

DETAILED VERSION  
Margin squeeze test for fibre based  
wholesale services in the Norwegian  
User manual  
Market 5

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## 1 Introduction

WIK Consult (WIK) has been assigned by the Norwegian Communications Authority (Nkom) to deliver an Excel based margin squeeze test (MST) for the Norwegian fibre based Market 5. This model is based on principles, which are described in a separate document called ‘Principles for margin squeeze tests for fibre access in Market 5’.

For public reference, this document describes the structure of the test and how to use the main functions. Both the principle document, the MST and this document have been sent for consultation with the Norwegian telecom industry.

WIK collected data from Telenor Norge AS (Telenor) and the most relevant Norwegian alternative operators to design and populate the model. The collected confidential data is removed from the model and consolidated in a separate data consolidation sheet. This allows Nkom to consult on the model and manual without disclosing confidential information.

The model is property of Nkom, however, it is developed by WIK and provided by WIK on the condition that it shall not be reproduced, copied, lent or disclosed, directly or indirectly, nor used for any other purpose except for investigations in the Norwegian fibre market. It should not be used outside this scope without prior notice and authorization from Nkom.

The structure of the document is as follows:

- Chapter 2 describes the main components of the model.
- Chapter 3 describes how to update the model.

## 2 Structure of the model

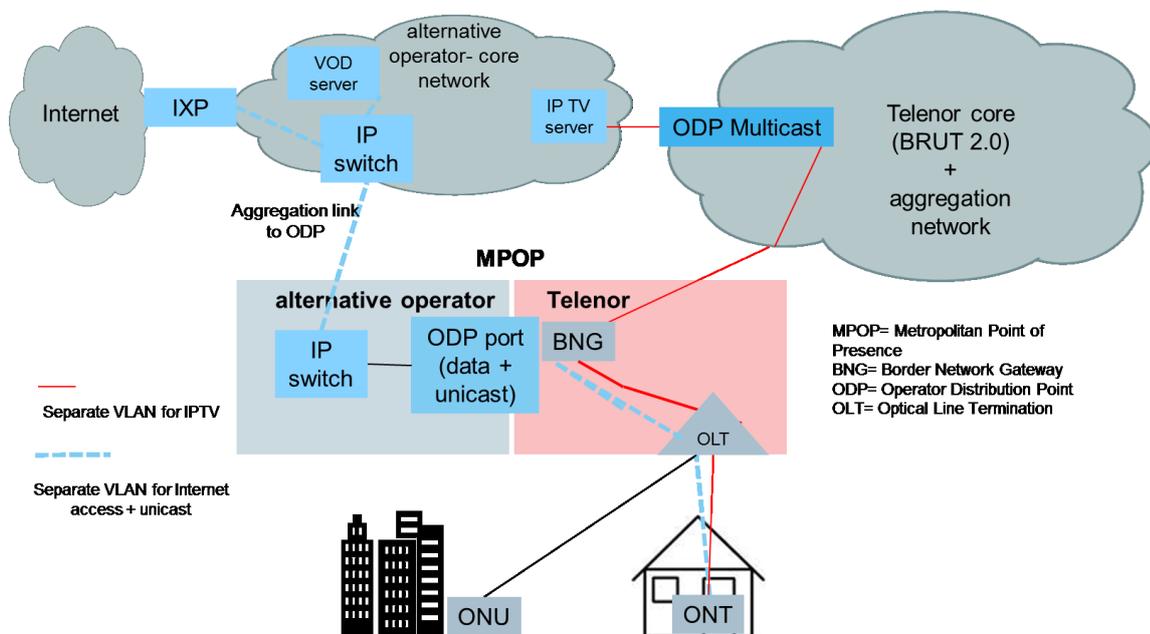
In the following paragraphs, first the modelled network components are described. Thereafter, descriptions and diagrams of the main components of the model follow.

### 2.1 Schematic overview of the modelled network

The majority of Telenor's fibre network is based on GPON. An alternative operator can reach end customers on Telenor's fibre network using the VULA wholesale service. For this purpose it has to connect to the handover points for VULA (called ODPs)

Figure 1 graphically displays the network access option of the alternative operator and the network components involved.

Figure 1 Wholesale access to GPON customers



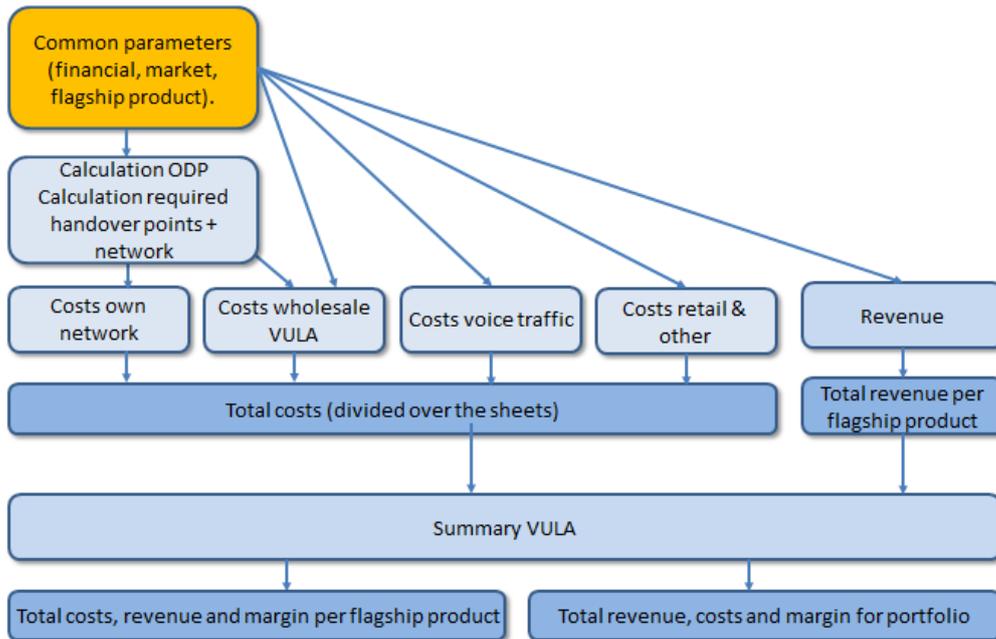
Required equipment for the alternative operator in each ODP point is an IP-switch with sufficient capacity at the ODP port to support its predicted internet and Video on demand (unicast) traffic. Multiple MPOPs can be connected via one ODP.

