5G frequency valuation consultation paper

In December, 2019, Georgian National Communications Commission published consultation document „Strategy for promotion of 5G Networks and Services development”. This document has been created with the purpose to make the spectrum dedicated for mobile broadband services available for operators in the first half of Y2020. This spectrum allows operators to develop and expand new generation (5G) networks and products.

In order to make the spectrum available on time, commission took important steps and addressed significant issues. Commission also announced a tender for the valuation of frequency, dedicated for 5G technology. The tender was won by “Ernst & Young” (Ernst & Young spółka z ograniczoną odpowiedzialnością Business Advisory sp.k). According to tender requirements, company presented frequency valuation based on business modelling approach. Valuation results and methodology are presented in Appendix to this document.

Communications Commission aims to hold an auction in Y2020, taking into account valuation results. Within the scope of auction, commission plans to make available following amount of spectrum in 700 MHz, 800 MHz, 3400 – 3800 MHz frequency bands:

Frequency band, MHz	Amount of spectrum, MHz
800	20
700	60
700 (SDL)	20
3400 - 3800	320

According to presented calculations, within each frequency band the market value of 1 MHz is following:

Frequency band, MHz	Spectrum price, GEL (thousand)/1 MHz
800	741
700	363
700 (SDL)	391
3400 - 3800	52

Communications Commission takes into consideration the presented valuation model and while preparing for the auction it shall l take into account above mentioned valuation results.

Communications Commission publishes this document for consultation purposes and calls for all involved and interested stakeholders to review the published document and send relevant questions/comments in writing (according to following instruction). For transparency purposes and involvement of wider audience, this document is presented in two languages: Georgian and English. Thus, the document is accessible for local and foreign interested parties, individuals, experts and potential investors.

Consultation process will last 11 weeks. Deadline for submission of questions/comments is 18:00 July 15, 2020. Questions and comments must be sent to the following e-mail: post@comcom.ge . In case of questions or clarification, please contact commission representatives: Market Analysis and Strategic Development department: Eka Kakhidze - ekakhidze@comcom.ge
Public Relations department: Lana Beridze - lberidze@comcom.ge

All related questions/comments with corresponding answers from The Commission shall be published on The Communications Commission's official web-pages: www.comcom.ge and www.5g.gov.ge until July 30, 2020.

Estimation of the market value of frequencies in the range

700 MHz, 800 MHz, 1400 MHz, 1800 MHz, 2100 MHz,

2600 MHz, 3400-3800 MHz

Georgian National Communications Commission

Building a better working world

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Definitions and abbreviations

BTS	Base Transceiver Station – base station of GSM network
BH	Busy Hour
CAGR	Compound Annual Growth Rate
CAPEX	Capital expenditures
EDGE	Enhanced Data rates for GSM Evolution
eNodeB	enhanced NodeB – base station of LTE network
FDD	Frequency Division Duplexing
gNB	Next generation NodeB – base station of 5G network
GPRS	General Packet Radio Service
GSM	Global System of Mobile Communication
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
LTE	Long Term Evolution
NodeB	Base station of UMTS network
NPV	Net Present Value
OPEX	Operational expenditures)
SDL	Supplementary Downlink
TDD	Time Division Duplexing
TRX	TRX Transceiver in BTS
UMTS	Universal Mobile Telecommunications System
WACC	Weighted Average Costs of Capital

1. Summary

This document has been prepared on the basis of the agreement of 24-th October 2019 to estimate the market value of frequencies in the bands 700MHz , 800MHz, 1800MHz, 1400MHz, 2100 MHz, 2600 MHz and 3400-3800Mhz. The study was commissioned by the Georgian National Communications Commission and was not intended to enable any decision to be taken by a third party on its basis. The content of the expert report should be treated only for informational purposes. The Contractor shall not be liable to any entity or natural or legal person which made a decision on the basis of the expert report. The use of the Expert Report by a third party is its sole decision and the third party bears all risks associated with the use of the Expert Report.

The results and content of the analysis are complete and should be read in this form. The frequency estimates presented in this document are based on the methodology presented later in this document and may therefore be different if another methodology, estimate or assumption is used.
The analysis carried out included estimating the value of the frequency band in the 700MHz, 800MHz, 1800MHz, 1400MHz, 2100 MHz, 2600 MHz and 3400-3800Mhz bands using the direct method, i.e. discounted additional financial flows that would have to be incurred by hypothetical mobile operators operating in Georgia if they did not have access to the above frequency band, but were to offer telecommunications infrastructure of similar capacity to the one they could have built if they had obtained such access. Depending on the assumptions made, inter alia, as to the increase in the volume of traffic and its structure, costs of construction and maintenance of telecommunications infrastructure or actions taken by operators to optimize the costs of network operation, the value of the frequency bands were estimated:

Table 1: Results of direct valuation for 700 MHz, 800 MHz and 3400-3600 MHz

Frequency band	Ammount of spectrum	Value of spectrum	Value of spectrum per 1MHz
	MHz	thou GEL	thou GEL / 1MHz
700	60	21,807	363
800	20	14,817	741
700 (SDL)	20	7,820	391
3400-3800	320	16,710	52

***<u>Disclaimer</u> – Limitation to the value analysis**
In accordance with GNCC request, Spectrum Value Analysis were prepared based on discount rate stipulated in the decision 655 / 19 - dated 29 November 2018 (https://gncc.ge/ge/legal-acts/solutions/2018-655-19.page). Respective pre-tax discount rate used is 14.95%. Summary table/report provides value analyses under this specific assumption on WACC.
As of the date of the valuation pre-tax WACC calculated based on effective market and macroeconomic statistical data of comparable companies was 14.15%.

The data traffic projection used in the valuation is based on forecast of mobile data traffic for the Central and Eastern Europe.
For the frequencies 1400 MHz, 1800 MHz, 2100 MHz, 2600 MHz, 3600-3800 MHz calculation was prepared assuming that spectrum will be distributed in Q2 2023.

Table 2: Results of direct valuation for 1400 MHz, 1800 MHz, 2100 MHz, 2600 MHz, 3600-3800 MHz

Frequency band	Ammount of spectrum	Value of spectrum	Value of spectrum per 1MHz
	MHz	thous GEL	thous GEL / 1MHz
1400	90	19,543	217
1800	10	1,719	165
2100	40	6,078	152
2600	180	4,911	27
3600-3800	80	2,692	34

***Disclaimer – Limitation to the value analysis**

In accordance with GNCC request, Spectrum Value Analysis were prepared based on discount rate stipulated in the decision 655 / 19 - dated 29 November 2018 (https://gncc.ge/ge/legal-acts/solutions/2018-655-19.page). Respective pre-tax discount rate used is 14.95%. Summary table/report provides value analyses under this specific assumption on WACC.
As of the date of the valuation pre-tax WACC calculated based on effective market and macroeconomic statistical data of comparable companies was 14.15%.

