Invitation for public hearing



Draft Modelling Results Report for a Bottom-Up LRIC Bitstream service in Republic of Macedonia

July 24, 2012



Invitation for public hearing

Dear all,

With this invitation we invite all interested parties in period of 30 days starting from day of publication of “Modelling Results Report for a Bottom-Up LRIC Bitstream service in Macedonia” to submit their views and comments about proposed subject of public hearing.

On the meeting held on 14.10.2011 the Agency for electronic communications informed interested parties that starts with development and implementation of Bottom-up LRIC model for Bitstream service. So far, the method for determining the prices for Bitstream service is implementing on the basis of retail minus. The technique of determining the price using this method is performed on the basis of the retail price of a certain service and by implementing of a defined control percentage is determined the amount of the wholesale price. This means that the prices are defined based on retail price of the SMP operator which may contain elements of inefficient operations and contain elements that are not necessary in creating the service. It was therefore necessary to develop and implement a model that enables calculation of prices based on costs incurred that are necessary and indispensable when creating the service.

The BU-LRIC model was developed in cooperation with Deloitte-Croatia based on contract for consultant services.

**Agency for Electronic Communications**

**Draft Modelling Results Report**

**for a Bottom-Up LRIC Bitstream service in Republic of Macedonia**

**July 24, 2012**



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# TABLE OF CONTENTS

[TABLE OF CONTENTS - 4 -](#_Toc330908215)

[1 INTRODUCTION - 5 -](#_Toc330908216)

[2 Demand projections - 6 -](#_Toc330908217)

[3 base case results - 8 -](#_Toc330908218)

# 1 INTRODUCTION

* 1. This Report presents base case scenario and draft results of BU LRIC modelling of bitstream services. Key assumptions and demand for base case scenario are presented first and LRIC estimates for select bitstream services second.
  2. In preparing this Report, we have relied upon a number of third party reports (AEC/operator subscriber/traffic estimates, network/cost data, etc). We have not undertaken any form of investigation, verification, audit or other work in relation to such information. In particular, the scope of our work has not included validating subscriber, traffic, tariffs (revenues) and cost assumptions contained in third party source documents. Accordingly we express no view on the reasonableness of said third party source documents.
  3. The scope of our work has not involved us in performing tests necessary for the purpose of expressing an opinion on the accuracy of any subscriber/traffic forecasts and/or projections. Neither do we express any overall opinion on the reliability of the forecasts/projections nor the reasonableness of the underlying assumptions. Since any forecast and/or projection relates to the future and may be affected by unforeseen events, actual results after our Base Case date of July 24, 2012 are likely to be different from those forecast/projected because events and circumstances do not necessarily occur as expected. Such differences may or may not be material. Such prospective information is not susceptible to audit and Deloitte expresses no opinion as to whether the actual results achieved will *ex post* correspond to those forecast or projected.
  4. Due to confidential information, some parts of the text are removed in the public version of the document. These parts are replaces by an ellipsis enclosed in square brackets – e.g. […].

# 2 Demand projections

* 1. Demand used for modelling and preparation of LRIC estimates are best described in several parts:
     + Number of subscribers of different services
     + Aggregate throughput for different services in the core network
     + Number of bitstream subscribers per different level of bitstream access

We address each one of these below in detail.

* 1. In preparation of base case scenario we have relied on a number of inputs from industry. Those inputs were available for year 2014 the latest, but due to expected dynamics and related unpredictability of market outcome, our base case refers to year 2013.
  2. Number of subscribers of different services is divided into three main categories:
     + Internet users over ADSL technology
     + IPTV users
     + VoIP users over ADSL lines
  3. As the broadband penetration in Macedonia is relatively low compared to the EU27, there is still space for growth. In that sense, number of ADSL users is projected based on historical growth data (2011/2010). Number of users applied in the model is thus 165.577.
  4. Similar to broadband penetration, IPTV penetration is relatively low compared to EU27 so assuming that IPTV penetration growth will continue with same CAGR is likely to be a conservative scenario. Number of IPTV users in the model is then 71.216.
  5. It should be noted that although IPTV subscribers CAGR is relatively high – i.e. 33,22%, we believe that this scenario is realistic since the latest reports about IPTV subscribers suggest growth rates of 28% globally and even higher for Eastern Europe.