The aggregation links connect the ODPs to the alternative operator's core network. The internet traffic is routed to the internet exchange (IXP), the Video on demand (VOD) traffic to the VOD server. Furthermore, the IPTV server is located in the core network, however this traffic is routed via the national handover point for multicast and thereafter routed via Telenor's network to the end customer.

## 2.2 Summary of the model

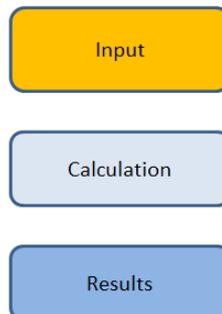
The MST is built in Excel and consists of 8 spreadsheets, which correspond with the pictured components in the overview below.

Figure 2: Overview of the MST for the fibre market in Norway



The color coding in the diagrams in this manual is in line with the color coding used in the tool.

Figure 3: Color coding in diagrams



## 2.3 Description of the tool components

The 8 spreadsheets out of which the model consists, are further described in the following table.

Table 1 Spreadsheets of the MST

Spreadsheet name	Function
Common parameters	Input for the main parameters (WACC, common costs, market share of the alternative operator in homes connected, total available current GPON customers, flagship product details, dimensioning, price information and regulated voice charges).
VULA Margin	Collection of all costs and revenues per flagship product and for the complete portfolio of flagship products based on the VULA wholesale service. Calculation of the resulting margin.
Revenue	Input of retail revenue parameters (monthly and one time retail charges, traffic profiles per flagship product, retail set up and minute prices). Calculation of monthly revenue per subscriber on subscription, voice and IPTV bundles where applicable.
Wholesale VULA costs	Input of wholesale charges for VULA (monthly and one time subscriber charges, costs ODP handover points and costs national multicast handover point). Calculation of total subscriber, ODP and multicast charges and distribution over the flagship products.
Own network costs	Input of core network costs, required investment for the multicast server in the core network and related link to the multicast hand over point, IP transit costs and CPE costs. Calculation of total core network costs, total costs multicast setup, total IP transit costs, required equipment at all ODP sites, total costs aggregation links and total CPE costs.
Voice traffic costs	Input: actual voice minutes, average termination costs on regulated destinations. Calculation of voice termination costs in other networks and costs of producing voice traffic in the own network of the modelled operator.
Retail and other costs	Input: retail and other costs (regulatory fees and retail order cancellation costs). Calculation of retail and other costs per flagship product.
Calculation ODP	Input: list with the current handover points for VULA, and the related connected GPON customers, additional dimensioning rules for the required ODP ports, IP switch and line card details and required rack space. First, calculation of estimated number of customers for the modelled operator distributed over the different ODP points and per flagship product. Second, calculation of required capacity per ODP point and resulting ODP equipment and aggregation. Third, calculation of required capacity in the core network.

## 3 Detailed description of the model components

### 3.1 Common parameters

The ‘Common parameters’ sheet contains the input fields for main parameters (WACC, common costs, market share, total GPON connected customers available on Telenor’s network, flagship product details, dimensioning, price information and regulated voice charges). These parameters are used in multiple sheets, so the centralized update ensures consistency and prevents mistakes. It also gives the ability to quickly change certain essential parameters to see the impact on the end results.

### 3.1.1 WACC and applied capital cost factor

As the model is a static steady state model, one time revenues, charges, costs or investments need to:

- be spread over the relevant lifetime (customer lifetime or asset lifetime).
- respect capital cost through the applied Weighted Average Cost of Capital (WACC),
- be corrected depending on their moment of occurring; charges applied at the end of the customer lifetime are discounted first to the current moment and then spread over the relevant customer or asset lifetime.

All calculations in the model are put on a „per month“ scale and the model applies the *capital cost factor* to transform an investment or an onetime charge at the current moment into a monthly cost. The capital cost factor is multiplied with the capital value at the current moment and is calculated according to the following formula:

$$\frac{WACC}{\left(1 - \frac{1}{1 + WACC}\right)^{lifetime}}$$

The relevant capital cost is determined on the basis of the WACC, which represents the relevant cost of capital of the competitor's retail business. For the purpose of the monthly calculations, the yearly WACC is translated into a monthly WACC and then applied in the capital cost factor formula.

The capital cost factors are calculated in the tool for the different retail products within the portfolio as lifetime could be different per product. They can be found in the calculation parts of the sheet, where first the investments or one-time charges are calculated and then converted into monthly amounts. The same principle applies to the different assets.

### 3.1.2 Common costs

Operators have provided absolute amounts of common costs for their fibre related customers/business. Therefore, common costs are expressed as % of the total fibre related revenue. In the sheet 'Retail and other costs', the tool calculates the total considered retail revenue and then the absolute common costs, which are further distributed among the relevant flagship products.

### 3.1.3 Share of available Telenor fibre connections

The share of available Telenor fibre connections describes the assumed size of the modelled alternative operator. It is applied to the available fibre connections on Telenor's GPON network. The total addressable market is determined by the number of connected GPON homes in Telenor's network at ODP's with more than 1000 connections.

### 3.1.4 Subscriber number GPON

The model works with the current spread of connected GPON homes over the different handover points (ODP) in Telenor's network and the total forecasted number of connected homes. The most up to date spread of Telenor's fibre connected homes is used as input in the sheet 'Calculation ODP'. The total forecasted / available connected customers on the GPON network of Telenor can be inserted in the sheet 'Common parameters'. This field is intended to give Nkom the flexibility to either use the current total or an (forecasted) average over the regulation period or whatever value seems realistic based on the real fibre roll out of Telenor.