At the current stage of development of LTE and 5G technology demand for mobile data transmission services, it is impossible to obtain an unambiguous forecast of this size, important for network dimensioning. Difficulties related to the determination of adequate forecasts in this respect may be evidenced both by the extent to which they have proved their worth in recent years and by discrepancies between various forecasts prepared by specialized research units. A particularly rapid change in the way mobile access devices are used, combined with an equally rapid increase in the number of their users, may result in greater uncertainty in the forecast. It should also be taken into account that with the extension of the forecast horizon, the probability of its accuracy decreases. Suffice it to mention that estimates of the volume of mobile data traffic in 2035 assume that this value will increase several dozen times in comparison to 2019.

2. Direct valuation of the frequency bands

2.1 Methodology of direct valuation

The attractiveness of acquiring an additional frequency band for a mobile network operator results primarily from the possibility of incurring lower capital expenditures related to increasing the network capacity than in case of network expansion with existing access to radio resources. Moreover, from the perspective of market development and changes in user needs, an important challenge for mobile operators today seems to be the construction of networks (e.g. based on 5G and LTE technologies), whose capacity would allow for the transmission of rapidly growing traffic volumes and where users could achieve data transfer speeds of several dozen Mbps. It should also be remembered that frequencies in the 700 MHz, 800 MHz and 900 MHz band have additionally better propagation properties than the majority of radio resources currently available to mobile operators (i.e. 1800 MHz, 2100 MHz, 2600 MHz and 3400-3800 MHz), which additionally reduces the costs of possible network development. From the other hand frequencies in band 2600 MHz and 3400-3800 MHz are offering wider bandwidth to develop high capacity base stations capable of handling traffic in densely populated areas. Moreover, wider bandwidth offered in 2600 MHz and 3400-3800 MHz frequency bands are required to fully utilize new functionalities provide by 5G technology (i.a. eMBB, mMTC) and are offering better effective spectral efficiency than networks developed in frequency bands under 1GHz[1].
Therefore, the attractiveness of access to the 700 MHz, 800 MHz, 2600 MHz and 3400-3800 MHz frequency bands should be considered first of all in the category of benefits that an operator could gain while expanding the capacity of the existing telecommunications infrastructure and/or building a new generation LTE/5G network, with or without access to new frequencies.

Assuming that a mobile operator would obtain a frequency reservation in the new frequency band, it could then build a network in 5G technology or expand capacity of existing network in LTE technology on the band made available and transfer surplus traffic from the GSM/UMTS network to that band. In the absence of additional frequency, the operator would have to free up part of the currently used spectrum (900 MHz, 1800 MHz or 2100MHz) bands for the construction of the LTE/5G. However, due to the reduction in the available frequency for GSM/UMTS networks, an increase in the number of base stations would be necessary to maintain the required level of capacity. In addition, the spectrum obtained for LTE/5G networks would be narrower than the spectrum in potentially reserved frequency bands. In order to extend the frequency band allocated to the LTE network, it would then be necessary to free up further resources in used frequency band in the following years from the GSM/UMTS networks and expand the LTE/5G network on these channels. Thus, achieving similar technical parameters without access to additional frequencies would in practice be a much more expensive and difficult task.

Therefore, in order to estimate the maximum value of the valuated bands, it was assumed that it is equal to the discounted additional financial flows that would have been incurred by hypothetical mobile operator, operating in the realm of Georgia, if they did not have access to the above frequency, and would offer telecommunications infrastructure of similar capacity to the one that they could build if they had obtained such access. In other words, the value of the additional bandwidth may constitute a difference between the two:

[1] Results of Nokia measurements presented in IEEE Summit, Rio de Janeiro, November 2018

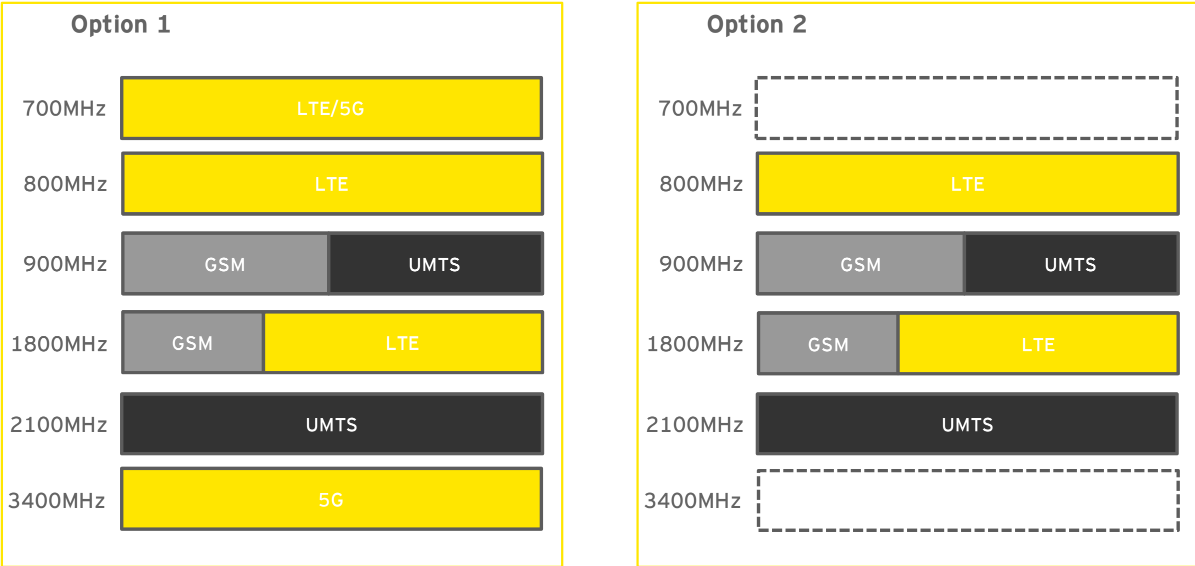
- capital expenditures and operating costs related to the extension and maintenance of the existing network, where 800MHz frequency band is used by LTE network, 900MHz frequency band is used by GSM and UMTS networks, 1800 MHz frequency band is used by GSM and LTE networks, 2100MHz frequency band is used by UMTS networks and additional (valuated*) frequency band is used for construction of LTE/5G networks ("Option 1");

  and

- capital expenditures and operating costs related to the expansion and maintenance of a network based on the already available frequency spectrum, where 800MHz frequency band is used by LTE network, 900MHz frequency band is used by GSM and UMTS networks, 1800 MHz frequency band is used by GSM and LTE networks, 2100MHz frequency band is used by UMTS networks ("Option 2").

