WIK-Consult • Report

Nkom Consultation on the Product Market for Broadband Access from 29 November 2021

Submission on behalf of
Tv2 and Riks TV

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Content

1 Introduction

1. WIK-Consult has been asked and mandated by TV2 which is the commercial public broadcaster in Norway, and RiksTV which is a TV content distributor over several technical platforms to provide a submission to Nkom's consultation on the product market for broadband access from 29 November 2021 on 28 December 2021.

2. This report is prepared for TV2 and RiksTV. Nevertheless, it is brought to the attention of Nkom as an independent expert opinion.

3. WIK-Consult is a German consultancy company with a broad expertise in telecommunications market regulation throughout Europe and beyond and the underlying communications technologies and their capabilities. WIK-Consult supported the European Commission e.g. in their recent recommendation on relevant markets and in the definition of the European Electronic Communications Code (EECC).

4. This report has been prepared by Dr Karl-Heinz Neumann, Dr Thomas Plückebaum and Dr Sonia Strube Martins.

5. Dr Karl-Heinz Neumann is an Economist specialised in regulatory economics. He acted as General Manager and Director of WIK and WIK-Consult until the end of 2014. Since then he works as Senior Advisor to WIK-Consult as well as to other international economic research and consultancy teams. Karl-Heinz has a broad experience in the consultancy of regulatory authorities, governments and telecommunications companies for more than 40 years. He has led and is leading WIK-teams in more than 100 European (and other parts of the world) regulatory policy consultancy projects. His main focus of work is related to cost modelling, pricing policy, market structures, regulatory policy, margin squeeze, broadband policy and fibre networks. Karl-Heinz also has a telecommunications industry experience as Member of the Board and as Member of the Supervisory Boards of several national and international telecommunications companies.

6. Dr Thomas Plückebaum is an economist and telecommunications engineer and has more than 40 years of professional experience in telecommunications, network planning, implementation, operations and evaluation with several network operators in Germany. Inter alia he has designed, implemented and operated a fibre based cable-TV network with DOCSIS technology in the metropolitan area around Düsseldorf/ Germany. He now works as a technical end economical expert and is a Director of WIK and WIK-Consult, Germany. His work includes studies on modern telecommunication network technologies and architectures, their technical capabilities, their cost structures and their profitability, their regu-

latory implications and how all of these will evolve in the future. Cable-TV DOCSIS and FTTH networks are an integral part of his work.

7. Dr Sonia Strube Martins is an economist specialized in regulatory economics, digitization of markets and business strategies. She has worked as Senior Economist for 10 years from 2000 to 2010 in one of WIK's regulatory research groups. From 2010 until 2014 she lived in Zurich where she worked as project leader for Swiss Economics from 2012 until 2014. Since 2015 she is working as Senior Consultant for WIK in the Business and Strategies department. She has gathered extensive consulting experience in market definition and market analysis under the European legal framework. Among others, she has worked on several projects on electronic communications services for non-residential customers in Germany as well as on the market definition and analysis of broadband markets. She has worked as an economic consultant to the Irish, Portuguese, German and Greek regulatory authorities and participated in various studies on regulatory issues such as the study for the European Commission on relevant electronic communication markets and the evaluation of the broadband cost reduction directive (BCRD). She has worked on various projects related to broadband rollout and demand for broadband infrastructure.

8. This submission is structured as follows. In Chapter 2 we provide our general view on the telecommunications market in Norway. Chapter 3 provides our response to Nkom's specific consultation questions. Chapter 4 concludes our analysis.

2 Our view on the Norwegian market

9. Nkom will have to conduct its upcoming market definition and market analysis in an environment where several major developments and changes in the access infrastructures have occurred or are still ongoing compared to the last market analysis in 2018. The most important developments are the following ones:

   a) Fibre coverage has achieved already the rather high level of 76% and is further growing to come close to 100% within this decade.

   b) More and more cable networks are upgraded from DOCSIS 3.0 to DOCSIS 3.1.

   c) The decisions to switch-off the copper network are taken and the process of the shut-down of MDFs is accelerating.

   d) FWA plays a relevant role in serving customers in certain areas and in serving certain customer groups (e.g. second homes).

10. These developments lead or will lead to quite different scenarios of infrastructure availability in various regions/areas of Norway in a forward looking perspective:

   a) Areas with only one fibre infrastructure.

   b) Areas with two fibre networks.

   c) Areas with one fibre and one cable network.

   d) Areas where there is only FWA access.

   e) Fibre and/or cable areas with some FWA at the margin.

   In a forward looking perspective the copper network will no longer be available as a broadband access platform.

11. The various scenarios of infrastructure availability seem to result in quite different competitive conditions in different areas of the country. Thus, a careful assessment of the need for a geographic definition and segmentation of market seems necessary. There is reason to assume that a regional definition of markets may be the outcome of the market analysis process.

12. It is hard to imagine that the broadband access markets in Norway will be competitive without access regulation measures and remedies. Fibre will be outcompeting other access technologies and will become the sole fixed-line infra-

structure in many areas. Even markets or market segments where two access infrastructures are available may not prove to be effectively competitive.

13. From an outside perspective, the whole or at least major parts of the Norwegian market seem to be characterised by an SMP market positon of one network operator. In some areas the preponderance of joint dominance by two operators cannot be excluded and has to be tested.

14. Given the infrastructural characteristics of the Norwegian market the regulatory instrument of symmetric regulation of operators providing broadband access might even be a viable option to generate competition in the market.

3 Addressing the consultation questions

3.1 Which of the changes and developments identified shall be highlighted in Nkom's assessment of the relevant end-user product market(s) in a forward looking perspective?

15. The most challenging development for Nkom's market analysis of fixed broadband access will be in our view the irrelevance of the copper access network as a technical platform to provide broadband access. Given the current path of migration of end-users away from the copper network and Telenor's/Nkom's decision to close the copper network by September 2025, the copper network will be a negligible technical platform to provide broadband access when Nkom will make its regulatory decisions on the fixed broadband access market(s) in 2023. By then, only a few thousand customers will still use the copper network either as direct retail customers of the incumbent or as customers of wholesale access seekers.

16. For the prospective view on the market development in the following five years the copper network is irrelevant, because it will be completely closed down in 2025 and the remaining (few customers) will be migrated to other technical platforms. Telenor intends to close down all MDFs by then and replace the copper lines with different technologies, e.g. FTTH, FWA, mobile networks and HFC. The MDF close down started with small and rural MDFs.[1] The larger urban MDFs are likely to be the last ones to be decommissioned.