### 3.1.5 Flagship products

Based on the latest market figures, the flagship products are identified as described in the principles document. The names and further details of the identified flagship products on the GPON network of Telenor are then used as input in the sheet.

### 3.1.6 Weight factors

Based on the current subscriber numbers for the flagship products of Telenor, weight factors are calculated, which determine the importance of each flagship product in the portfolio. The weight factors are used in the sheet 'Calculation ODP' to distribute the total estimated subscribers of the modelled alternative operator over the flagship products.

### 3.1.7 Customer lifetime flagship products

The customer lifetime is used to spread the one time revenue and charges via the capital cost factor, so we can evaluate the monthly margin. Hence this impacts the importance of the one-time revenue and charges. The model is constructed in such a way that per flagship product a different customer lifetime can be used.

Telenor has calculated the customer lifetime expressed in months of their fibre based and copper based broadband products by using the yearly cancellation numbers of 2014 and expressing these as a percentage of the total customer base of 2014. Expressed as formula, this is:

$$\frac{1}{\left(\frac{\text{yearly cancellations 2014}}{\text{total subscribers 2014}}\right)} \times 12 \text{ months}$$

### 3.1.8 Dimensioning information

Dimensioning information is required to estimate the capacity for the:

- core network, transporting internet traffic, VOD and voice;
- aggregation network, linking the ODP to the alternative operator's core network; and
- capacity at each connected ODP in terms of equipment and ODP port size.

The detailed dimensioning ODP/MPOP is calculated in sheet 'Calculation ODP' and explained in the respective paragraphs. The dimensioning of the national multicast ODP is calculated in sheet 'Own network costs' and described in the respective paragraph.

### 3.1.9 Economic lifetime of assets

Certain equipment is required to produce the fibre based retail services by an alternative operator. This is equipment in its core network, aggregation network and at the ODPs. The amount of equipment required is calculated in the tool. Based on the available data either an average monthly cost is used or the one-time purchase price and related setup costs. If the latter are available, they are converted into a monthly costs per subscriber by considering the economic asset lifetime and the estimated amount of subscribers using the particular equipment.

Nkom has already set certain asset lifetimes for equipment in its fixed long-run incremental cost model. While validating the model, the same asset economic lifetime are used where possible to stay consistent.

### 3.1.10 OPEX

Operational expenses are estimated on a yearly basis by using a percentage of the initial capital investment.

### 3.1.11 Price information

For the estimation of the costs of the aggregation links, commercial market prices for leased lines (core with one access point) in Norway are used. Furthermore, the regulated voice originating and terminating charges as set by NKOM can be inserted.

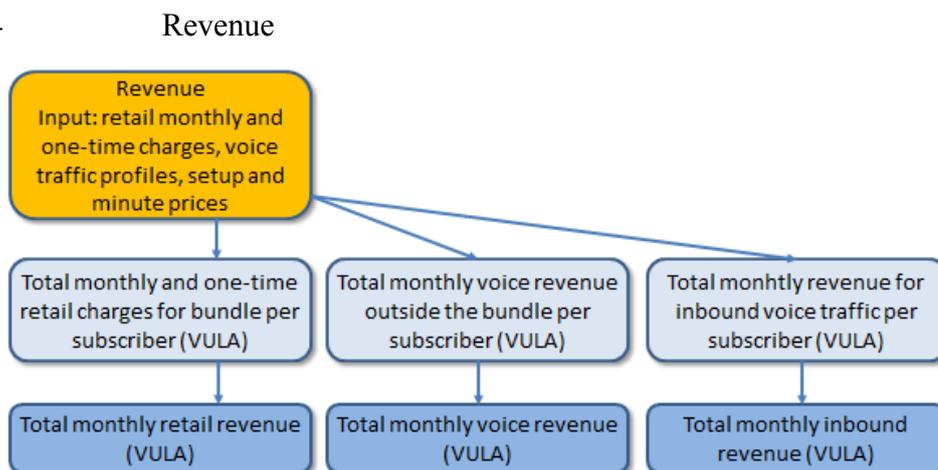
### 3.2 VULA Margin

The ‘VULA Margin’ sheet reflects the overall result of the MST. The unit of measure is Norwegian Kroners (NOK) per fibre subscriber per month. At the bottom, the detailed breakdown of totals per subcategory of revenues and costs are displayed to evaluate what are the most important components leading to the final result. On the top left, the important parameters for WACC, market share, common costs and share of available Telenor fiber connections are displayed. The totals on the left side, emphasized by blue background color, display the totals of the portfolio and the resulting portfolio margin. On the right side the specific totals and resulting margin for each identified flagship product are displayed.

### 3.3 Revenue

The functions in this sheet are displayed in following figure.