* 1. As it is common practice for IPTV service to include VoD services, VoD users were not estimated separately but instead all IPTV users are assumed to be VoD users as well.
  2. […]. However, there are several developments that need to be taken into account to estimate the number of users:
     1. In recent years, in Macedonia as well as in some surrounding countries, there was a noticeable trend of mobile-to-fixed substitution. However, in the last year this trend has reversed – see figure below.
     2. Maktel’s market share in terms of fixed lines has been constantly declining over the past several years. If this trend continues at the same rate, in the base case year Maktel would have approximately 56% of market share.
  3. Applying CAGR for above trends (see table below), the number of VoIP users in applied in the base case is equal to […].

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **CAGR** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** |
| Fixed lines | -2,21% | 451.299 | 437.301 | 415.144 | 422.053 | 412.732 | 403.616 |
| Penetration | -2,33% | 22,07 | 21,35 | 20,22 | 20,56 | 20,08 | 19,61 |
| SMP’s share | -9,72% | 94% | 84% | 77% | 69% | 62% | 56% |

* 1. Last input to the model regarding subscribers is number of bitstream users. Estimates used in the model are again based on growth rates from 2011 over 2010. Resulting percentage of bitstream users is used for base case scenario is 15.34%.
  2. Share of bitstream subscribers using VoIP/IPTV services is assumed to be the same as for retail subscribers.
  3. Summary of subscriber inputs is presented in the following tables.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Maktel’s ADSL lines** | **CAGR** | **2010** | **2011** | **2013** |
| Bitstream | 13,07% | 18.957 | 20.897 | 25.393 |
| Retail lines | 5,71% | 130.127 | 137.563 | 140.184 |
| Total lines | 6,74% | 151.218 | 161.410 | 165.577 |
| Bitstream as % Internet | 5,93% | 14% | 15% | 15,34% |
| IPTV | 33,22% | 30.123 | 40.129 | 71.216 |

* 1. Basis for projections of aggregate throughput for different services at the core network level were obtained from Maktel.
  2. Overview of traffic projections is presented in the following table.

[…]

# 3 base case results

* 1. This chapter presents the results our Base Case analysis for selected profiles and services. All numbers refer to monthly rental fees.
  2. The model supports LRIC and LRIC+ cost calculation for 4 (four) levels of bitstream as defined in ERG’s common position (ERG (03) 33rev2). The levels are depicted and explained below.

**Figure-1.1 Different levels of bitstream**



* 1. The ERG common position describes the following wholesale bitstream access levels:

1. Level 1: DSLAM[[1]](#footnote-1) access – incumbent provides the DSL access link and hands over the bitstream to the new entrant directly after the DSLAM. In this option the new entrant is physically present at the DSLAM and is supplying the backhaul product. This enables him to differentiate himself through the backhaul product but requires large investments since due to presence at each DSLAM.
2. Level 2: aggregation network – the new entrant connects to the incumbent network at an aggregation point behind DSLAM thus reducing the number of points at which the new entrant must be present. In this scenario the new entrant uses a bigger part of incumbent’s network but can still control the quality of service since it operates its own BRAS server as well as part of the backhaul.
3. Level 3: IP level – in this scenario the demarcation point is at/after the managed IP core network. The traffic goes over managed IP network only and the incumbent controls the BRAS.
4. Level 4: unmanaged IP – in this scenario the new entrant only brands, sells and bills the product. It has no control over technical characteristics and in effect is providing only a resale.
   1. Before detailed explanation of modelled services, it is necessary to note that cable access network is not covered by this model. Instead, prices for cable access up to the DSLAM access node are determined by the referent unbundling offer (RUO).
   2. Level 1 bitstream services are modelled in the following manner:

* Network access point for alternative operator is on DSLAM and bitstream service access link is based on Ethernet technology.
* Charges for end customer access in the local loop are taken from RUO.
* Customer premises equipment (CPE) is assumed to be provided by the alternative operator.
  1. Level 1 bitstream includes the following network components:
* Bitstream access link from handover ODF to DSLAM
* DSLAM port card
* Access network in the local loop (charges taken form RUO) without CPE
  1. Level 1 bitstream is modelled both with and without PSTN subscription (“standalone bitstream”).
  2. Level 2 bitstream is modelled in the following manner:
* Network access point for alternative operator is on the aggregation network and bitstream access link is based on Ethernet technology.
* Aggregation network is charged per capacity required to provide access to alternative operator’s end users in the respective aggregation part of the network from network access point.
* Charges for end customer access in the local loop are not calculated but taken from RUO.
* CPE is assumed to be provided by the alternative operator.
* BRAS server (Broadband Remote Access Server) is provided by Alternative Operator.
* Capacity of the bitstream access link is assumed to be greater or equal to the capacity reserved in the backhaul. This provides the alternative operator with possibility to optimize cost with respect to planned expansion. No concentration ratio for Bitstream access link will be assumed, so AO is self-responsible for the quality of best effort internet services that are provided to end subscribers.
  1. Level 2 bitstream is modelled both with and without PSTN subscription (“standalone bitstream”).
  2. Level 2 bitstream includes the following network components
* Bitstream access link from handover ODF to a port on aggregation network node
* Backhaul aggregation network capacity up to the DSLAM
* DSLAM (uplink and port cards)
* Access network in the local loop (charges taken form RUO) without CPE
  1. Level 3 bitstream is modelled in the following manner:
* Network access point for alternative operator is on the core network and bitstream access link will be based on Ethernet technology.
* Backhaul network capacity network (core and aggregation) is charged per capacity required to provide the service to alternative operator’s end users from network access.
* Optional BRAS node – see explanation in the following point.
* Charges for end customer access in the local loop are not calculated but taken from RUO.
* CPE is assumed to be provided by the alternative operator.
* Capacity of the bitstream access link is assumed to be greater or equal to the capacity reserved in the backhaul. This provides the alternative operator with possibility to optimize cost with respect to planned expansion. No concentration ratio for Bitstream access link is assumed, so AO is self-responsible for the quality of best effort internet services that are provided to end subscribers.
  1. Level 3 is modelled with two variants: i) with BRAS node provided by the SMP; ii) with BRAS node provided by the alternative operator. This effectively means that level 3 bitstream will be provided as OSI stack Layer 2 service but on a core network level. Availability of this service is subject to technical and security requirements of the SMP operator.
  2. Level 3 bitstream is modelled both with and without PSTN subscription (“standalone bitstream”).
  3. Level 3 bitstream includes the following network components
* Bitstream access link from handover ODF to a port on core network node
* Core and aggregation backhaul network capacity up to the DSLAM
* BRAS node (optionally – see above)
* DSLAM (uplink and port cards)
* Access network in the local loop (charges taken form RUO) without CPE
  1. The model covers three basic classes of services: Internet access, VoIP and IPTV.
  2. All of these services are modelled with the same QoS and overbooking factors used by the SMP to for its own end customers.
  3. Results for basic internet service per selected profile are presented in the following table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Profile (downlink/uplink) | **Level 1** | **Level 2** | **Level3 without BRAS** | **Level3 with BRAS** |
| 1024/512 Kbps | **110,35 MKD** | **114,44 MKD** | **118,96 MKD** | **121,79 MKD** |
| 2048/512 Kbps | **110,87 MKD** | **117,69 MKD** | **125,23 MKD** | **129,94 MKD** |
| 3072/512 Kbps | **111,39 MKD** | **120,94 MKD** | **131,50 MKD** | **138,09 MKD** |
| 4096/768 Kbps | **112,05 MKD** | **125,00 MKD** | **139,33 MKD** | **148,27 MKD** |
| 5120/768 Kbps | **112,57 MKD** | **128,25 MKD** | **145,60 MKD** | **156,42 MKD** |
| 6144/768 Kbps | **113,09 MKD** | **131,50 MKD** | **151,87 MKD** | **164,57 MKD** |
| 7168/768 Kbps | **113,61 MKD** | **134,75 MKD** | **158,13 MKD** | **172,72 MKD** |
| 8192/1024 Kbps | **114,27 MKD** | **138,81 MKD** | **165,97 MKD** | **182,91 MKD** |
| 9216/1024 Kbps | **114,79 MKD** | **142,06 MKD** | **172,24 MKD** | **191,06 MKD** |
| 10240/1024 Kbps | **115,31 MKD** | **145,31 MKD** | **178,50 MKD** | **199,21 MKD** |
| 11264/1024 Kbps | **115,84 MKD** | **148,56 MKD** | **184,77 MKD** | **207,36 MKD** |
| 12288/1024 Kbps | **116,36 MKD** | **151,81 MKD** | **191,04 MKD** | **215,51 MKD** |
| 13312/1024 Kbps | **116,88 MKD** | **155,06 MKD** | **197,31 MKD** | **223,66 MKD** |
| 14336/1024 Kbps | **117,40 MKD** | **158,31 MKD** | **203,57 MKD** | **231,81 MKD** |
| 15360/1024 Kbps | **117,93 MKD** | **161,56 MKD** | **209,84 MKD** | **239,96 MKD** |
| 16384/1024 Kbps | **118,45 MKD** | **164,81 MKD** | **216,11 MKD** | **248,11 MKD** |