17. Nkom will be one of the first if not the first European NRA which will have to conduct its market analysis of the market for wholesale local access provided at a fixed location in an infrastructure environment without a copper access network. This means that there is no (relevant) precedence or benchmark Nkom can rely its own analysis upon. Instead, Nkom has to be the innovative NRA which has to solve and manage a major new regulatory challenge which will become a precedent and benchmark for other NRAs. Also the new recommendation of the European Commission (EC) on relevant markets[2] which Nkom intends to apply for its own analysis still foresees and rests on the assumption that xDSL and therefore the copper network remains the largest broadband access platform in the (relevant) near future. In that respect the European recommendation rests on assumptions which are no longer valid in and representative for the Norwegian broadband market.

1 See BEREC (2019), p. 8ff.
2 See EU (2020a) and (2020b).

18. This development is highly relevant also insofar as the (nationwide) availability of the copper access network of the incumbent telco operator is a central pillar of the current regulatory framework for fixed broadband access as determined by Nkom in its regulatory decisions relating to market 3a in 2018.[3]

19. The possible upgrade of the copper access network and its disciplinary effect on the pricing of local fibre operators was a relevant factor for Nkom in defining the broadband access market geographically as a national market. The actual and/or potential competitive threat by the copper access network no longer prevails to a great extent presently and ceases to prevail when the copper network is fully closed down.

20. Developing a regulatory framework in a market environment where fibre is the dominant access infrastructure therefore is the main task for the upcoming market analysis. This framework has to be designed to cope with a market structure where there is in major areas of the country no or only a limited competition between different technological infrastructures. Remaining relevant terrestrial infrastructures are FTTH and HFC (cable-TV) networks. Although there are several operators rolling out fibre networks it remains to be critically assessed to what extent there is parallel roll-out of fibre networks resulting in effective and sustainable competition at retail level.

3.2 Are there other changes or developments as summarized by Nkom which need to be taken care of and assessed in the definition of relevant end-user product markets by Nkom in a forward looking view of the market?

21. We see two developments in the Norwegian market which need special attention in market definition and analysis of Nkom and which are not referred to in the consultation document: (a) Bundling of services and the vertical integration of telcos and (b) geographic segmentation of the market(s).

(a) Bundling of services

22. Bundling of telecommunications services and of telecommunications services with other services like TV content is a predominant strategy of telecom operators in Norway. The big telecom operators have vertically integrated the provision of TV content. Bundling is used to safeguard revenues and to reduce churn. It is also used to foreclose markets in particular against standalone service offerings such as traditional TV distribution but also increasingly streaming services. The provision of exclusive content, in particular with reference to the transmis-

3 See Nkom (2018a) and (2018b).

sion of sport events, allows vertically integrated broadband access and TV content providers to leverage market power from content markets into broadband access markets. Also SMP on broadband markets can potentially be leveraged into content markets. Nkom should therefore consider and include product bundling into its definition and analysis of the broadband retail market(s).

23. Nkom should give special attention to bundling because the barriers for switching providers are likely higher for bundled customers than for subscribers of several standalone services. Bundling generates lock-in effects and (higher) switching costs for customers. The lock-in effect of bundling may thus make it more difficult for operators to attract customers from their competitors.

24. Given the high relevance of bundling in Norway, it will become a key issue in the market definition and analysis, whether (separate) bundled markets may be identified at the retail level and, whether at the wholesale level, all inputs are available or can be supplied on a competitive basis to enable competition in the bundled retail service(s) market(s). We see a lot of reasons to define bundled services at the retail level as separate markets in Norway. At least, this issue has to be comprehensively assessed as part of market definition and analysis.

25. Special attention should also be given to the importance which exclusive content rights and price discounts for bundled vs. standalone services have in the bundling strategies of operators.

26. As a rule, the bundled services are offered at a lower price than the sum of the standalone prices for these services. In the bundles, services can be tailored to the customer in various combinations. End-customers also benefit from the fact that they only receive one bill and are looked after by one customer service. However, depending on the type of bundling, it can also lead to end-customers having to purchase services in the bundle that have no added value for them. Bundling may also lead to customers committing to several services for the duration of lock-in periods. Bundling can also reduce price and product transparency. Recent distribution conflicts between Norwegian telcos and broadcasters indicate the competitive distortions caused by actual bundling behaviours.

27. The bundling of services tends to reduce the willingness of customers to switch to the standalone services included in the bundles, if it is not possible to terminate the contract for an individual component of the bundle. If services are offered exclusively in bundles, end-customers will have fewer choice, not only between standalone products, but also between providers of standalone services.

(b) Geographic segmentation of the market(s)

28. To date NRAs have found most markets to be national because the incumbents' copper network had a national coverage. However, as the deployment of alternative networks progresses, competitive conditions can vary significantly and sustainably between different areas of a country, e.g. between urban and rural areas. Significant variations of competitive conditions have to be taken into consideration on a forward looking basis already at the stage of market definition. Thus, making it necessary to define separate geographic markets.

29. This issue has high relevance for the Norwegian market because the (nationwide available) copper network will no longer be a relevant broadband infrastructure nor a telecommunications infrastructure at all. This is actually the case for the upcoming market analysis.

30. Variations of competitive conditions are already and will primarily be defined by the availability of infrastructures in various areas of the country. In Norway the following infrastructure scenarios are prevalent in different parts of the country:

(a) Only one FTTH infrastructure,

(b) Two FTTH networks,

(c) Only one HFC network,

(d) One FTTH and one HFC network,

(e) Two FTTH networks and one HFC network.

We do not include the prospective overlap of HFC networks into consideration since there is no overlap of the infrastructure provided by the large HFC operators today and it is not likely that it will happen in future. Instead, if there is economic viability for a second infrastructure in an area it will be fibre. We did not include FWA into these scenarios because we see FWA access mostly complementary and not substitutable to HFC and FTTH.

31. These infrastructure scenarios cannot only be analysed statically because operators continue to invest in infrastructure. This may add the following prospective scenarios:

(f) Deploying a second FTTH network,

(g) Deploying a (new) FTTH network in a cable area,

(h) Upgrading an HFC network to an FTTH network.

These prospective infrastructure scenarios have to be mapped as part of the market definition to be able to analyse competitiveness of the respective markets, because it is obvious that competitive conditions are different in each of the infrastructural scenarios identified above with regard to actual and potential competition. However, it is important to emphasize that merely the presence of several infrastructures does not imply that there is sustainable competition. The mapping of network infrastructure has to be linked with an analysis of market shares and prices to assess competition in a certain area.

32. Competitive conditions on retail markets provide the starting point for geographical market analysis. This should be carried out following a modified Greenfield approach. This means conditions should be considered in the absence of ex ante SMP regulation. Thus, competition between different network infrastructures are key for conducting this analysis. Differences in product offerings and pricing between different regions/areas which do occur or would occur in the absence of SMP regulation are also relevant. This analysis of the retail market is an important basis for the wholesale market analysis.

3.3 Will todays copper access broadband customers consider broadband via FTTH, HFC or FWA as substitutable products once the supply of broadband access over the copper network expires?