Figure 4



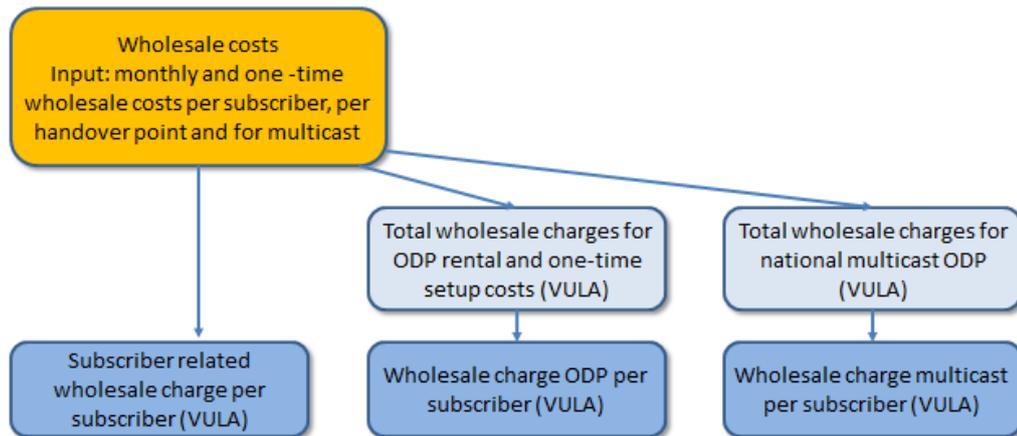
Per revenue category (subscriber, outbound voice, inbound voice), first the input values are listed, followed by a table which calculates the annualized monthly value for the different products. The one-time retail charges at the beginning of the customer lifetime are spread over the lifetime by multiplying them with the capital cost factors. For revenues from one-time charges which might occur during the customer lifetime, such as relocating expenses, this is expressed as a percentage per year assuming an equal distribution. The monthly revenues are then calculated by dividing them by 12 months. One-time charges at the end of the customer lifetime are first discounted back to the current time and then distributed over the customer life again with the capital cost factor. For retail bundles with voice services, there is additional revenue for the alternative operator by charging (out of the free bundle) voice traffic. This is based on user profiles for the specific retail bundle indicating how the voice traffic is distributed over the different destinations. Thereafter, based on the relevant retail charge, the resulting revenue is calculated.

The third revenue category, inbound voice traffic, is generated by incoming voice traffic to its customers for which the modelled alternative provider can charge other networks based on the regulated terminating charge.

### 3.4 Wholesale VULA costs

The functions in this sheet are displayed in the following figure.

Figure 5 Wholesale VULA costs



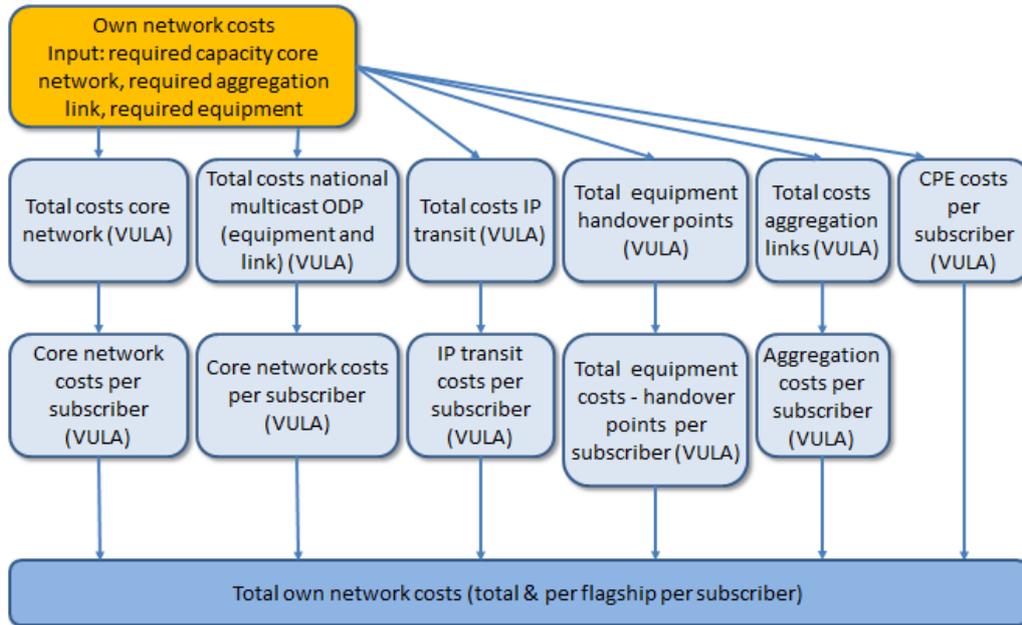
The sheet consists of the three above mentioned blocks of wholesale costs (subscriber related, ODP and multicast ODP). Per block, first the wholesale costs need to be inserted at the top in the orange fields. The blue fields then calculate the monthly costs. The one-time charges are spread over the customer lifetime in the same manner as described before.

Wholesale ODP costs are based on the number of 1 Gbit/s and 10 Gbit/s ODP ports. Furthermore, the one-time setup costs per VULA ODP is spread over the ODP lifetime. Thereafter the total monthly ODP costs are distributed over the flagship products using the required capacity per flagship as allocation key. We assume that due to the continuous fibre rollout a capacity adjustment on 50% of the ODP points is necessary per year. This results in yearly modification costs, which are distributed over 12 months. For the multicast wholesale charges, first the estimated required multicast capacity is calculated based on the offered IPTV channels (mix of standard and high definition channels). Thereafter a maximum utilization of the handover point of 75% is assumed and the nearest available wholesale capacity is selected. In addition to the monthly costs, the one-time setup costs are spread over the asset lifetime as well. The separate national handover point for Multicast traffic is dimensioned based on an estimated number of TV channels (mixture of standard and high definition). The tool looks at the nearest capacity required with a related monthly rental and onetime setup charge. The total multicast costs are thereafter distributed over the different flagship products. First, it is tested whether there is IPTV in the bundle, and if so, costs are allocated based on the number of TV subscribers.

### 3.5 Own network costs

The functions in this sheet are displayed as illustrated in the following figure.

Figure 6 Own network costs



#### 3.5.1 Core network

The main input for this sheet comes from the sheet ‘Calculation ODP’ where the required capacity per ODP and in total is calculated. Based on these inputs, the costs of the alternative operator’s core network are estimated based on an average cost value. This value is verified by a separate model of a hypothetical core network with 2 redundant network nodes connected by redundant links. Thereafter, the total costs for core network are distributed over the flagship products by using the required bandwidth as allocation key.

#### 3.5.2 Multicast ODP

The IPTV server of the alternative operator is located in its core network. The handover of the TV stream is done via 1 national handover point (called multicast ODP). The alternative operator needs to reach this multicast ODP and hence there are link costs assumed beside the one time equipment costs.

The total multicast costs in the alternative operator’s network is thereafter distributed over the relevant flagship products. First it is tested whether the bundle contains IPTV, and if so, the allocation key is the number of IPTV subscribers.

