholesale.Consumption fee for exceeding monthly basic volume'.** The service includes the extra cost incurred by the wholesale customers from other network operator for exceeding the monthly consumption limit. In terms of unit cost, it represents the cost associated to the transmission/core networks.

  - **'Ancillary.Ancillary.Wholesale.1 GE Port'.** This wholesale service comprises the cost associated to the usage of 1 Gigabit Ethernet Port in the transmission network.
  - **'Ancillary.Ancillary.Wholesale.10 GE Port'.** This wholesale service comprises of the cost associated to the usage of a 10 Gigabit Ethernet Port in the transmission network.
  - **'Ancillary.Ancillary.Wholesale.100 GE Port'.** This wholesale service comprises of the cost associated to the usage of a 100 Gigabit Ethernet Port in the transmission network.

- **Other supporting services:** includes a list of services which are employed for the costing of the rest of above listed services (equivalent to KPIs that are required), and which are:

  - **Broadband.Broadband.Retail.Lines (not for costing).** It includes the total number of broadband lines associated to retail customers. This supporting service is employed to calculate the cost of some core platforms that are assigned to the broadband services listed previously.