33. If the current speed of migration from xDSL to other broadband access infrastructures prevails, only between 1% and 2% of all broadband connections will be provided by the copper access network by the end of 2023, when the new market analysis phase begins. By the end of 2025 broadband access over the copper access network will no longer be provided, if Telenor will manage the MDF shut down as planned. This may even be earlier, if Telenor and its access seekers follow an approach of forced migration of customers.

34. If the developing path of copper-based broadband access properly anticipates the upcoming reality, it will in our view not be appropriate to further consider copper-based broadband access as part of the relevant end-user broadband access market. Even if there would be chain substitution between copper-based and broadband access products provided over other infrastructures, relying on such results for the upcoming market analysis could be misleading for three reasons.

35. Firstly, consumer behaviour in a shut-down scenario is different than in a stable market scenario where users have choice. Choice in a shut-down scenario, however, is limited insofar as users do not longer have the choice to stay with their current product. They only have the option to choose a different product

which may or may not be similar to the current product chosen or to step away from (fixed) broadband access and become a mobile-only customer.

36. Secondly, chain substitution is also heavily influenced and distorted by pricing and other supply-side (incentive) measures from operators to motivate customers to actively migrate away from the copper access network. Operators might even terminate the customer contract in a forced migration phase.

37. Thirdly, including a product into the relevant market and product definition which only has a minor importance in the beginning of the relevant prospective market analysis period and is no longer present for all or most of the relevant period, may lead to misleading conclusions in the market analysis: Market structure may be assessed wrongly, because suppliers will be included in the analysis which are not relevant in a forward looking perspective. Low priced products may be included in the market analysis and suggest competition although such offerings do not survive in the long- or even medium-term or may also only be relevant in a minor area. This holds in particular, because the relevant information for conducting the market analysis will be collected and assessed one to two years before Nkom will make its final decisions and determinations. A product in a downward dynamic is hard to assess properly.

38. The best regulatory approach to deal with these economic and market dynamic characteristics of copper-based broadband access will in our view be to treat copper access as a separate product market. This will enable to define an appropriate, efficient and proportionate regulatory approach to protect customers which still will use the copper network either as end-users or as access seekers.

39. We agree with Nkom’s assumption that the migration of end-users from copper-based access to broadband products provided over other infrastructures can generate information on the assessment of the substitution between alternative access technologies. The findings on this migration has, however, to be collected in a rather granular form. Otherwise, misleading interpretation may occur.

40. First of all, aggregated data of migration from copper access only allows for a limited assessment of substitution between alternative access technologies. In some regions/cities/municipalities/MDF areas customers can only migrate either to FTTH, to HFC or to FWA. In those areas customers de facto do not have the choice between different (fixed) access technologies. They can only select one particular fixed access technology or become a mobile-only user (or leave the system totally and become a non-liner).

41. In other areas users may have the choice between two or three fixed access technologies. To assess demand-side substitutability Nkom has to collect the

relevant data in a granular way such that the available access options for customers are included.

42. Even if customers can choose between different access technologies in a certain area, the consumer decision to migrate may still be influenced or even distorted by a certain migration policy of the operator. He may set migration incentives such that the choice of customers is distorted. In particular, if the operator only offers to migrate to one particular alternative infrastructure, customer choice is strongly distorted.

43. To assess demand-side substitutability also the particular product characteristics (e.g. download speed) of the copper-based product(s) and the new product(s) have to be taken into consideration. Remaining customers of the copper network may have different demand patterns. Often they are telephony-only users or the copper access line is used for other purposes than broadband access, e.g. for alarm systems or elevator emergency call systems.

44. The relevance of bundling also plays a role in this context, in particular if certain technologies do not allow competitors to replicate bundles with TV content. In this context it is very important to analyse geographically differentiated data to be able to assess whether the technology an end-user migrates to is only used in less dense areas (e.g. mobile networks when there is no business case for fibre roll-out). In this case the technology is used complementarily to fibre or cable technology. In particular with reference to bundled services, there will not be infrastructure based competition relying on FWA or mobile networks unless they are capable to provide sufficient quality for such bundles.

45. In summary, migration of copper network customers to alternative fixed access technologies may provide some information on demand-side substitutability. In any case, the relevant data have to be collected and interpreted on a granular level. Overall, we believe, migration generates limited information on substitutability in a forward looking perspective because of the peculiarities of the migration situation.

3.4 To what extent are broadband access products provided over FTTH and HFC recognized as substitutable products on the basis of product characteristics, price and applications in a forward looking perspective?

46. This question has two dimensions: Firstly, it addresses objective differences of access products provided over FTTH and HFC networks. Secondly, it addresses the recognition of such differences by customers.

47. While FTTH coverage was 76% in mid 2021, HFC coverage was 49% in 2018 and did not expand since then according to Nkom. HFC coverage has increased slightly from 2014 to 2016, but fell in 2018 back to the 2016 level of 49%.[4] Almost all the households with HFC coverage are now offered DOCSIS 3.0.

48. The DOCSIS technology has originally been introduced for the cable based distribution of TV-signals, taking a coaxial cable string connecting all homes served, which is ideally suited for transmitting high bandwidth TV-signals in a broadcast manner, meaning all customers have been connected to the copper wire, thus receiving the same TV-signal, transmitted downstream unidirectional from the receiving head-end to the customer's TV-sets. This approach has later been amended by the capability of bidirectional data communication, separating the frequency band on the coax cable, resulting in two downstream bands, one for TV- and radio signals and a second for data downstream. Another frequency band is dedicated for data upstream communications. This data communication capability is called DOCSIS.[5] All frequency bands are provided over the same copper wire, thus have to be used in a shared manner among all end-customers connected. Regarding the TV-signals it has no impact on communication privacy, but individual data communications need some additional provisions of preventing collisions by reserving individual time slots for the end customers sending upstream and addressing the end-customers explicitly for individual downstream communications. Hence, all end-customers connected to the same coax-cable share the data communication capacity on this shared transmission medium.

49. Such sharing also happens in radio communications (Mobile or FWA, using the same frequency bands for many end-customers) or in PtMP fibre networks (point-to-multipoint), where the end-customer connections are spliced to one single fibre strand by splitters. Such networks have a specific characteristic: the effective bandwidth of the end-customer's communication depends on the other users' behaviour at the same time. The telephone copper networks of the past (copper wire pairs) and the modern FTTH PtP (point-to-point) networks instead offer individual physical connections between the end-customers home and the local exchange locations and thus are unshared media offering its full capacity to each individual end-customer.