### 3.5.3 IP transit

From the core network, the alternative provider needs to exchange its internet traffic and therefore connects to an internet exchange point (IXP) and/or other internet service providers. This results in IP transit costs. These costs are modelled by using an average monthly cost per Mbit/s, which is multiplied with the estimated amount of IP traffic per flagship product. Therefore, first it is tested which bundle contains internet and if so, how many customers demand the bundle and which amount of total IP transit capacity results from it.

### 3.5.4 Equipment ODP sites

The equipment costs at the ODP sites is calculated based on input from the sheet 'Calculation ODP'. From there, the amount of monthly rack and energy costs is received. In addition, the capital investments required for IP-switches and ports are transferred and converted into a monthly amount with the capital cost factor. This factor is based on the WACC and estimated asset lifetimes. Furthermore, the set-up costs for co-location are considered per ODP site and are similarly spread over the asset lifetime.

### 3.5.5 Aggregation link costs

The setup cost for aggregation links (connecting ODP sites to the alternative provider's core network) is derived from the calculated capacities in the sheet 'Calculation ODP'. These one-time setup costs are spread over the asset lifetime of an ODP site with the capital cost factor. Thereafter the total monthly cost is distributed over the flagship products by using the required capacity as allocation key.

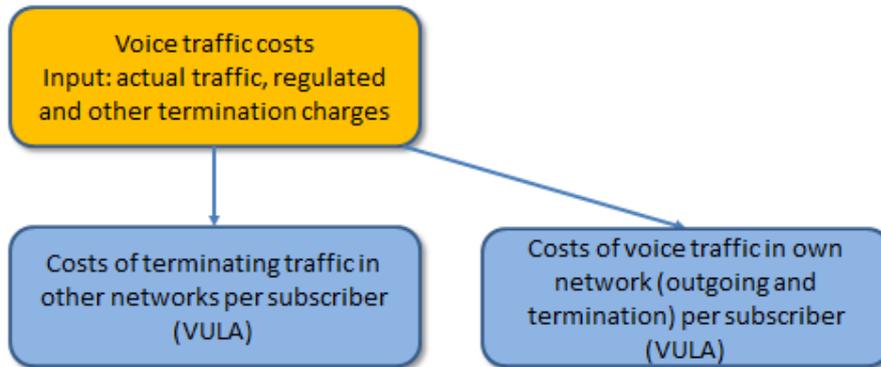
### 3.5.6 CPE

There is separate customer premises equipment (CPE) modelled for internet access (internet router) and for the provisioning of IPTV (TV set-top box). The one time capital investment is spread over the asset lifetime with the capital cost factor. Thereafter it is tested which CPE is relevant for which flagship product so that the correct total amount of monthly CPE costs is allocated.

### 3.6 Voice traffic costs

The functions in this sheet are displayed in the following figure.

Figure 7 Voice traffic costs



As displayed, the costs are estimated for:

- Terminating outbound traffic in other networks
- Producing the originating calls from the alternative operator's network

For the voice termination costs per flagship product, the traffic profiles need to be inserted reflecting the amount of voice traffic to each destination. For each destination either the regulated charge or the estimated average costs are used to determine the total voice costs. Setup and per minute costs are used while considering the average call duration.

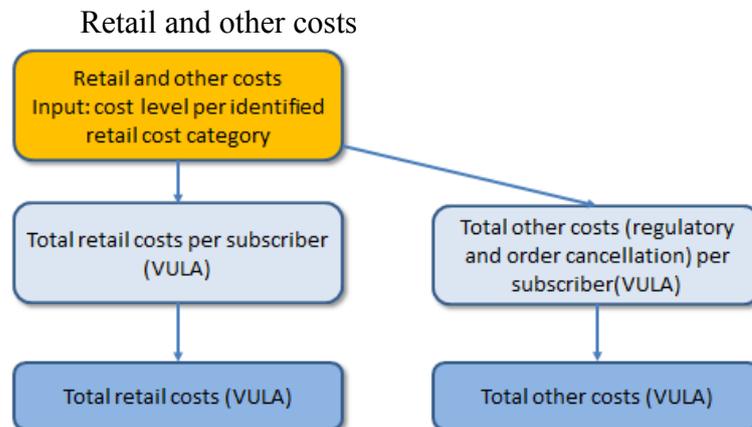
In respect to the production costs of voice in the alternative provider's own network, the model considers first what is called a 'single leg of a voice call'. First, all outgoing traffic is considered as one leg from the end customer to the voice interconnection point. In addition, the incoming traffic is also considered as one leg from the voice interconnect to the end customer. This is an opposite flow, however the same network elements are used, hence we assume the same costs. And finally the so called 'on-net' calls are counted double as these can be envisaged having a 'double leg' as the traffic first originates in the network (from end customer to voice interconnect) and then goes down in the network again when the switch recognizes this number is on its own network (from voice switch to the end customer).

The total amount of 'single legs' of traffic is so calculated and multiplied by the regulated charge for OLO origination (one leg). Per flagship product the voice production costs are calculated and then totalized for the portfolio.

### 3.7 Retail and other costs

The functions in this sheet are displayed in the following figure.

Figure 8



#### 3.7.1 Retail costs

The following retail costs are considered to be required to maintain a distribution channel for the modelled alternative operator:

- Customer Acquisition and retention
- Customer care
- Marketing and advertising
- Sales personnel salary / Sales commission
- Billing
- Bad debt
- Product development / Management

The retail cost items for CPE and common costs are already considered elsewhere in the model namely in the sheet 'Own network costs' and the sheet 'Common parameters' and 'VULA Margin'. As the retail costs are expressed as percentage of the revenues, they are based on the modelled total revenue per flagship product, which is displayed in the sheet. After calculating the retail costs per flagship product, the total retail costs are calculated based on the estimated subscriber numbers for the alternative operator.