A comparison of the described Options for frequencies valuated in Step 1 is shown in Figure 1.

Figure 1: Use of frequency under Option 1 and Option 2 - Step 1



Source: Own study

It is assumed in both options that operators will stop using GSM system by 2028 and UMTS system by 2030 and re-farm frequencies for the purpose of LTE and 5G. The switch-off GSM and UMTS systems need to be correlated with end user requirements. Therefore, the switch-off dates are based on forecasted decommission of user equipment supporting only GSM and UMTS technologies, which is assumed respectively for years 2028 and 2030[2]. This process has been already started in some European countries. According to already announced plans, GSM decommission should be completed until end of 2020 in Netherlands and in Switzerland, until end of 2021 in Lichtenstein and until end of 2025 in Norway. The UMTS decommission should be done until end of 2020 in Norway and Sweden, and until end of 2024 in Switzerland.

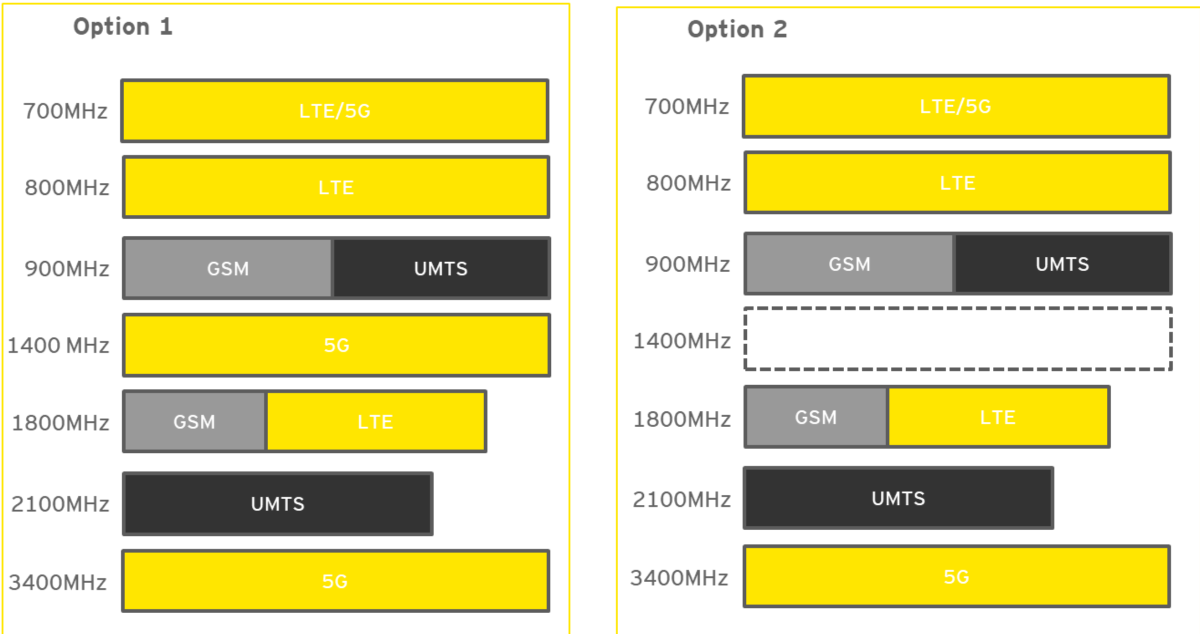
As mentioned earlier, Option 2 will require greater capital expenditures and operating costs than Option 1. This is due to lower frequency range than in option one for LTE/5G networks. This implies lower base station capacity and need to build more base stations in the 5G/LTE network than in the first variant.

[2] Estimation based on Analysis Mason, Central and Eastern European telecoms market: trends and forecasts 2019-2024, November 2019

In the direct valuation methodology, it is crucial to set the order of the frequency allocation. From the perspective of business modeling it is most effective to coordinate the plan of spectrum allocation with the demand for the increase of the network capacity driven by the behavior of end users.

Valuation of the frequencies in Step 2 is prepared using the same approach assuming that all frequencies have been distributed in Step 1. A comparison of the described Options for valuation of 1400 MHz frequency band is shown in Figure 2.

Figure 2: Use of frequency under Option 1 and Option 2 – Step 2



Source: Own study

Such approach is used for all frequencies valuated under Step 2.

2.2 Valuation of the frequency range

As indicated earlier, the attractiveness of acquiring an additional frequency band by a mobile operator is crucially affected by the range of reserved frequencies in the 800 MHz, 900MHz, 1800MHz and 2100MHz bands, as well as the range of additional frequencies to be allocated to mobile operators. Therefore, the analysis includes hypothetical operator using 1/3 of the frequencies available to mobile operators on Georgian market. The assumed frequency reservations are presented in Table 3.

Table 3: Comparison of frequency reservations of real and hypothetical

	Operator 1	Operator 2	Operator 3	Hypothetical
800 MHz	2 x 5 MHz	2 x 5 MHz	2 x 10 MHz	2 x 5 MHz
900 MHz	2 x 11,8 MHz	2 x 13,2 MHz	2 x 5,5 MHz	2 x 10,2 MHz
1800 MHz	2 x 29,9 MHz	2 x 29,9 MHz	2 x 10 MHz	2 x 23,3 MHz
2100 MHz	2 x 15 MHz	2 x 15 MHz	2 x 10 MHz	2 x 15 MHz

The valuation assumes that the valuation of the frequency band is based on the valuation of the band for the hypothetical operator assuming that this operator will acquire 1/3 of the available spectrum. Based on the result of valuation for hypothetical operator, the value of 1MHz of frequency band is calculated and then multiplied by entire available spectrum. The valuation takes into account just the costs incurred by operators in connection with the construction and maintenance of the network and does not take into account the considerations regarding market behavior of operators based on game theory.

2.3 Model construction scheme

As already mentioned, in order to estimate the maximum cost of a frequency reservation, it was assumed that its values result from the difference between the discounted operating costs and the capital expenditure under Option 1 and Option 2 for a hypothetical operator.
The basis for determining infrastructure development and maintenance costs is the size of the network:

- required to handle the assumed volume of traffic that needs to be handled in BH,

  and

- providing the geographical and population coverage of the defined area.