50. In DOCSIS networks the central access control unit is called CMTS (Cable Modem Termination System). The control unit at each end-customer site is the cable-modem. In PtMP networks the OLT (Optical Line Terminator) at the central site coordinates the access hand in hand with all end-customer ONU (Optical

4 See Nkom (2018a), p. 80.
5 Data Over Cable Service Interface Specification.

Network Unit). The common name for such splittered fibre technologies is GPON (Gigabit Passive Optical Network).

51. State-of-the-art DOCSIC technology are the releases 3.0 and 3.1, Release 4.0 is under development. They differ in the kind and width of the frequency use on the copper wire in total and in its allocation to TV and radio communication at the one hand and to the bidirectional data communication at the other hand, allowing higher data communication capacity especially for the latter.[6]

52. There are 4 GPON technologies market available, called GPON, XG.PON, XGS.PON and NG.PON2 providing increasing bandwidth and up-/downstream symmetry and splitting factors in the order mentioned.[7]

53. In order to reduce the (limiting) bandwidth effect of sharing for the end-customers, one can reduce the size of the shared media areas, thus reducing the number of end-customers accessing the same copper or fibre strand. In DOCSIS networks such approach is called fibre node splitting or deep fibre, in Fibre PtMP networks it is controlled by the splitting factor used.

54. The comparison of the different fixed access broadband technologies will concentrate on end-customer observable criteria. We do not comment the differences in the provision of wholesale services. Customer observable criteria are predominately qualitative criteria such as:

- Capacity (i.e. speed), up- and downstream, stability/uniformity
- Latency/ delay
- Jitter/ variability/ congestion/ packet loss
- Electromagnetic sensitivity/ packet loss
- Humidity/ water sensitivity
- Reliability/ vulnerability
- Ease of provider change by end-customer
- Upgrade path

According to these criteria the coax cable access network technology is inferior to copper pair and both are significantly inferior to the FTTH technology, as detailed below.

Capacity, up- and downstream, stability/uniformity

55. The copper pair access technologies all suffer from line length dependent capacities, which even vary in neighbouring surroundings, thus there is no uniform

6 DOCSIS 3.0: 120 Mbps up-, 1,200 Mbps downstream; DOCSIS 3.1: 1,000 Mbps upstream, 10,000 Mbps downstream; DOCSIS 4.0: 10;000 Mbps for both directions.

7 GPON: 1,250 Mbps up, 2,500 Mbps down, XG.PON: 2,500 up, 10,000 Mbps down; XGS.PON: 10,000 Mbps for both directions, NG.PON2: n x 10,000 Mbps for both directions, n up to 8 times on different wavelengths.

bandwidth offer in a neighbouring area. Some technologies[8] also depend in their capacity on the number of neighbours active at the same time. Supervectoring and G.fast may compete with the peak bandwidth of DOCSIS 3.0 networks. But both by far cannot compete with an FTTH network like XGS.PON, neither in capacity (more than 10-fold more)[9] nor in the stability of the bandwidth and its uniformity. With DOCSIS 3.1 the capacity gap to FTTH will be reduced, but the other characteristics (and limitations) remain unchanged.

Latency/ delay

56. Latency is the time required for the information passing through a communication system from its entry to the network until it reaches the other end of the connection. Assume that the capacity of the access line is sufficient for the data volume transmitted, the latency of the transmission is predominately determined by the number of active electronic systems passed by in the access network and by the complexity of the algorithms applied. Any of the systems contributes to and causes delay.

57. In the copper pair access network architecture there are the intermediate DSLAMs aggregating the traffic to the feeder network or disaggregating it from there. In the higher bandwidth sphere (Vectoring, G.fast) the vectoring process comes on top delaying the signals. DOCSIS networks have an intermediate fiber node and a number of amplifiers on the access path between the cable modem and the CMTS contributing to delay. The copper pair network does not need CMTS and cable modems, thus may perform better regarding delay than DOCSIS. The FTTH networks do not have any intermediate systems which would cause additional delay. They perform best regarding delay. In addition, fiber offers the highest capacity and hence transmits larger information blocks faster than the lower capacity copper and coax access lines.

58. In case of fiber PtMP topology OLT and ONU are required. In general these additional systems may generate some milliseconds of additional delay. This delay is negligible compared to the copper and coax networks' delay. Both shared media topologies (coax and fiber PtMP) require the access control function of CMTS and cable modem respectively OLT and ONU). Overall, the FTTH networks perform best regarding latency.

59. In case of fibre PtP the intermediate GPON systems (OLT and ONU) with the shared media access control are not required at all, thus improving (reducing) the delay even more.

8 Those without Vectoring.
9 200 – 800 Mbps compared to 10 Gbps (factor >10).

Jitter/ variability/ congestion/ packet loss

60. Jitter is the variation of latency, caused by the fact, that not all messages (Ethernet frames) are transmitted within the same time. The effect of Jitter may become observable watching real time communication, i.e. voice/ telephony or video chats/ conferences. In the access network jitter might be caused because the data to be transmitted has to wait in queues before being transmitted because the capacity is exhausted at a certain point in time.

61. Assuming the same communication behaviour, the probability for jitter occurring is higher in access networks with lower bandwidth (i.e. copper pair ADSL networks) and in shared networks, like HFC networks. In fiber PtP there is no shared medium at all. Comparing DOCSIS and fiber PtMP the probability of jitter is significantly lower with fiber PtMP, because of the significant capacity difference. Comparing fibre PtMP with PtP the latter performs better regarding jitter because of its independence from the end-user access arbitration process in PtMP topologies.

62. If queues get too long, congestion and queue overflow might occur. Typically, the networks then drop packets, so that they get lost and might be retransmitted later in time, if at all. This would have serious impact on customer experience. The probability of this is significantly lower, but oriented or caused by the reasons explained before (sufficient capacity on the access link). From this point of view fiber PtMP performs significantly better than DSL and DOCSIS, but poorer than fibre PtP.

Electromagnetic sensitivity/ packet loss

63. The traditional copper pair access networks are rather sensitive being affected by electromagnetic interference, since the copper pairs are not shielded. Less sensitive are the coaxial cable network links, but these still might be affected at the amplifiers. Also the intermediate active components are sensitive for electromagnetic interference (DSLAMS in case of copper pairs, fiber nodes and amplifiers in case of DOCSIS). Electromagnetic interference may generate packet loss, if the transmission correction procedures may not help, i.e. in case of major bit/ frame errors). In contrast, FTTH networks transfer information using beams of light, and therefore, are entirely insensitive to electromagnetic interference and the types of failures present in DOCSIS and DSL networks.

