WIK-Consult • Final Report

Study for the Australian Competition & Consumer Commission

Benchmarks for the Cost of the Mobile Termination Access Service in Australia

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Bad Honnef, 15 April 2015

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0 Executive summary

1. We have been commissioned by the Australian Competition & Consumer Commission (ACCC) to carry out a study with the following (abbreviated) terms of reference:

   - Determine the cost of voice termination on mobile networks in Australia, using as basis corresponding benchmarks from cost models used in other jurisdictions
   - Provide advice on setting the SMS termination rate relative to the mobile voice termination rate using a conversion factor

   We report here the results of our study.

0.1 Benchmarks for the cost of voice termination

2. A requirement was that the cost models from which the benchmarks are obtained apply the TSLRIC+ or a comparable cost standard. A further requirement was that the benchmarks for the cost of voice termination be adjusted for country specific factors (parameters) that may impact the cost of providing this service in Australia. This required information regarding such parameters from the Australian operators. The ACCC obtained these parameter values the averages of which were considered to be applicable to the hypothetical efficient operator to which the results of the study are to apply. By relating the benchmarks and their underlying parameters to the corresponding averages of the three Australian operators, representing the hypothetical efficient operator, it is assumed that that operator has a market share of 33 %.

3. The ACCC suggested the following factors that may impact the costs of the mobile termination services:

   - Currency conversion
   - Geographic terrain
   - Population density
   - Network usage
   - Spectrum allocation
   - Mobile network technology
   - Scope of service offered (including 4G services)

   We removed from this list the factor “Population density”, because its effect is also covered by the factor “Network usage”, the factor “Spectrum allocation”, since differences in the availability of spectrum do not affect the benchmarks for the cost of termination, and the factor “Scope of service offered (including 4G services)”, since its effect is also covered by the factor “Mobile network technology”.

4. We added the following two factors:
   - Level of the WACC
   - Cost of spectrum

   They are added, because the levels of the WACC and of the cost of spectrum vary substantially between the models and, further, their averages differ substantially from the levels applicable in Australia. They therefore account for correspondingly large differences in the calculated costs.

5. Cost models from the following countries could be identified and were found suitable for the study:
   - Denmark
   - Mexico
   - the Netherlands
   - Norway
   - Portugal
   - Romania
   - Spain
   - Sweden
   - the United Kingdom

   A number of models could not be used, because they were either not populated or were populated with dummy values of the parameters. Further, while in respect of a number of countries it is known that their regulators use models, these could not be used here as they are not in the public domain

6. The first task consisted in converting the benchmarks expressed in local currencies into AU currency. This involved already the first adjustment, as a part of each local currency benchmark was converted on the basis of the relevant exchange rate adjusted for the difference in the purchasing power parity (PPP) between the benchmark country and Australia, given that the price level in Australia, when expressed at the nominal exchange rate, is one of the higher ones in the world. Further, we used the 10 year average of the nominal exchange rates, since it evens out deviations of the exchange rates from their basic values that are due to current world market conditions. Table 0-1 shows the benchmark values for voice termination for the year 2015, expressed in AU cents converted on a 50/50 basis at the nominal exchange rates and the exchange rates adjusted for PPP differences.

Table 0-1: Benchmarks converted into AU cents

Country	Benchmark converted into AU cents …	
	at 10 year average of nominal exchange rate	on 50/50 basis of straight exchange rate and PPP adjusted exchange rate
Denmark	1.894	2.113
Mexico	1.947	3.569
Netherlands	2.786	3.420
Norway	3.137	3.241
Portugal	2.908	4.362
Romania	1.762	3.699
Spain	2.141	2.973
Sweden	1.999	2.230
UK	2.141	2.627
Average:	2.302	3.137

7. The other adjustments were carried out in the following order:

- Step 1 of adjusting for local spectrum fees: Elimination of the spectrum fees from the benchmark figures; spectrum fees applicable to the benchmark to reflect those in Australia are added as a last step
- Differences in the use of 2G and 3G network technology
- Differences in the WACC
- Differences in network usage
- Differences in geographic terrain
- Step 2 of adjusting for spectrum fees: Adding spectrums fees relevant for Australia

The averages of the benchmarks after each adjustment are shown in Table 0-2.