Based on the size of the network (i.e. number of locations, base stations, TRX, etc.), capital expenditures (CAPEX) and operating costs (OPEX) are determined.
The last stage consists in determining the sum of discounted cash flows (investment expenditures and operating costs) for both options of dimensioned networks and calculating their difference, which can be considered as the maximum cost that the operator would be ready to bear for the reservation of a band in the valuated frequency.

2.4 Assumptions regarding network dimensioning

The dimensioning of the network is based primarily on:

- The number of available GSM channels and available UMTS, LTE and 5G bands;
- Traffic volume forecast and its distribution between GSM, UMTS, LTE and 5G networks.

It is assumed that in Step 1 a hypothetical operator in Option 1 would have access additionally to frequencies:

- 2x10 MHz in the 700 MHz frequency,
- 2x5 MHz in the 800 MHz frequency,
- 10 MHz in the 700 MHz frequency for SDL,
- 100 MHz in the 3400-3800 MHz frequency band.

And in Step 2 a hypothetical operator in Option 1 would have access additionally to the frequencies:

- 30 MHz in the 1400 MHz frequency,
- 2x5 MHz in the 1800 MHz frequency,
- 2x10 MHz in the 2100 MHz frequency,
- 60 MHz in the 2600 MHz frequency band,
- 25 MHz in the 3600-3800 MHz frequency band.

In Option 2 it would not have such an access.

In both options it is assumed that with the decline in traffic supported by the GSM network, some radio channels in the 900MHz and 1800 MHz band can be freed up and used by the 5G/LTE system. The number of channels that can be freed is determined optimally, depending on the network load with assumption that one or two radio channels (TRX) within each GSM 900 MHz sector must be reserved to ensure coverage by voice services provide over GSM network at least until 2028, when the GSM decommission is assumed. For example, assuming that a hypothetical operator holds a reservation of 50 channels (10.2 MHz) and a frequency re-use rate in the 900 MHz band would be 10, the total number of channels needed to provide voice coverage would be at least 10 or 20, resulting in a band width of 2 MHz or 4 MHz. The remaining part of the band, i.e. the band of 8 MHz or 6 MHz could be used in short term by existing UMTS 900 system and in long term by 5G/LTE 900 systems.

As the volume of traffic supported by 5G/LTE increases, it would be necessary to extend the 5G/LTE band and include additional frequency bands in the GSM 1800 MHz band. It was assumed, at an initial stage, one radio channel (TRX) within each GSM 1800 MHz sector must be reserved for the provision of voice services. The number of channels reserved for the provision of voice services is optimized in relation to network load. The remaining part of the band could be used by the LTE 1800 system. Subsequently, as GSM traffic decreases, the whole spectrum of GSM 1800 can be freed up and used by the LTE system until full GSM decommission in 2028.

Same approach is adopted for UMTS networks. It is assumed that voice and data traffic will be migrated from UMTS do LTE/5G networks which will allow to gradually release the 900 MHz and 2100 MHz frequencies used by UTMS and allocate them to 5G/LTE systems. The full migration from UMTS to LTE/5G will be achieved after decommissioning of UMTS in 2030. The number of carries use by UMTS system is optimized in relation to network load.

In both variants, the division of voice traffic in the network (GSM, UMTS and 5G/LTE) was optimized in terms of expenditures on its expansion, within the scope limited by the structure of technologies supported by access equipment.

2.5 Assumptions regarding the coverage of network

Data regarding geographical coverage are used to calculate the amount of base station.

Data regarding the population coverage for GSM, UMTS and LTE network were calculated based on data on geographical coverage provided by GNCC present in Table 3. The calculation was done taking into account data regarding the split of area and population to urban and suburban areas. This split of area and population to urban and suburban areas was calculated based on statistical data provided by Georgian statistical office. According to provided data 58.66% of Georgian population inhabits urban areas and 41.34% inhabits rural areas. The 2.56% of total area of Georgia (excluding occupied territories) is urban and 97.44% is rural.

The population coverage for 5G is based on coverage obligations related to license where respectively 30%, 50%, 75%, 90% of populated areas should have 5G coverage in 2,3,5,7 years after issuing license. The geographical coverage of 5G was calculated taking into account the population coverage and statistical data regarding split of area and population to urban and suburban areas.

Tables below are presenting data regarding population and geographical coverage of hypothetical operator by technology

Table 4: Population coverage by technology

	2019	2020	2021	2022	2034
GSM	94%	94%	94%	94%	0%
UMTS	96%	96%	96%	96%	0%
LTE	89%	91%	93%	96%	96%
5G	0%	0%	0%	16%	96%

Table 5: Geographical coverage by technology

	2019	2020	2021	2022	2034
GSM	86%	86%	86%	86%	0%
UMTS	90%	90%	90%	90%	0%
LTE	73%	79%	84%	90%	90%
5G	0%	0%	0%	1%	90%

2.6 Required network capacity

The model calculates the required network capacity taking into account the volume of the traffic generated by subscribers in BH. The required network capacity is calculated taking into account:

- total volume of mobile traffic;
- hypothetical operator's market share in the mobile market;
- internal traffic structure (i.e. daily traffic structure, geographical traffic split, average routing factors),
-

The total volume of mobile traffic consists of:

- volume of voice traffic;
- the volume of SMS and MMS;
- the volume of data traffic.

Volume of voice calls and SMS/MMS messages traffic

The annual volume of voice traffic, SMS and MMS messages for years 2019-2035 were estimated based on the historical data from GNCC Analytical Portal for years 2015-2019 and average growth trend from that period, according to the following formula:

$$d_{t+1} = d_t * a$$

where,

d_t – annual volume of minutes, SMS or MMS in year t,

a - annual growth rate of the voice traffic, SMS or MMS traffic in the period 2015-2018,

Table 6: Annual volume for voice minutes, SMS and MMS

		2019	2020	2021	2022	2 034	CAGR
Voice traffic	(million minutes)	13,996	14,147	14,301	14,456	16,453	1.1%
SMS traffic	(million SMS)	6,673	6,114	5,555	5,047	1,596	-9.1%
MMS traffic	(million MMS)	4	4	3	3	1	-9.1%

Volume of data traffic

The annual volume of mobile data traffic for years 2019-2035 was estimated based on the historical data from GNCC Analytical Portal where data for 2019 were used as a starting point for estimation. The forecast for subsequent years was determined based on the forecast of the mobile traffic increase for the European counties, according to the following formula:

$$d_{t+1} = d_t * a$$

where,

d_t – annual volume of data traffic (PB),

a - annual growth rate of the data traffic.

The annual growth rate of the data traffic is calculated based on forecast of mobile data traffic for the Central and Eastern Europe prepared by Mason Analysis[3]. The forecast of Mason Analysis was compared to other sources e.g. Ericsson Mobility Report from June 2019 and the values were on similar level.