Humidity/water sensitivity

64. Humidity (also called moisture) or even water entry in locations where electronic equipment is located and water entry in telecommunication ducts will affect (intermediate) transmission mediums and the characteristics of copper cables for

paired copper as well as for coaxial. Either the links can no longer meet capacity or attenuation expectations, or they fail completely. The same may happen to the intermediate systems. Thus, there is always a probability of failure caused by humidity and water which cannot occur with FTTH networks, since the fiber links are not sensitive to water.[10]

Reliability/ vulnerability

65. All access networks bear the risk that access lines may be interrupted by excavation works. Such risk can only be excluded when the access network infrastructure is constructed in ring structures connecting each location from two independent local exchange sites. This is not state-of-the-art everywhere. Sometimes active cabinets in ring structures can be observed. But these can only reduce such risk a little bit for networks with active intermediate network components (copper pair, DOCSIS).

Ease of provider change by end-customers

66. It may be relevant for an end-customer which hurdle he/she will experience when making use of an alternative provider in the telecommunication market. It gives comfort to an end-customer when he/she will not have to coordinate being connected to another high performant infrastructure when he intends to change its retail provider, or even causes in-building construction work.

67. From this point of view, any technology inferior to FTTH in its technical and operational performance characteristics will cause a change of the access line technology when the end-customer decides for such superior FTTH based provider service. If the end-customer is already connected by FTTH the change to another operator present on the FTTH network as wholesale customer is easy in this regard. While the traditional copper network still offers low performant wholesale access a provider change may be easy too for such low performant access services, but migrating to high performant FTTH wholesale services requires an access infrastructure change to FTTH. Since coax networks typically do not provide wholesale services at all, a customer leaving the operator has to change the access infrastructure in any case too.

Upgrade path

68. Network providers keeping pace with increasing bandwidth demand will have to upgrade their network over time. Of course customers are interested in new and performant services, but typically are not interested in being bothered by the upgrade process itself.

10 Except in case of natural catastrophes like the rain floods in Germany in the summer 2021 with large physical damages in cities and along roads, where all the cables have been destroyed completely.

69. In copper pair networks upgrades did occur by moving the DSLAMs even closer to the end-customer premises. Upgrades then have been performed during product upgrades, hand in hand with a short interruption and the exchange of the CPE.

70. In DOCSIS networks upgrades would require either shifting the fiber nodes closer to the end-customers, and or increase the frequency band and upgrade the amplifiers. Changing the frequency band and its radio- and TV-channel allocation typically affects the customers severely[11]. Furthermore, the customers are affected when the cable modem has to be exchanged. DOCSIS technology is made for smooth migration to a large extent. But upgrades will unavoidably affect the customer sometimes.

71. For both technologies a major upgrade step would be a complete change to an FTTH network. FTTH networks are already deploying fiber to each end-customer's home, so the exchange of the access technology can no longer occur. FTTH is the most future-proof type of access network.[12] The upgrade path for FTTH PtMP can remain in the existing fibre plant until the last GPON technology has been implemented. The OLT and ONU have to be exchanged according to the technology generation applied, thus affecting the end-customer located ONUs and thus may cause field service effort. Since the fiber plant is passive and since the different technologies can operate on different wavelength using the same fiber plant in parallel, the technologies may coexist for a while which allows smooth migration over time. Upgrading PtMP to PtP requires adding fibre cable capacity from the splitter location, where the end-customer fibres are aggregated by a splitter to a single fibre strand, to the local exchanges hosting the OLT. The local exchange equipment has to replace the OLT, the ONU can be bypassed. Within a fibre PtP topology upgrading simply is upgrading the capabilities of the local exchange based central aggregation switch port and the CPE. This can be done individually per end-customer line by line and on his demand and thus has the lowest impact of all.

Summary and overview of qualitative differences in access network technologies

72. The qualitative differences observable from a customer's point of view are summarized in Table 3-1 in a qualitative manner. We have chosen such qualitative assessment approach with "–" and "+" because many individual network architectures are compressed into technology classes (columns of the table), hindering more exact quantitative comparisons at least in those qualitative characteristic items (lines of the table) being fully quantifiable.

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11 Many end-customers are not capable to adapt their preferred program list to the new frequency plans or even find "their" preferred programs.

12 For the foreseeable future.

Table 3-1: Qualitative differences in access network architectures

Quality characteristic	VDSL	DOCSIS 3.1	FTTH PtMP	FTTH PtP
Constant capacity	--	+	+	++
Latency/ delay	-	-	+	++
Jitter/ Congestion	+	--	++	++
Electromagn. sens.	--	-	++	++
Humidity/ water	--	--	++	++
Reliab./ vulnerability	-	-	++	++
Provider change	+	--	++	++
Upgrade	-	--	++	++
Overall	+	-	++	+++

Source: WIK

73. This evaluation may be subjective to some extent, but we have fully explained the reasons for our assessment above. In its overall result it clearly favours full fiber access networks as most advantageous for the end-customers, thus demonstrating that from a technical perspective, full fiber networks possess by far superior qualitative differences compared to VDSL and DOCSIS 3.1.

74. Although broadband access via HFC networks was and still is the second largest form of access in the residential broadband retail market in Norway, the number of subscriptions is declining since 2017.[13] Fibre access on the other hand is significantly growing and is the largest access technology since 2017. This development and its further trend clearly indicates the preference of Norwegian users of fibre over HFC. If users have the choice, they seem to prefer fibre[14] which is not surprising to us given the superior quality differences in favour of fibre as described above.

75. Given the objective quality differences between FTTH and HFC and the customer preferences, it is critical from a consumer policy point of view that Telenor and Telia market FTTH access and HFC access under the same product label. This should indicate to users that both types of products are identical. This is misleading consumer information and advertising which is subject to regulatory and/or consumer policy interventions and also subject to court cases in several European countries and also abroad.

13 See Nkom (2020b), p. 16.
14 This also seems to be Telenor's assessment. See Telenor, Capital Market Day 2020, p. 45.

76. In Europe, using the label fibre in relation to mixed network technologies like HFC networks for internet access services has been classified as misleading fibre advertising in the UK, France, Italy and the Netherlands.[15] In France and Italy this even resulted in multi million euro fines and damage compensation payments. In France, the Government intervened early through a Decree in 2016 to restrict the circumstances in which the term 'fibre' can be used in advertising to FTTH cases only.

77. In Italy, the NRA AGCOM adopted a mandatory 'traffic light' system whereby the word 'fibre' and green labelling is reserved for FTTH/B, while yellow refers to part fibre (e.g. FTTC)[16] and red to copper (ADSL) services. Furthermore, AGCOM ruled that the implicit association of several technological architectures under the same commercial brand in one-to-many communication is not allowed.

78. In the Netherlands, the Dutch Advertising Code Committee (DACC), a self-regulatory organisation, intervened in a dispute between the fibre operator Reggefiber and the cable company Ziggo in 2013/14. The case was brought to the Board of Appeal which judged that:

- The FTTH network is different than the DOCSIS cable network and that these differences can be important to the average consumer and need to be explained.
- Ziggo's claim of a 'second fibre network' as 'its own fibre network' is misleading advertising.
- Misleading advertising may lead to constraining fibre roll-out if FTTH operators do not achieve a relevant up-front marketing success.