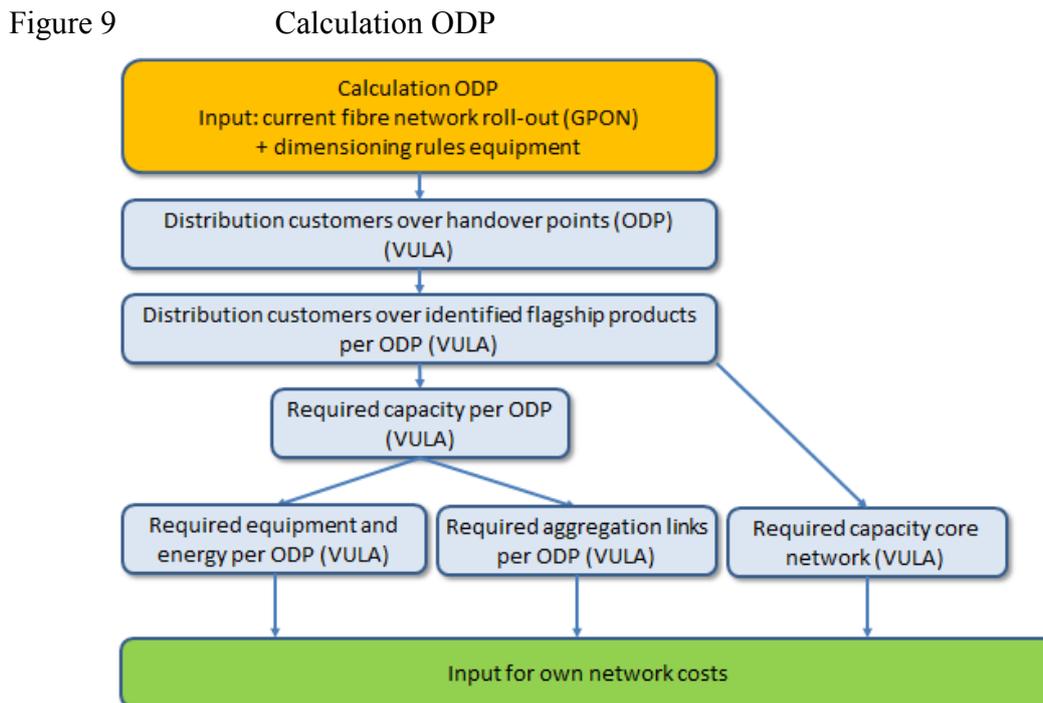
#### 3.7.2 Other costs

Other costs include regulatory state fees and retail order cancellation costs. Also IPTV content costs for the basic TV package are included. The required wholesale costs (multicast) and the related revenue of the basic IPTV package are considered as well. Number portability charges are already included in the sheet 'Wholesale VULA costs'

### 3.8 Calculation ODP

The bottom-up modelling of the number of subscribers, the traffic generated by the subscribers and the dimensioning of equipment and the uplinks according to the traffic is the purpose of the tab ‘Calculation ODP’.

Figure 9 illustrates the modelling procedure.



At the ODP site, the VULA connected customers are handed over to the network of the alternative operator. For the alternative operator to offer his services it is required that it is co-located at the relevant sites so that it can install its own equipment to connect its customers to the network.

The alternative operator needs to rent ODP ports for the traffic handover and connect the VULA customers to his network via IP-switch equipment. The IP-switches are connected with its core network via uplinks for which the costs are approximated by prices for commercial leased lines. The equipment and the uplinks are dimensioned according to the number of subscribers and the amount of traffic generated by the customers of the alternative operator at each ODP. This approach appears appropriate since the cost of the equipment is sensitive to scale and the customer potential at each ODP turns out to be quite varied.

The details of the modelling steps in the sheet ‘Calculation ODP’ are described in the chapters 3.8.1-3.8.7. These chapters correspond with the blue marked headers and related tables in the tool. The calculated totals from this sheet are re-used in the sheet

“Own network costs” to convert the one-time capital investments into annualized monthly amounts.

### 3.8.1 Estimate the number of subscribers of the alternative operator per ODP

The number of subscribers for VULA are basically deducted from the number of homes connected per ODP in the network of Telenor. The most detailed data available features the current network deployment of Telenor in terms of homes connected per ODP service area. At the moment from the total of ODP sites those are selected with more than 1,000 homes connected. This amounts to 17 ODP sites which are defined plus a spare of several sites considered for VULA for future use as the fibre network will evolve.

From the basic input data of the currently connected homes per ODP, the share of connected homes per ODP is calculated as a percentage of the total number of homes connected. It is subsequently used to determine the forecasted number of connected homes per ODP service area (if forecasted number is used else the current number of connections). Here an update of the number of homes connected may be fit in whenever indicated.

The number of subscribers of the alternative operator for VULA is determined by multiplying the customer base available for VULA at each ODP with the market share of the alternative operator for VULA. These market shares are input values determined in the sheet “Common parameters”.

### 3.8.2 Estimate the subscriber distribution according to the flagship products

Having determined the number of VULA subscribers of the alternative operator the number of subscribers is distributed to the products they demand according to the probability of demand of the flagship products of the alternative operator. The probability of demand is a linked input that can be changed in the sheet “Common parameters”.

The split up of the customers according to products is necessary to determine the bandwidth requirements in nominal and busy hour terms at each ODP.

### 3.8.3 Estimate the traffic demand per ODP for aggregation and core network

The bandwidth requirements for the different flagship products will typically differ. This may apply for different line speeds (nominal bandwidth requirement) and differing busy hour bandwidth demand of the distinct customer groups.

For VULA the nominal bandwidth requirement is computed per product and ODP by multiplying the number of subscribers per product and ODP with the line speed per product, which is a linked input that can be changed in the sheet “Common parameters”. This information is used to dimension the ODP ports required for VULA including VOD services.

The busy hour bandwidth requirements per product and ODP are calculated by multiplying the subscribers per product and ODP with the respective busy hour bandwidth demand per customer and product. These parameters are a linked input that can be changed in the sheet “Common parameters”.