* 1. Results for “standalone” basic internet service – i.e. when there is no active PSTN subscription associated with ADSL line - per selected profile are presented in the following table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Profile (downlink/uplink) | **Level 1** | **Level 2** | **Level3 without BRAS** | **Level3 with BRAS** |
| 1024/512 Kbps | **320,35 MKD** | **324,44 MKD** | **328,96 MKD** | **331,79 MKD** |
| 2048/512 Kbps | **320,87 MKD** | **327,69 MKD** | **335,23 MKD** | **339,94 MKD** |
| 3072/512 Kbps | **321,39 MKD** | **330,94 MKD** | **341,50 MKD** | **348,09 MKD** |
| 4096/768 Kbps | **322,05 MKD** | **335,00 MKD** | **349,33 MKD** | **358,27 MKD** |
| 5120/768 Kbps | **322,57 MKD** | **338,25 MKD** | **355,60 MKD** | **366,42 MKD** |
| 6144/768 Kbps | **323,09 MKD** | **341,50 MKD** | **361,87 MKD** | **374,57 MKD** |
| 7168/768 Kbps | **323,61 MKD** | **344,75 MKD** | **368,13 MKD** | **382,72 MKD** |
| 8192/1024 Kbps | **324,27 MKD** | **348,81 MKD** | **375,97 MKD** | **392,91 MKD** |
| 9216/1024 Kbps | **324,79 MKD** | **352,06 MKD** | **382,24 MKD** | **401,06 MKD** |
| 10240/1024 Kbps | **325,31 MKD** | **355,31 MKD** | **388,50 MKD** | **409,21 MKD** |
| 11264/1024 Kbps | **325,84 MKD** | **358,56 MKD** | **394,77 MKD** | **417,36 MKD** |
| 12288/1024 Kbps | **326,36 MKD** | **361,81 MKD** | **401,04 MKD** | **425,51 MKD** |
| 13312/1024 Kbps | **326,88 MKD** | **365,06 MKD** | **407,31 MKD** | **433,66 MKD** |
| 14336/1024 Kbps | **327,40 MKD** | **368,31 MKD** | **413,57 MKD** | **441,81 MKD** |
| 15360/1024 Kbps | **327,93 MKD** | **371,56 MKD** | **419,84 MKD** | **449,96 MKD** |
| 16384/1024 Kbps | **328,45 MKD** | **374,81 MKD** | **426,11 MKD** | **458,11 MKD** |

* 1. VoIP service is modelled as an additional channel per user with guaranteed QoS in access, aggregation and core network. VoIP service will be modelled in the following manner:
* Terminal equipment will be provided by alternative operator (e.g. IP telephone, Softphone).
  + Three bandwidth profiles are modelled (per bandwidth per user in backhaul - aggregation network and, on level 3 bitstream, core network):
    - 128kbps/128kbps (downlink/uplink)
    - 256kbps/256kbps (downlink/uplink)
    - 512kbps/512kbps (downlink/uplink)
* Bitstream access link for is modelled as a virtual link provided over the same physical bitstream access link used for best effort Internet service. VoIP bitstream access is modelled as a symmetrical link with capacity calculated as explained below. This capacity is an additional capacity to the capacity needed for Internet service.
* Overbooking factor applied for backhaul bandwidth and VoIP Bitstream access link is 1:5. Thus, the capacity reserved for VoIP traffic in backhaul and over bitstream access link is calculated according to the following formula:

BW = (N128\*128kbps+N256\*256kbps+N512\*512kbps)/5

where N128,N256,N512 stands for the number of subscribers using VoIP services with 128kbps/128kbps, 256kbps/256kbps and 512kbps/512kbps profile, respectively.