The DACC stopped the cable company further using the term 'own fibre network' for its HFC network.

79. Recently, in April 2021, in New Zealand the Auckland District Court decided that cable operator Vodafone engaged in conduct that was liable to mislead consumers in relation to its 'FiberX' branded internet access services and confirmed a corresponding decision of the Commerce Commission. The Court confirmed that the word 'fibre' is a generic description of a FTTH service, where there is an end-to-end fibre connection. The Court also confirmed that fixed line internet access networks are identified (and differentiated) by the technology used for the

15 See WIK-Consult (2020b).
16 There are no HFC networks in Italy.

last mile to the home (copper cable/DSL, coaxial cable/HFC, fibre cable/FTTH).[17]

3.5 Do you expect that broadband access via FWA provided in 4G and 5G networks are substitutable products for fibre and/or HFC access on the basis of product characteristics, price and application in a forward looking perspective?

80. The current use of FWA in Norway seems to be complementary to fixed-line access technologies. This seems to hold from the demand side and the supply side. FWA is primarily provided and offered in areas where there is no HFC or FTTH access. This becomes obvious as part of Telenor's copper shut down policy. Telenor offers customers to migrate to FWA if there is not sufficient demand to build a viable FTTH infrastructure. Furthermore, FWA plays an important role to serve second homes which are located in remote and rural areas. Nkom's market analysis should give special emphasis on the user behaviour when they have the choice between FWA and FTTH/HFC in a particular area.

81. Another indicator for complementarity between FWA and FTTH and HFC so far is the rather stagnant development of FWA in Norway in the last years. Since 2015 Telenor reports a nearly unchanged number of FWA customers in the band between 43-45.000 connections[18]. From 2018 to 2019 the number even dropped from 45.000 to 43.000 subscribers. This seems to have changed in the last two years. Nkom reports about 104.000 FWA broadband connections by mid 2021 in its consultation document.

82. We believe that the product characteristics and capabilities of FWA provided over 4G as well as over 5G networks are limited and constrained in particular in comparison to FTTH so that these access technologies are not substitutable. This is also the conclusion which WIK-Consult has developed within the study to advise the European Commission on the new Recommendation on relevant markets in 2020.[19] We will therefore cite the main paragraphs of this study on this subject matter here.

83. "*In conclusion, hybrid offers, FWA and mobile broadband seem only to provide a full functional substitute for fixed connectivity in specific circumstances today (mainly where fixed networks have yet to be fully upgraded to NGA, or where it is not economically viable to deploy NGA fixed networks e.g. in very rural areas). The upcoming deployment of 5G offers the prospect for FWA to provide long term Gigabit connectivity in rural areas in place of fixed connections. 5G FWA*

17 See Commerce Commission (2021).
18 Telenor (2020), Modernising Norway, presentation by P.-B. Furberg and C. Amundsen, p. 2.
19 See WIK-Consult (2020a).

could also become a credible substitute more generally, but its capabilities are limited to the lower range of bandwidths possible via upgraded FTTH networks, and is thus the use of 5G FWA in urban settings is likely to be more relevant in countries and areas where FTTH is not already widely deployed. Such patterns of substitution might also change over time in cases where FTTH is deployed in the future. The potential for alternative operators to supply fixed wireless and mobile 5G technology also depends on the degree to which such operators can deploy or access fibre backhaul."

84. "*NRAs should consider whether in the circumstances present in their market, 5G FWA should be included in the retail market for mass-market broadband connections, but in doing so, they should also consider the degree to which the current status in fixed infrastructure deployment has reached its end-state (which may be the case in rural areas) or is likely to further evolve over the period of the market review.*"

85. "*An important development during the period of this Recommendation is the deployment of 5G. However, 5G mobile services are not expected to substitute for fixed broadband, due to the prevalence of data caps within mobile pricing models and the shared nature of the medium, which limits its potential to carry the high data load currently supported by the fixed network. Moreover, 5G will likely require the deployment of fibre further into the network to provide high capacity backhaul to existing base stations, and in time, new small cells. The increasing reliance of mobile technologies on fixed backhaul provides a signal that VHC fixed networks and 5G technologies are likely to be complementary. 5G fixed wireless access (FWA) offers more promise as a potential alternative to wireline VHC broadband connections. However, its capabilities lie at the lower end of those available via FTTH. NRAs should thus consider whether it offers a substitute on a case by case basis, noting that it may offer a permanent alternative to copper infrastructure in very rural areas, while substitution between FWA and wireline VHC technologies in other areas may depend on the presence of and prospects for FTTH. 5G FWA is likely to be able to serve the needs of less demanding business users and use-cases, but is unlikely to provide an alternative to dedicated connections that are likely to be required for high-end business use, public institutions, educational facilities and hospitals.*"

86. The Commission followed WIK's recommendation regarding FWA when it concluded: "*5G FWA offers more promise as a potential alternative to wireline VHC broadband connections. However, its capabilities lie at the lower end of those available via FttH. NRAs should thus consider whether it offers a substitute on a case by case basis, noting that it may offer a permanent alternative to copper infrastructure in very rural areas, while substitution between FWA and wireline*

VHC technologies in other areas may depend on the presence of and prospects for FttH deployment."[20]

87. 5G high capacity networks based on high frequencies (i.e. above 3.5 GHz) which can cover small cells of approximately 400 m radius, offer up to 10G peak bandwidth, shared between the users being active at the same time, using typical fixed network services like video streaming at a medium to high quality (bandwidth). In the worst case there are several independent users per home and several homes to be served. So it is a question of likely use scenarios if and when the radio cell's capacity is exhausted. On the other hand such cells require backhaul fibre to be able to provide 10G capacity. Depending on the edge cloud computing scenario it is more than one fibre pair required per cell. Thus, deploying the fibres to the home may be at comparable cost than serving the cell's antenna, with the typical radio transmission disadvantages in case of snow, fog, rain, lightning etc.[21]

3.6 Will the further deployment of FTTH in the coming years lead to increased actual or potential competition for the existing fibre customers, because competing fibre networks come closer to each other and partially overlap?

88. This question is related to the following FTTH deployment scenarios in Norway:

(a) Increase of the coverage of fibre in Norway up to 100%.

(b) Overbuilt of an existing fibre network by a second fibre infrastructure.

(c) Upgrade of HFC networks to full FTTH networks in areas where there is already a FTTH network.

In the following paragraphs we will analyse each of these scenarios separately. There is the theoretical possibility that deployment scenarios (b) and (c) will emerge in the same area so that there will be three competing FTTH infrastructures in that area. Because we consider such a market outcome as highly unrealistic we will not further describe and analyse this scenario.