Table 7: Annual volume of data traffic (PB)

		2019	2020	2021	2022	2034	CAGR
Data traffic	**(PB)**	87.73	118.36	150.96	185.39	1 359.43	20.0%
GSM/GPRS	(PB)	1.76	1.36	0.98	0.67	0.00	
UMTS/HSDPA	(PB)	40.32	40.32	40.32	40.32	0.00	
LTE/5G	(PB)	45.65	76.69	109.66	144.41	1,359.43	25.4%

The split of the data traffic to the technologies was prepared taking into account the following assumptions:

- GSM/GPRS traffic trend is calculated based on the forecasted share of GSM only mobile devices,
- UMTS/HSDPA traffic trend is calculated taking into account that number of base stations currently used should not increase, therefore the amount of traffic provided over UMTS/HSDPA should remain on similar level.
- LTE/5G traffic trend is calculated assuming that LTE/5G networks will handle remaining traffic increase.

Market share of the hypothetical operator

The analysis assumed the hypothetical operator's market share at the level of 33.33%.

Assumptions regarding the internal traffic structure

The last factor influencing the volume of traffic in the operator's network is the assumptions concerning the internal traffic structure.

Telecommunication networks are designed to handle peak traffic levels in the network. To determine the peak traffic volume for a given network element, it is necessary to calculate the volume of traffic supported by that network element during the Busy Hour - BH. The volume of BH traffic for each network element is calculated according to a formula:

$$T_{ES} = \sum_{n}^{i} T_n \times f_{RF} \times f_{BH} \times \frac{1}{365} \times \frac{1}{24},$$

Where

T_{ES} - the volume of traffic in the BH for a given network element;

n - service;

i - number of services provided in the network;

T_n – annual traffic volume for the service;

f_{RF} – the average routing factor for the service and the network element;

f_{BH} – the ratio of average traffic volume in BH to average traffic volume per year.

It is assumed that 12% of the daily traffic is generated during Busy Hour. This is an average value calculated on the basis of traffic statistics of selected mobile operators from the CSE region.

[3] Central and Eastern European telecoms market: trends and forecasts 2019–2024, Mason Analysis

The average routing factor is a parameter that determines the average usage of a given network element in the provision of a specific service. Table 7 shows the average usage of radio access network elements by particular voice and data transmission services.

Table 8: Average driving distance BTS / NodeB / eNodeB / gNB

Service	Average routing factor
Voice services	
On-net minutes	2
Incoming minutes	1
Outgoing minutes	1
SMS services	
On-net SMS	2
Incoming SMS	1
Outgoing SMS	1
MMS services	
On-net MMS	2
Incoming MMS	1
Outgoing MMS	1
Data transmission services	1

Source: Own study

For example, for calls made within an operator's network (i.e. calls between two subscribers of the same operator), radio access network elements (BTS / NodeB / eNodeB / gNB) are used on average two times. The call is initiated by a subscriber supported by the first element of the radio access network. It is then transmitted over the backbone network to the second element of the radio access network that supports the subscriber receiving the call.

For outgoing calls to other networks, the radio access network element is used on average once. The call is initiated by the subscriber supported by the first element of the radio access network (BTS / NodeB / eNodeB / gNB). It is then transmitted over the backbone network to the contact point of another operator's network.

In addition, the model assumes the division of the country into two geotypes:

- urban areas, which constitute 2.56% of the country's area;
- rural areas, which constitute 97.44% of the country's area.

The division was made on the basis of data from the National Statistics Office of Georgia.

Assumptions regarding capital expenditures and operating costs

Costs of construction and maintenance cost of infrastructure were estimated on the basis of cost benchmarks incurred by operators in European countries.

Assumptions regarding the calculation of the discount rate

In accordance with GNCC request, Spectrum Value Analysis were prepared based on discount rate stipulated in the decision 655 / 19 - dated 29 November 2018 (https://gncc.ge/ge/legal-acts/solutions/2018-655-19.page). Respective pre-tax discount rate used is 14.95%. Summary table/report provides value analyses under this specific assumption on WACC.
As of the date of the valuation pre-tax WACC calculated based on effective market and macroeconomic statistical data of comparable companies was 14.15%.

2.7 Calculation results for a selected hypothetical operator – 700 MHz

This report presents calculation results for a selected hypothetical operator.

Valuation assumes that the operator has built the network on the obtained frequency reservations in the following range:

- 2 x 5 MHz frequency in the 800 MHz band;
- 2 x 10,2 MHz frequency in the 900 MHz band;
- 2 x 23,3 MHz frequency in the 1800 MHz band.
- 2 x 15MHz frequency in the 2100MHz band.

Moreover, it is assumed that the hypothetical operator would obtain a reservation for a 2x10MHz 700MHz band in Option 1 and use it for the construction of the 5G/LTE network. In Option 2 it would not have had such a reservation.

The difference between the discounted cash flows in Option 2 (no access to 2x10MHz frequency in the 700MHz band) and Option 1 (access to 2x10MHz frequency in the 700MHz band) was estimated at GEL 7.269 mln.

The following paragraphs present the detailed results of the calculations and a summary for all hypothetical operators and frequency value ranges in the 700 MHz band.

2.7.1 Network dimensioning

Table 9 presents a summary of the number of network elements necessary to ensure geographical coverage of present mobile networks, with a capacity sufficient to transfer the present volume of traffic in BH.

Table 9: Network dimensioning in 2019

	Number of elements
Locations	1,073
Base stations	
eNodeB and gNB	723
nodeB	930
BTS	982
TRX	8,826
Transmission links	1,073

Source: Own elaboration

Regardless of the investment variant under consideration, the dimensioning of the network for 2019 is the starting point for the calculation of capital expenditures and operating costs required to be incurred in order to develop and maintain the network in subsequent years of the analysis.

Table 10 shows the number of additional network elements that would be necessary to develop the network to meet the assumed volume of demand. The second and third columns show the number of additional network elements of, respectively, Option 1 (with access to 700 MHz frequency) and Option 2 (without access to 700 MHz frequency) necessary to be built in the period 2020-2025; while the fourth column shows the differences between the number of necessary elements in Option 2 and Option 1 during the period 2026-2034.