* 1. VoIP services are modelled for 2-nd and 3-rd level of bitstream.

|  |  |  |  |
| --- | --- | --- | --- |
| Profile | **Level 2** | **Level3 without BRAS** | **Level3 with BRAS** |
| 128/128 Kbps | **7,19 MKD** | **8,88 MKD** | **9,59 MKD** |
| 256/256 Kbps | **14,39 MKD** | **17,75 MKD** | **19,19 MKD** |
| 512/512 Kbps | **28,77 MKD** | **35,51 MKD** | **38,38 MKD** |

* 1. IPTV multicast services are modelled as an additional channel per user with guaranteed QoS in access, aggregation and core network. IPTV multicast service are modelled in the following manner:
* Terminal equipment will be provided by alternative operator (e.g. STB).
* Content and IPTV platform is provided by the alternative operator.
* Total bandwidth reserved in the backhaul network is calculated depending on the number of SD and HD channel the alternative operator wants to provide.
* Bandwidth capacity reserved per SD and HD channel is 2.7Mbps and 7Mbps, respectively.
* Bitstream access link for IPTV is modelled as a virtual link provided over the same physical bitstream access link used for best effort Internet service. Link capacity reserved for IPTV is equal to the capacity reserved in backhaul for IPTV. This capacity is an additional capacity to the capacity needed for Internet service.
  1. IPTV multicast services are modelled for the 2-nd and 3-rd level.
  2. IPTV multicast SD channels are calculated per user in increment of 10 and HD channels in increment of 5 channels. Table below presents the results of the model.

|  |  |  |  |
| --- | --- | --- | --- |
| Package | **Level 2** | **Level3 without BRAS** | **Level3 with BRAS** |
| 10xSD | **18,40 MKD** | **26,43 MKD** | **26,65 MKD** |
| 5xHD | **23,85 MKD** | **34,25 MKD** | **34,54 MKD** |

* 1. Video on Demand (VoD) service is modelled as an additional channel per user and per channel with guaranteed QoS in access, aggregation and core network. VoD service is modelled in the following manner:
* Terminal equipment is assumed to be provided by alternative operator (e.g. STB).
* Content and VoD platform is provided by the alternative operator.
* Total bandwidth reserved in the backhaul network is calculated depending on the number of users and number of SD and HD channels the alternative operator wants to provide.
* Bandwidth reserved per SD and HD channel is the capacity required transfer of the TV channels with same quality as SMP provides to its own subscribers (2.7Mbps for SD, 7Mbps for HD).
* Bitstream access link for VoD is modelled as a virtual link provided over the same physical bitstream access link used for best effort Internet service. Link capacity reserved for VoD will be equal to the capacity reserved in backhaul for VoD. This capacity is an additional capacity to the capacity needed for Internet service.
  1. Overbooking factor applied for VoD service is 1:10. In that respect, required capacity of bitstream access link is calculated using the formula below:

BW = (NHD\*7Mbps + NSD\*2,7Mbps)/10

where NHD and NSD stand for the number of VoD users with HD and SD channels, respectively.

* 1. VoD services are modelled for the 2-nd and 3-rd level.
  2. VoD services are assumed to be charged per MB of usage. Results of modelling are presented in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Level 2** | **Level3 without BRAS** | **Level3 with BRAS** |
| Per MB | **0,0007 MKD** | **0,0011 MKD** | **0,0011 MKD** |