89. Norway has achieved a fibre coverage of 76% by mid 2021. This is one of the most advanced coverage ratios in Europe. All players in the market – Telenor, the utilities companies (under the roof of Altibox) and other alternative network

20 European Commission (2020b), p. 36.

21 A recent study on behalf of BNetzA states that the 3 existing 4G mobile radio networks in Germany together are not capable of providing the universal service obligation even in rural areas: https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Grundversorgung/Gutachten_umlaut_WIK_Mobilfunk.pdf;jsessionid=AAD9C492AFD15DF85BA510638EDC28C0?__blob=publicationFile&v=3.

operators – are on their way to further expand their fibre footprint. Telenor itself intends to increase its fibre footprint from 26% to 30% in 2025.[22] Market observers assume that Norway may have achieved a close to 100% FTTH coverage by 2025.[23] This may be a bit optimistic but it is obvious that Norway will significantly increase fibre coverage in the next few years above the current level.

90. It is realistic to assume that the areas which are not yet covered by fibre will belong to the higher cost of deployment areas. We further expect that in at least some of the yet uncovered areas it may not be economically viable to roll-out fibre without governmental subsidies. Energy utilities might have used in a number of regions cross-subsidies to roll-out fibre networks which would be a confirmation of the assumption mentioned above. Therefore we conclude that it is highly unprobable that in the remaining fibre coverage areas a duplication of fibre infrastructure will occur. It is realistic to assume that in the currently uncovered areas only one fibre infrastructure will be deployed, if at all. Nevertheless, infrastructure competition may still be possible in those areas if two or more operators engage in a co-invest model to jointly deploy the fibre infrastructure.

91. Also regarding scenario (b), our overall conclusion is that a duplication of the already existing fibre infrastructure by a second FTTH network is not so likely. This does not exclude that this may occur at the margin. The main reason for this conclusion is that fibre networks usually need take-up rates of more than 50% to be operated economically viable at reasonable price levels. Our fibre cost models show that only in high density low cost of deployment areas it is possible to operate two fibre networks in parallel in a profitable manner. Those conditions can only be found in high density areas requiring short trench length per home passed. We assume that there will be only some parts of Norway which have such high density of homes. Duplication of fibre may nevertheless occur, if retail prices and margins are artificially high due to limited competition.

92. The conclusion in para 91 is coherent with current market outcomes in Norway and in other European countries. Although Nkom reports a partial overlap of fibre networks it does not quantify. It will become one of the tasks of the upcoming market analysis to identify the exact amount of FTTH network duplication in Norway. The data reported by the investment bank Credit Suisse[24], however, indicate that the number of FTTH homes passed by operator exceeds the number of net FTTH homes passed by less than 10%. This relationship is an indicator of the degree of network duplication. Credit Suisse forecasts that this degree of overlapping will only slightly increase until 2024, being in line with our modelling based expectations.

22 Telenor (2020).
23 See f.i. the estimates of Credit Suisse (2020), p. 69.
24 Credit Suisse (2020), p. 69.

93. Infrastructure competition based on the duplication of FTTH infrastructure is by far the exemption in Europe. There is no fibre duplication at all in Germany, Austria and Switzerland, except in some business districts. We mention these countries because we see a lot of cost similarities in these countries to Norway. Competing fibre infrastructures can be found in some East European countries where the cost of deployment are relatively low and the copper network coverage was mostly poor or not existing. There is nearly no fibre duplication in France. Infrastructure competition is mostly based on a co-invest model here. There is some FTTH network duplication in Spain and Portugal but co-investment dominates.

94. We believe that the most likely scenario of competing FTTH networks in Norway will be related to scenario (c). We do not know the degree of overlapping of FTTH and HFC networks today but the subscription numbers indicate that there is some. At the same time Nkom reports that HFC is losing market share against FTTH. Not all HFC networks are upgraded already to DOCSIS 3.1 which may explain the loss of market share to some degree. Given the superior performance of FTTH towards HFC (see para. 48ff.) and the probably further growing preference of customers towards FTTH, it can be anticipated that HFC will further lose market share against FTTH. To meet this competitive challenge, it would be a rational strategy for HFC operators to upgrade the network to full fibre.

95. When HFC operators increase the network's capacity they reduce the size of their coax cable areas, also called fibre node areas, by fibre node splitting. In addition, the migration towards DOCSIS 4.0 requires the reduction of the fibre node to less than 48 homes connected for interference reasons. Both tend to become FTTB solutions. Innovating inbuilding coax infrastructures then naturally result in FTTH. Such FTTH can be operated by DOCSIS 4.0 RFoG[25] technology or by GPON PtMP or Ethernet PtP technologies, operated without DOCSIS but integrating the TV signals in a separate wavelength and using the established data communication capabilities of the advanced legacy technologies.

96. The incremental cost of upgrading HFC networks to full FTTH networks are significantly lower than building a new FTTH infrastructure from scratch. If the HFC network is fully ducted these incremental cost amount to a few 100 € per home passed for the increment of additional fiber replacing existing coax cables. If the upgrade has been conducted, two fully developed FTTH networks would compete against each other.

25 Radio Frequency over Glas.

3.7 To what extent will wireless fixed broadband access in 4G and 5G networks contribute to an increased actual and potential competition against FTTH connections in the years to come?

97. We refer to our answer to question 5.

3.8 Will the competition for current HFC customers increase due to the stepwise upgrade of HFC networks to pure FTTH networks in the next years? Will competition develop differently in the MDU compared to the SDU market segment?

98. Most cable networks in Norway have been upgraded from DOCSIS 3.0 to DOCSIS 3.1 in the last few years. This software and active components upgrade has increased the performance of cable networks already significantly.[26] Compared to the upgrade to DOCSIS 3.1 a migration of the HFC network to a full FTTH network is a much more time consuming and investment-intensive exercise. The still existing coax cables have to be replaced by fibre links and the electronics in the central offices and at the customer side have to be exchanged, depending of the future technology applied (DOCSIS 4.0, GPON or Ethernet). In particular the exchange of the inhouse cable system from coax to fibre cables requires permission from and interaction with all building owners and access to all homes (apartments, flats). Cable operators will define deployment areas and priorities for the upgrade to FTTH. They usually cannot start deployment in each municipality at the same time. Thus, developing todays cable networks to FTTH network will take several years for completion. It may also be the case that some cable networks will not be upgraded at all, or only to some extent (deep fibre).

99. Our overall conclusion on the competitive impact of upgrading HFC networks is that competition for current HFC customers will not be increased. We will discuss and demonstrate this conclusion in two different infrastructure scenarios: (a) In the upgraded areas is already an alternative FTTH network present and (b) the HFC network is the only VHCN infrastructure in the respective area.