The model allows for a distinction between aggregation and core busy hour bandwidths per user and product to apply. According to operator information the core network dimensioning rules allow for lower bandwidth requirements per user than those used in the aggregation network. Consequentially in the model we compute the busy hour bandwidth per ODP which is used to dimension the aggregation network equipment per ODP (equipment at the ODP and uplinks) and we also compute the core network bandwidth demand used to dimension the core network usage. In the case of the core network dimensioning the differentiation according to ODP sites is not needed thus only the aggregate (nation-wide) busy hour traffic is computed.

#### 3.8.4 Determining the number and capacity of ODP ports required for VULA services

VULA wholesale service is available at each ODP site and is currently defined to be available to the alternative operator via 1G and 10G ports. The alternative operator has to rent one or several ports from the incumbent to be able to offer his services to the customers connected via VULA.

To be in compliance with EU-regulation the incumbent, in principle, has to deliver the nominal bandwidth (tariff bandwidth) of the end customer product he offers, without contention. This is the reason to base the ODP port dimensioning on the nominal and not on the peak (busy hour) bandwidth. Since overbooking is used in the incumbent network, the nominal bandwidth of each product is weighted with the contention ratio used by the incumbent to determine the contention weighted “ODP bandwidth demand”. This capacity forms the maximum ODP port capacity the alternative operator will demand.

The alternative operator in contrast may apply his own overbooking rules while dimensioning his equipment. In the model we apply two restrictions while dimensioning the ODP port demand of the alternative operator, taking the least restricting (higher bandwidth requirement) to apply. One is the alternative operators contention ratio expressed as a percentage of nominal bandwidth (100% means no overbooking while 25% means 4 times overbooking) which reflects the internal overbooking policy of the alternative operator. The other input parameter refers to the multiple of the busy hour bandwidth to guarantee (2 means that 2 times the busy hour bandwidth is at minimum assured). These considerations lead to the “ODP port bandwidth required”, considering alternative operators dimensioning policy.

The demand for the wholesale VULA ports to rent from the incumbent at each ODP is based on the value of “ODP port bandwidth required”. The incumbent’s wholesale offer currently permits to rent 1G and 10G ports. To determine the number and type of the ports to demand the rule applied first allocates the higher capacity (10G) ports if the demand is sufficient. It leaves the rest to be supplied by multiples of 1G ports

considering an input factor (“low cost factor”) that determines at which point it is better to switch to the higher capacity port than demanding multiples of the lower capacity ports. If the “low cost factor” is e.g. 3 then the choice will be an extra 10G port if the resulting rest of the division of the “ODP port bandwidth required” by 10 (“capacity highest port option” input value) is larger than 3. If it is lower or equal to 3 then the corresponding multiple of the lower port capacity (1 Gbps) will be demanded, in addition to the number of 10 Gbps ports. The input value of the “low cost factor” should reflect the relative prices of the port rentals and may also include spare capacity considerations. This avoids having to change port demand with each new customer.

### 3.8.5 Determining the switch equipment for VULA services

At each ODP site the alternative operator is assumed to install IP switches to connect its customers with his network. The switch equipment is designed to handle the traffic of customers connected via VULA and connect them with the core network of the alternative operator. The switches considered are composed of user sided line cards, the switching unit and the network sided line cards defined by the uplink requirements. The model allows to define 3 types of line cards LC1..LC3, differentiated by the number of ports of a given capacity per line card (100 M, 1G and 10G are considered) and the respective investment price. Further, the model allows to define three types of switching units distinguished by the maximum number of line cards that can be plugged in (maximum number of slots), the maximum capacity (in Gbps) the switch can handle and the respective investment price per switching unit. These distinguishing features are a special input parametrized within the tab “Calculation ODP”.

For the computation of the investments for user sided line card equipment first the number of ports are derived for the considered port speeds of 100 Mbps, 1 Gbps and 10 Gbps separately. In case of VULA the number of ports match the number of ODP ports for the two speed capacities of 1 G and 10 G, described in the section above. Having defined the number of ports needed for each speed class, the number of line cards that are needed for each of the three line card types (LC1..LC3) is determined and the investments for these line cards are computed. The combination with the lowest investment value is chosen. These optimization steps are repeated for each port speed class (100 Mbps, 1 Gbps and 10 Gbps). The optimization computations are separately carried out in the section “Optimization of equipment at ODP” within the tab “Calculation ODP”.

The network sided line cards are dimensioned according to the number and speed class of the uplink capacities required and the investment value of these cards are determined separately. The optimization of the switching units is carried out in several steps. First, the number of slots resulting from the line card optimization is determined. Second, the required throughput capacity of the switching units are determined. These requirements form the basic restrictions on the switch size to choose. For each of the three possible types of switching units (small S, medium M and large L) the required number of switch units according to capacity and according to slot restriction is computed. The required number of switch units is determined from the maximum number of switch units resulting from both restrictions. For each switch unit size the resulting investments are

computed (number of units times unit price) and the combination with the smallest investment value is chosen.

The optimized investment values for the switching equipment (user sided line cards, network sided line cards and the switching units) are computed for each ODP site. From the number of switches the required number of racks is derived by division of the number of switches with the input value of the number of switches per rack. The resulting number of racks is valued with the “monthly costs per rack” which is an available input from the operator responses to the questionnaire. The monthly costs per rack includes the costs for the rack and the monthly co-location cost for the space required. The power consumption costs are also derived from the number of switches multiplied by the input values of the monthly power consumption in Watt of the corresponding switch unit and valued with monthly costs per Watt.

### 3.8.6 Determining the uplink requirements

The uplinks connect the IP-switches at the ODP sites with the core network of the alternative operator. The link costs are approximated by leased line rentals for which operator information is available. The dimensioning of the uplinks follows from the busy hour capacity requirements per ODP. In a first step the smallest capacity that is able to fulfill the busy hour requirements at the ODP is looked up from a menu of leased line capacities. In a second step the number of such links is determined. For each such uplink capacity the setup investment value is chosen from the input table and multiplied by the number of uplinks to determine the investment value for the setup of the demanded leased lines per ODP. In the same way the monthly rental costs for the uplink leased lines per ODP is determined. The table of leased line charges is an input defined in the sheet “Common parameters”.