Table 10: Comparison of the required additional number of network elements in investment variants in 2020-2025 and in subsequent years

	2020-2025			2026 – 2034		
	Option 1	**Option 2**	***O2 - O1***	**Option 1**	**Option 2**	***O2 - O1***
Locations	1,073	1,073	0	1,512	1,700	188
Base stations						
eNodeB and gNB	1,005	1,059	54	1,512	1,700	188
nodeB	959	959	0	959	959	0
BTS	982	982	0			0
TRX	8,826	8,826	0			0
Transmission links	1,073	1,073	0	439	627	188

Source: Own elaboration

2.7.2 Cash flow

On the basis of the dimensioned networks, both variants estimated the operating costs and capital expenditures that the operator would have to incur to develop the network to a level ensuring assumed geographical coverage of the national territory and capacity to handle the estimated volume of the traffic.

Table 11 presents estimated discounted capital expenditures and operating costs in the period 2020-2034 necessary to be incurred in both Options and their differences.

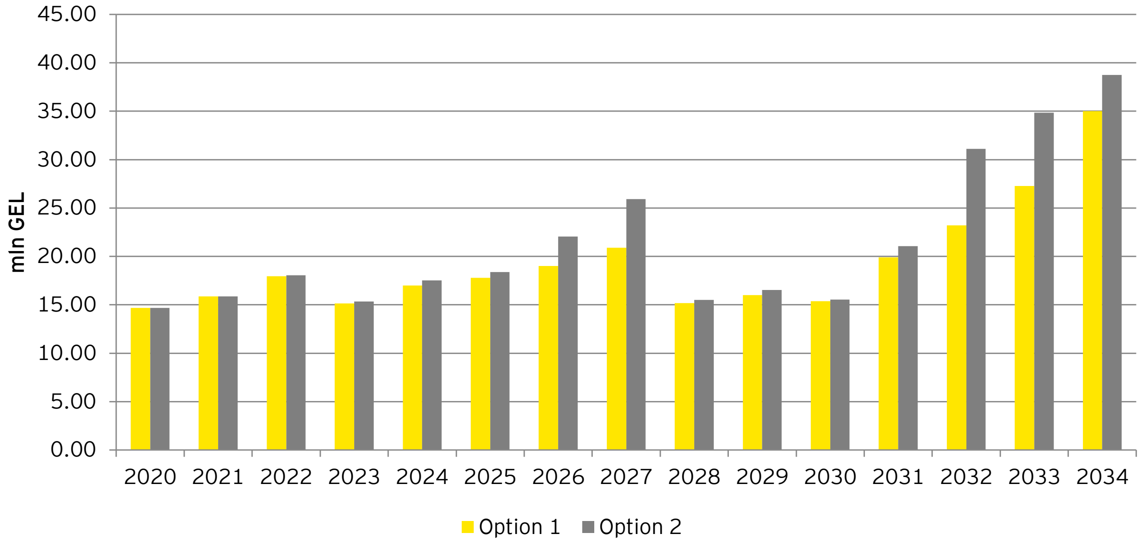
Table 11: Comparison of discounted capital expenditures and operating costs in the considered investment variants [thou. GEL]

	Option 1	**Option 2**	***O2 - O1***
Capital expenditures	20,214	25,762	5,548
Locations	4,666	6,808	2,142
Base stations			
Cabinet	729	1,063	335
Antenna	2,024	2,743	718
Digital Unit	4,804	5,666	862
Radio Unit	5,057	6,903	1,846
TRX - license per one TRX	0	0	0
3G/4G/5G - license per one cell	1,777	891	-886
Transmission links	1,157	1,688	531
OPEX	90,065	91,786	1,721
Direct OPEX	80,588	82,121	1,533
Non-direct OPEX	9,476	9,665	189
SUM	110,279	117,548	7,269

Source: Own elaboration

Diagram 1 presents cash flows in subsequent years of forecasts for the considered network expansion variants.

Diagram 1: Cash flows in subsequent years forecasts for the considered network expansion variants



Source: Own elaboration

2.8 Calculation results for a selected hypothetical operator – 800 MHz

This report presents calculation results for a selected hypothetical operator.

Valuation assume that the operator has built the network on the obtained frequency reservations in the following range:

- 2 x 10 MHz frequency in the 700 MHz band;
- 2 x 5 MHz frequency in the 800 MHz band;
- 2 x 10,2 MHz frequency in the 900 MHz band;
- 2 x 23,3 MHz frequency in the 1800 MHz band;
- 2 x 15MHz frequency in the 2100 MHz band.

Moreover, it is assumed that the hypothetical operator would obtain a reservation for a 2x5MHz 800MHz band in Option 1 and use it for the construction of the 5G/LTE network. In Option 2 it would not have had such a reservation.

The difference between the discounted cash flows in Option 2 (no access to 2x5MHz frequency in the 800MHz band) and Option 1 (access to 2x5MHz frequency in the 800MHz band) was estimated at GEL 7.408 mln.

The following paragraphs present the detailed results of the calculations and a summary for all hypothetical operators and frequency value ranges in the 800 MHz band.

2.8.1 Network dimensioning

Table 12 presents a summary of the number of network elements necessary to ensure geographical coverage of present mobile networks, with a capacity sufficient to transfer the present volume of traffic in BH.

Table 12: Network dimensioning in 2019

	Number of elements
Locations	1,073
Base stations	
eNodeB and gNB	723
nodeB	930
BTS	982
TRX	8,826
Transmission links	1,073

Source: Own elaboration

Regardless of the investment variant under consideration, the dimensioning of the network for 2019 is the starting point for the calculation of capital expenditures and operating costs required to be incurred in order to develop and maintain the network in subsequent years of the analysis.

Table 13 shows the number of additional network elements that would be necessary to develop the network to meet the assumed volume of demand. The second and third columns show the number of additional network elements of, respectively, Option 1 (with access to additional spectrum in 800 MHz frequency) and Option 2 (without access to additional spectrum in 800 MHz frequency) necessary to be built in the period of 2020-2025; while the fourth column shows the differences between the number of necessary elements in Option 2 and Option 1 during the period 2026-2034.

Table 13 : Comparison of the required additional number of network elements in investment variants in 2020-2025 and in subsequent years

	2020-2025			2026 – 2034		
	Option 1	Option 2	*O2 - O1*	Option 1	Option 2	*O2 - O1*
Locations	1,073	1,073	0	1,437	1,512	75
Base stations						
eNodeB and gNB	921	1,005	84	1,437	1,512	75
nodeB	959	959	0	959	959	0
BTS	982	982	0			0
TRX	8,826	8,826	0			0
Transmission links	1,073	1,073	0	364	439	75

Source: Own elaboration

2.8.2 Cash flow

On the basis of the dimensioned networks, both variants estimated the operating costs and capital expenditures that the operator would have to incur to develop the network to a level ensuring assumed geographical coverage of the national territory and capacity to handle the estimated volume of the traffic.

Table 14 presents estimated discounted capital expenditures and operating costs in the period 2020-2034 necessary to be incurred in both Options and their differences.