100. In some cable areas there are already FTTH networks build. In these areas there is infrastructure competition today. Given the strong preference of Norwegian customers towards fibre, cable is losing market share and cable broadband customers churn to FTTH. This competitive development may incentivize the cable operators to upgrade their network towards a full fibre network, if they are not part or subsidiaries of the fibre roll-out company of the specific area. This will make the operator more competitive against the FTTH operator in that particular

26 See para. 48ff.

area. They can reduce churn and the (previous) HFC customer base becomes less threatened than before.

101. In scenario (b) the cable operator upgrades the cable network to a full fibre network without the competitive pressure of an actual FTTH competitor. By upgrading the operator not only increases customer satisfaction, he also reduces the threat of potential competition from a second FTTH operator. This is because the economic incentives to build a competing FTTH network against a cable network are higher than to build a second FTTH network in an area where there is already a FTTH network in place, because FTTH is of higher quality than HFC. Thus, upgrading the cable networks protects the customer base against (actual and) potential competition.

102. The second part of the question addresses competitive differences between the MDU and the SDU market segment. It is obvious, that the MDU segment is more competitive than the SDU segment. If an FTTH operator is present in a certain cable area, it is much more cost effective to connect an MDU than an SDU. The benefits not only relate to network cost, they also relate to administrative and marketing cost, because the building owner of an MDU may act on behalf of all tenants in the building.

103. The competitive implications of upgrading the HFC networks to full FTTH networks will depend on the amount of homes passed to be upgraded and the cost and speed at which this process will develop. To better assess the competitive implications Nkom should take the opportunity of the market analysis procedure to let operators report on their upgrading plans.

3.9 Do you expect that an increased provision of FWA in 4G and 5G networks will lead to an increased actual or potential competition for the existing HFC customers in the next years?

104. First of all we refer to our answer to question 5 and our analysis of the performance of HFC networks in para. 48ff.

105. We have described the performance of FWA in para. 82ff. This is significantly lower than the performance of cable broadband access as described in para. 48ff. Here we also demonstrated that the performance of FTTH as a broadband access technology is significantly higher than the performance of DOCSIS 3.1. This implies that the actual and potential competition of FWA towards cable is more intense than towards FTTH. Nevertheless, FWA remains more a complement to HFC networks to close coverage gaps than it is a major competitive threat.

3.10 Do you expect that the competition for the current FWA customer base will increase due to more fixed-line FWA operators and the expansion of 5G networks in the next years.

106. We do not expect that there will be more competition for the current FWA customer base. Instead, we expect that new FWA operators and mobile operators will focus on new customers in remote and rural areas not yet covered by sufficient bandwidth fixed network technologies if they expand or intensify their FWA offerings.

107. According to our current knowledge, FWA is mainly provided in remote and rural areas. Many second homes are served with this infrastructural approach. Telenor is relying on FWA in those areas in connection with the close down of MDFs and if the demand for fibre is not sufficient to justify a (profitable) roll-out. If that is the predominant demand and supply pattern of FWA – which Nkom has to check and verify within its market analysis – customers will not have the choice between several FWA offerings within one area. This hypothesis, however, has to be tested against the actual FWA deployment of Norwegian operators as part of the upcoming market analysis.

108. Building a second (or even third) FWA network infrastructure in remote and rural areas is rather costly in particular when the relevant demand will be split between the competing operators. This even more holds for 5G networks. To offer high speed broadband access over 5G and its higher frequencies requires a denser mobile network infrastructure than for 4G. It is simply not profitable to give a priority to deploy 5G infrastructure in remote and rural areas to compete for a few customers of the current FWA customer base.

109. If there had been a coverage obligation for 4G or 5G mobile operators even for remote areas which has to be fulfilled by separate mobile radio infrastructures (and not by mobile radio frequency sharing or national roaming) there may be a competitive thread for FWA operators, because there will be spare capacity of the mobile networks which can be filled with FWA customers. But such roll-out is motivated by coverage obligations/regulatory pressure and not by usual economic considerations.

110. In denser populated areas one can assume that mobile operators have no spare capacity but rather capacity scarcity for adding FWA customers on their mobile network, and that they have to compete with higher quality fixed HFC or fiber networks. Thus, FWA in these areas is unattractive for the mobile network operators.

111. Thus, if fixed-line and 5G operators will expand their FWA customer base, they will not compete for current FWA customers but will try to address new custom-

ers. We expect that 5G operators will at least test their FWA offerings in areas where they cannot rely on their own FTTH networks, given the characteristics and capabilities of the 2,6 and 3,6 GHz-band. Such offerings will be more relevant in high density than in low density areas, where FWA is mainly deployed today.

3.11 Do you expect that the further fibre deployment in geographical areas, which do not have fibre yet, will contribute to an increased actual or potential competition for the current FWA customer base in the next years?

112. We have recognized the superior performance of FTTH over FWA in answering previous questions. Together with the strong fibre preference of Norwegian customers it is obvious that customers would take fibre for broadband access if they had the choice between FWA and FTTH at fair and competitive prices. Thus, if fibre deployment continues into uncovered areas, FWA will come under significant competitive pressure.

113. This general trend of increased competitive pressure against FWA due to further fibre deployment may not hold for all market segments. In particular, for second home connections in remote and rural areas, FWA has a major cost advantage over FTTH (or any other fixed-line infrastructure). Thus, for this market segment there is a limited supply-side substitution. Demand-side substitution may also be lower if such second connections are not used permanently but only for certain periods of the year and if that is reflected in the tariff system.

114. The intensity of competition is also influenced by the operator which actually conducts the fibre roll-out. If the FTTH operator is different from the FWA operator in a particular area, there will be heavy competition to win current FWA customers for FTTH. If the same operator deploys the FTTH infrastructure besides its existing FWA network, he will smoothly manage the transition from FWA to FTTH where that is cost-effective.

4 Concluding remarks

115. Nkom will have to conduct its market definition and market analysis in an infrastructural and market environment which looks quite different compared to the previous market analysis in 2018. This environment will further change in a forward looking perspective compared to what the market data on the last two years reveal and which will form a major empirical base for the market analysis.

116. Furthermore, the progressive and successful deployment of fibre in Norway has generated and will further generate a market structure which will be rather complex and difficult to analyse. The Norwegian market shows several peculiarities which makes it different to many other European markets. Nkom will therefore not be able to rely its own market definition and market analysis on those European benchmarks and precedents. Instead, Nkom will have to develop its own innovative approach to define a new regulatory framework for the Norwegian market which enables and guarantees effective competition in favour of Norwegian users.

117. In order to cope with Norway's complex technological, infrastructural and market developments Nkom will have to collect and assess market data at a rather granular level. We have derived the need and the structure of a detailed data collection and analysis at various aspects presented in this document. If needed we are prepared to make even more detailed proposals and remarks. We are keen to take notice of Nkom's next steps and proposed outcomes of its market analysis.

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