* 1. VoIP, IPTV and VoD services are modelled as add-on services to best effort Internet service. In this respect, additional channels for VoIP, IPTV and VoD services do not use additional physical network elements but only additional bandwidth with QoS guarantees.
  2. It should also be noted from previous points that the same physical bitstream access link will be used for all services (best effort internet services, VoIP, IPTV and VoD). This means that no additional charges are required for VoIP, IPTV and VoD Bitstream access link.
  3. Bitstream access link for alternative operator is priced according to link speed and link length.
  4. Link speeds modelled are the following:
* 1Gbps
* 10Gbps
  1. Link distances modelled are the following:
* Up to 60m – in the building link
* From 60m up to 2km
* From 2km up to 10km in increments of 1km
* From 10km to 150km in increments of 10km
  1. Tables below present the results of modelling for bitstream access links for various speeds and distances and levels of access.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **L2 - 1Gb** | **L2 - 10Gb** | **L3 - 1Gb** | **L3 - 10Gb** |
| In building - up to 60m | **1.841,73 MKD** | **43.405,00 MKD** | **8.921,66 MKD** | **28.524,96 MKD** |
| Up to 2km | **6.132,79 MKD** | **47.696,05 MKD** | **13.212,71 MKD** | **32.816,01 MKD** |
| Up to 3km | **8.278,31 MKD** | **49.841,58 MKD** | **15.358,24 MKD** | **34.961,54 MKD** |
| Up to 4km | **10.423,84 MKD** | **51.987,10 MKD** | **17.503,76 MKD** | **37.107,06 MKD** |
| Up to 5km | **12.569,37 MKD** | **54.132,63 MKD** | **19.649,29 MKD** | **39.252,59 MKD** |
| Up to 6km | **14.714,89 MKD** | **56.278,15 MKD** | **21.794,81 MKD** | **41.398,11 MKD** |
| Up to 7km | **16.860,42 MKD** | **58.423,68 MKD** | **23.940,34 MKD** | **43.543,64 MKD** |
| Up to 8km | **19.005,94 MKD** | **60.569,21 MKD** | **26.085,87 MKD** | **45.689,17 MKD** |
| Up to 9km | **21.151,47 MKD** | **62.714,73 MKD** | **28.231,39 MKD** | **47.834,69 MKD** |
| Up to 10km | **23.297,00 MKD** | **64.860,26 MKD** | **30.376,92 MKD** | **49.980,22 MKD** |
| Up to 20km | **44.752,26 MKD** | **86.315,52 MKD** | **51.832,18 MKD** | **71.435,48 MKD** |
| Up to 30km | **66.207,52 MKD** | **107.770,78 MKD** | **73.287,44 MKD** | **92.890,74 MKD** |
| Up to 40km | **87.662,78 MKD** | **129.226,04 MKD** | **94.742,70 MKD** | **114.346,00 MKD** |
| Up to 50km | **112.801,51 MKD** | **223.907,78 MKD** | **134.041,28 MKD** | **186.696,70 MKD** |
| Up to 60km | **134.256,77 MKD** | **245.363,04 MKD** | **155.496,54 MKD** | **208.151,97 MKD** |
| Up to 70km | **155.712,03 MKD** | **266.818,30 MKD** | **176.951,80 MKD** | **229.607,23 MKD** |
| Up to 80km | **177.167,29 MKD** | **288.273,56 MKD** | **198.407,06 MKD** | **251.062,49 MKD** |
| Up to 90km | **202.306,02 MKD** | **309.728,82 MKD** | **237.705,64 MKD** | **272.517,75 MKD** |
| Up to 100km | **223.761,29 MKD** | **331.184,08 MKD** | **259.160,90 MKD** | **293.973,01 MKD** |
| Up to 110km | **245.216,55 MKD** | **352.639,34 MKD** | **280.616,16 MKD** | **315.428,27 MKD** |
| Up to 120km | **266.671,81 MKD** | **374.094,60 MKD** | **302.071,42 MKD** | **336.883,53 MKD** |
| Up to 130km | **291.810,54 MKD** | **395.549,86 MKD** | **341.370,00 MKD** | **358.338,79 MKD** |
| Up to 140km | **313.265,80 MKD** | **417.005,13 MKD** | **362.825,26 MKD** | **379.794,05 MKD** |
| Up to 150km | **334.721,06 MKD** | **438.460,39 MKD** | **384.280,52 MKD** | **401.249,31 MKD** |

* 1. As noted before, none of the charges above include CPE equipment. However, as requested by interested parties, Home Gateway (HGW) device monthly rental charges were modelled as an addition to the above services.
  2. Calculated monthly rental charge for HGW device, including operation, maintenance and fault repairs is presented in the table below.

|  |  |
| --- | --- |
| HGW | **105,39 MKD** |

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1. Although the access node can also be an MSAN, for simplicity on DSLAM is used throughout this chapter. [↑](#footnote-ref-1)