Resilience considerations concerning the uplinks can be introduced, if necessary, by the demand of double connected leased lines (with corresponding rentals) or by doubling the demanded uplinks. In both cases the demanded network sided ports have to be considered twice.

### 3.8.7 Determination of co-location costs

At each ODP site the alternative operator is assumed to rent space from the incumbent to house its own equipment. In the model the costs of co-location are included in the monthly cost per rack of the equipment (switches). The co-location setup costs (one off charges) are derived from an investment value per ODP site with positive demand and are transferred to cost figures in the tab “Own network costs”. The setup fee is an input value derived from operator responses.

## 4 How to use the model

### 4.1 Formatting conventions

The sheet ‘Contents’ gives an overview of the different components of the model and the color coding of the fields in all sheets.

Figure 10 Color coding in spreadsheets

Color Code	
2314	Input data, collected from the operators and validated
2134	Calculation sub results based on the input data
2134	Key result, total calculations based on input data and sub results
2134	Linked cell, value derived from other cell with input data

The orange marked fields are meant to be used to input data (like WACC or customer lifetime). Blue fields are resulting calculation fields, where there is a distinction between sub calculations and key results (totals) in darker blue. Green fields are obtaining their value from an original input field to link the different Excel tabs and to avoid errors when changing input data while updating the tool. The tool will be protected in a manner that allows the user only to update the orange input field.

### 4.2 Using the model

In order to use the model, all orange fields in all sheets need to be filled. Only exception is where voice /internet /IPTV product details are not relevant for the respective flagship as the bundle does not contain one or more of the products. The relevant orange input fields are filled in with validated data, hence the most important parameters need to be verified every 6 months . Important here is the actual GPON roll out of Telenor and how long the considered forecast horizon is (one could use the forecast for this year, for next year or the current connections).

The sheet ‘VULA’ directly present the end results after the data is inserted. For practical purposes, all fields except the input fields are protected. In addition, the sheet structure and layout are protected as well.

## 5 Data set used in the model

### 5.1 Data collection and validation

For the establishment of the margin squeeze tool, information is required about the costs and revenue components related to the modelled hypothetical alternative operator and the business case, based on fibre wholesale access. As the structure of the data has an impact on how the different components are modelled, data has been collected. Nkom

has sent out data requests to the operator with significant market power (Telenor) and the main alternative operators in the residential and business market. The collected data has been validated by WIK and Nkom. WIK has compared received data between operators and proposed a certain value while considering the different alternative operators in the Norwegian market and by comparing data with benchmark data. With the proposed values the draft model is tested. The final data set to be applied in the final model needs to be validated by Nkom.

Where collected data deviates significantly between operators and benchmark values, the general approach is to use the conservative values (lower costs and higher revenues, hence a higher calculated margin will result than might occur in reality) in order to increase the defensibility of any observed margin squeeze.

Although not explicitly indicated by the Norwegian operators, WIK and Nkom have assumed that all collected data is confidential. The data collection sheet and the final applied values in the model are not publicly released. Therefore, the consulted model documentation and the tool itself contain limited data.

## **5.2 Note on conservatism in the chosen approach**

A MST models a hypothetical alternative operator, however the modelled business case is made as realistic as possible. Together with applying conservative values for the parameters in the tool, this increases the validity of the outcome of the tool. Conservative values mean that the costs are estimated more towards the lower end and revenues more towards the higher end, thus increasing the calculated margin. Beside the conservatism in the used values for the parameters, there is an in-built conservatism in a MST already. Replicating the incumbent's retail prices by itself is a conservative approach as alternative operators are usually not in a position to charge the same retail prices. In general, the market requires them to price 10% or even more below the incumbent's price level. This is due to long lasting incumbency or first mover advantages. Furthermore, alternative operators face the asymmetry that they can only earn margins on their downstream business, while incumbents earn margin on their upstream and downstream business.

The tool allows considering the planned fibre rollout of Telenor in the near future by allowing the insertion of a forecasted number on the total of connected subscribers or to use the current number. The used figure is therefore an average for the coming time period, which implies that in the beginning the real number of homes connected is lower, hence costs per subscriber are higher and resulting margin is lower. In the case of a forecasted number, this means that, if a margin squeeze is observed in the model, it reflects that Telenor's current wholesale pricing causes a margin squeeze not only now but also in the coming time period (for which the forecasted network roll out figure is used).

<b>Annex</b>	<b>Acronyms used</b>
BH	Busy Hour
BHB	Busy Hour Bandwidth
BNG	Border Network Gateway
BW	Bandwidth
Cap	Capacity
CPE	Customer Premise Equipment
Gbit/s	Gigabit per second
Gbps	Gigabit per second
GPON	Gigabit Passive Optical Network
HD	High Definition
IP	Internet Protocol
IXP	Internet Exchange Point
LC	Line Card
LER	Label Edge Router
LSR	Label Switch Router
Mbit/s	Megabit per second
Mbps	Megabit per second
IP-Switch S	Internet Protocol Switch – small
IP-Switch M	Internet Protocol Switch – medium
IP-Switch L	Internet Protocol Switch – large
IPTV	Internet Protocol Television
IP Transit	Internet Protocol transit
MPOP	Metropolitan Point of Presence
NOK	Norwegian Kroner
ODP	Operator Distribution Point
OLO	Other Licensed Operator
OLT	Optical Line Termination
OPEX	Operational Expenditures
OTC	One Time Charges
SD	Standard Definition
VAT	Value Added Tax
VOD	Video on Demand
VoIP	Voice over IP
VULA	Virtual Unbundled Local Access
WACC	Weighted Average Cost of Capital
1G	1 Gigabit
10G	10 Gigabit
100M	100 Megabit