Table 14: Comparison of discounted capital expenditures and operating costs in the considered investment variants [thou. GEL]

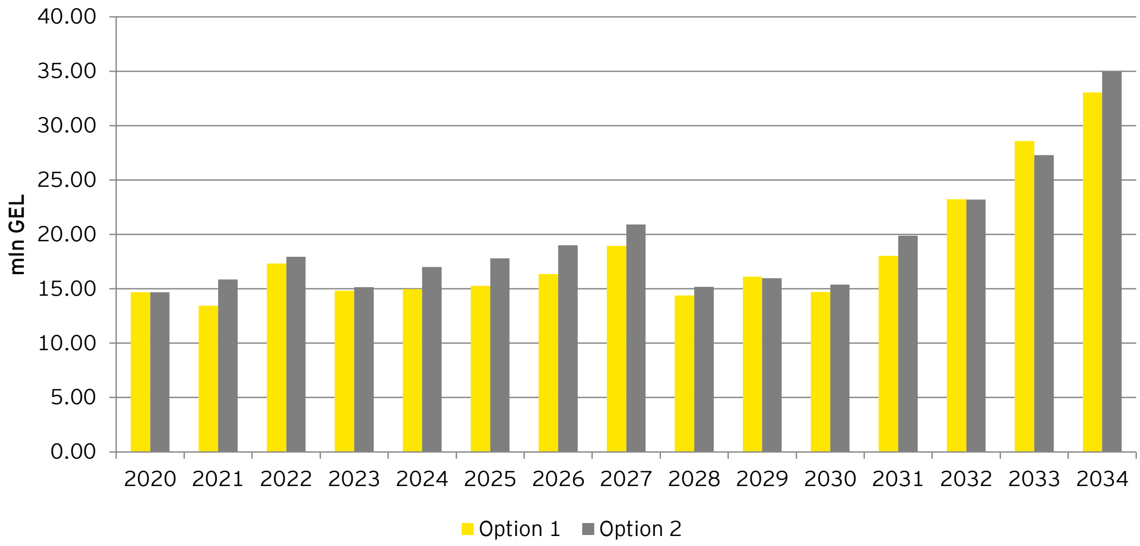
	Option 1	Option 2	*O2 - O1*
Capital expenditures	15,004	20,214	5,210
Locations	3,091	4,666	1,575
Base stations			

	Option 1	Option 2	*O2 - O1*
Cabinet	483	729	246
Antenna	1,521	2,024	503
Digital Unit	3,839	4,804	965
Radio Unit	3,735	5,057	1,322
TRX - license per one TRX	0	0	0
3G/4G/5G – licenses	1,569	1,777	208
Transmission links	766	1,157	391
OPEX	87,866	90,065	2,198
Direct OPEX	78,619	80,588	1,969
Non-direct OPEX	9,247	9,476	229
SUM	102,871	110,279	7,408

Source: Own elaboration

Diagram 2 presents cash flows in subsequent years of forecasts for the considered network expansion variants.

Diagram 2: Cash flows in subsequent years forecasts for the considered network expansion variants



Source: Own elaboration

2.9 Calculation results for a selected hypothetical operator – 3400 MHz-3800 MHz

This paragraph presents valuation results for frequencies 3400 MHz-3800 MHz results for a selected hypothetical operator.

Valuation assumes that the operator has built the network on the obtained frequency reservations in the following range:

- 2 x 10 MHz frequency in the 700 MHz band;
- 2 x 10 MHz frequency in the 800 MHz band;
- 2 x 10,2 MHz frequency in the 900 MHz band;
- 2 x 23,3 MHz frequency in the 1800 MHz band.
- 2 x 15MHz frequency in the 2100MHz band.

Moreover, it is assumed that the hypothetical operator would obtain a reservation for a 100 MHz 3400-3800 MHz band in Option 1 and use it for the construction of the 5G network. In Option 2 it would not have had such reservation.

The difference between the discounted cash flows in Option 2 (no access to 100 MHz frequency in the 3400-3800 MHz band) and Option 1 (access to 100 MHz frequency in the 3400-3800 MHz band) was estimated at GEL 5.222 mln.
The following paragraphs present the detailed results of the calculations and a summary for all hypothetical operators and frequency value ranges in the 3400 MHz-3800 MHz band.

2.9.1 Network dimensioning

Table 15 presents a summary of the number of network elements necessary to ensure geographical coverage of present mobile networks, with a capacity sufficient to transfer the present volume of traffic in BH.

Table 15: Network dimensioning in 2019

	Number of elements
Locations	1,073
Base stations	
eNodeB and gNB	723
nodeB	930
BTS	982
TRX	8,826
Transmission links	1,073

Source: Own elaboration

Regardless of the investment variant under consideration, the dimensioning of the network for 2019 is the starting point for the calculation of capital expenditures and operating costs required to be incurred in order to develop and maintain the network in subsequent years of the analysis.

Table 16 shows the number of additional network elements that would be necessary to develop the network to meet the assumed volume of demand. The second and third columns show the number of additional network elements of, respectively, Option 1 (with access to 100 MHz frequency in the 3400-3800 MHz band) and Option 2 (without access to 100 MHz frequency in the 3400-3800 MHz band) necessary to be built in the period 2020-2025; while the fourth column shows the differences between the number of necessary elements in Option 2 and Option 1 during the period 2026-2034.

Table 16: Comparison of the required additional number of network elements in investment variants in 2020-2025 and in subsequent years

	2020-2025			2026 – 2034		
	Option 1	Option 2	*O2 - O1*	Option 1	Option 2	*O2 - O1*
Locations	1,073	1,073	0	1,106	1,461	355
Base stations						
eNodeB and gNB	866	946	80	1,239	1,461	222
nodeB	959	959	0	959	959	0
BTS	982	982	0			0
TRX	8,826	8,826	0			0
Transmission links	1,073	1,073	0	33	388	355

Source: Own elaboration

2.9.2 Cash flow

On the basis of the dimensioned networks, both variants estimated the operating costs and capital expenditures that the operator would have to incur to develop the network to a level ensuring assumed geographical coverage of the national territory and capacity to handle the estimated volume of the traffic.

Table 17 presents estimated discounted capital expenditures and operating costs in the period 2020-2034 necessary to be incurred in both Options and their differences.

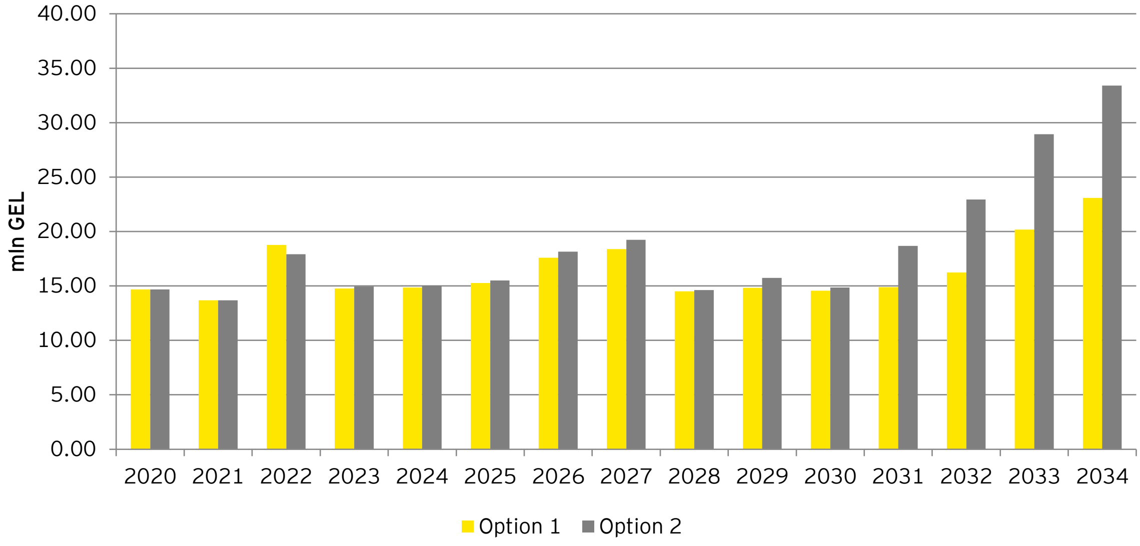
Table 17: Comparison of discounted capital expenditures and operating costs in the considered investment variants [thou. GEL]

	Option 1	Option 2	*O2 - O1*
Capital expenditures	11,958	16,285	4,327
Locations	2,026	3,490	1,464
Base stations			
Cabinet	316	545	229
Antenna	1,472	1,618	146
Digital Unit	3,270	4,109	840
Radio Unit	3,056	4,028	972
TRX - license per one TRX	0	0	0
3G/4G/5G - license per one cell	1,315	1,628	313
Transmission links	502	865	363
OPEX	87,532	88,428	895
Direct OPEX	78,326	79,122	796
Non-direct OPEX	9,206	9,306	100
SUM	99,491	104,713	5,222

Source: Own elaboration

Diagram 3 presents cash flows in subsequent years of forecasts for the considered network expansion variants.

Diagram 3: Cash flows in subsequent years forecasts for the considered network expansion variants



Source: Own elaboration

2.10 Calculation results for a selected hypothetical operator - 700 MHz SDL

This paragraph presents valuation results for frequencies 700 MHz SDL results for a selected hypothetical operator.

Valuation assumes that the operator has built the network on the obtained frequency reservations in the following range:

- 2 x 10 MHz frequency in the 700 MHz band;
- 2 x 10 MHz frequency in the 800 MHz band;
- 2 x 10,2 MHz frequency in the 900 MHz band;
- 2 x 23,3 MHz frequency in the 1800 MHz band;
- 2 x 15MHz frequency in the 2100MHz band.

Moreover, it is assumed that the hypothetical operator would obtain a reservation for an unpaired 10MHz in the 700MHz SDL band in Option 1 and use it for the construction of the 5G network. In Option 2 it would not have had such reservation.

The difference between the discounted cash flows in Option 2 (no access to 10 MHz unpaired frequency in the 700 MHz band) and Option 1 (access to 10 MHz unpaired frequency in the 700 MHz band) was estimated at GEL 3.910 mln.

The 700 MHz SDL frequency band is the sum of valuations of the 10 MHz bands for two hypothetical operators, the valuation value amounts to GEL 7.820 million.

2.11 Results of frequency band valuation 700 MHz, 800MHz and 3400 MHz - 3800 MHz

The valuation of the entire 700 MHz frequency band is the sum of valuations of the 20 MHz bands for three hypothetical operators and a prior assumption that within the framework of the auction procedure operators will be able to obtain a maximum booking of 2 x 10 MHz bands, the valuation value amounts to GEL 21.807 million.

The valuation of the entire 800 MHz frequency band is the sum of valuations of the 10 MHz bands for two hypothetical operators, the valuation value amounts to GEL 14.817 million.

The valuation of the entire 3400 MHz – 3800 MHz frequency band is valuated assuming 100 MHz per one hypothetical operator. The valuation value amounts to GEL 16,710 million.

The 700 MHz SDL frequency band is the sum of valuations of the 10 MHz bands for two hypothetical operators, the valuation value amounts to GEL 7.820 million.

2.12 Valuation of frequency bands 1400MHz, 1800MHz, 2100MHz, 2600MHz and 3600-3800Mhz

Results of direct valuation are strictly related to the allocation of spectrum in the 1-st Step and allocation date of the spectrum bands in 2-nd Step. Additionally, it is assumed that each frequency in 2-nd Step is allocated separately, as an additional frequency to the scenarios defined in Step 1. Taking into account the above if any of those assumptions will change the spectrum valuation results should be recalculated. The calculation is prepared for a selected hypothetical operator.

The valuation of 1400MHz, 1800MHz, 2100MHz, 2600MHz and 3600-3800Mhz have been prepared taking into account same approach as frequencies 700 MHz, 800 MHz and 3400-3800Mhz. So, it calculates as a difference between the discounted cash flows in Option 2 (no access to valuated spectrum) and Option 1 (access to valuated spectrum).

Valuation assumes that the operator has built the network on the obtained frequency reservations in the following range:

- 2 x 10 MHz frequency in the 700 MHz band;
- 2 x 10 MHz frequency in the 800 MHz band;
- 2 x 10,2 MHz frequency in the 900 MHz band;
- 2 x 23,3 MHz frequency in the 1800 MHz band.
- 2 x 15MHz frequency in the 2100MHz band.
- 100 MHz frequency in the 3400-3800 MHz band.

The results of the calculation for the whole spectrum are presented in the table below.

Table 18: Results of direct valuation for 1400 MHz, 1800 MHz, 2100 MHz, 2600 MHz, 3600-3800 MHz – total spectrum value

Frequency band	Ammount of spectrum	Value of spectrum	Value of spectrum per 1MHz
	MHz	thous GEL	thous GEL / 1MHz
1400	90	19,543	217
1800	10	1,719	165
2100	40	6,078	152
2600	180	4,911	27
3600-3800	80	2,692	34

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