Table 0-2: Effects of adjustments on average of benchmarks

Factor for which adjustment is carried out	Average change	Benchmark after adjustment
	AU cents	
Average value of benchmarks after conversion to AU cents, taking account of differences in PPP		3.137
Average adjustments		
- Spectrum fees – step 1	-0.249	2.888
- Network technology	-1.061	1.827
- WACC	-0.153	1.675
- Network usage	-0.115	1.560
- Geographic terrain	+0.009	1,569
- Spectrum fees – step 2	+0.016	1.585
Average of benchmarks after all adjustments		1.585

8. As shown in Table 0-2, after performing all adjustments, the average of the benchmarks amounts to 1.585 AU cents. We briefly comment on the adjustments In order of the magnitude of their impact:

- Differences in the network technologies used have the largest impact. This is due to the fact that in Australia 94 % of voice is carried over 3G whereas in the benchmark models this share averages to only 54 % and an average share of 46 % of voice is still carried over the much less efficient 2G technology. When corrected for this, the benchmark values decrease on average by 1.061 AU cents.

- Spectrum fees make up on average 7.8 % of the benchmarks; for Australia only a 1 % share of the resulting cost estimate is justified. On balance, this decreases the average of the benchmarks by 0.233 AU cents (the balance of minus 0.249 AU cents and plus 0.016 AU cents).

- The WACC values applied in the benchmark models have an average value of 9.64 % compared to a value of 5.43% relevant for Australia. Corresponding adjustments decrease the average of the benchmarks by 0.153 AU cents.

- Network usage per site is in Australia more than three times higher than on average in the benchmark models, most of that, however, due to data traffic. The cost of voice traffic is affected by this through a smaller share of fixed infrastructure cost, which decreases the average of the benchmarks by 0.115 AU cents.

- Adjustments for difference in geographic terrain are appropriate for only a subset of the benchmarks, and some of those that proved to be necessary go in different directions. On balance, the average of benchmarks is increased by 0.009 AU cents.

9. As candidates for the benchmark of the cost of voice termination for the hypothetical efficient operator in Australia in the year 2015, we considered three statistics: the average (mean), the mean with the upper and lower extreme values removed, and the median of the adjusted model benchmarks. Their values are shown in Table 0-3. The median and the mean with extremes values removed are usually considered to be the statistics that are less affected by possible biases.

Table 0-3: Means and median of adjusted benchmarks

Statistic	Value (AU cents)
Mean (average)	1.59
Mean with extreme values removed	1.61
Median	1.50

We selected the mean with extreme values removed, since it seemed appropriate, of the two preferable statistics to use the more conservative one and thus disregard the median. Removing the upper and the lower extreme values when computing the mean is justified, because it appeared that in both cases the original benchmarks were derived on unlikely cost driver / output relationships (which became apparent only in the process of carrying out the adjustments).

10. Operators in Australia are expected to start offering voice service on the basis of 4G technology during the upcoming regulatory period. Therefore, for the forecast values for the years 2016 through 2020 this has to be taken into account. The forecasts were derived from one benchmark model which included the provision of voice service on the basis of this technology during the regulatory period. They were obtained both directly from this one benchmark model as well as on the basis of the cost relationship between 4G and 3G technology and the assumed share of 4G technology used in 2020 for voice service in that model.

11. Our recommendation regarding the cost range for voice termination for the years 2015 through 2020 is based on the forecasts discussed above and the observed standard deviations of +/- 15 % around the 2015 mean value with extremes removed. These recommended cost ranges are shown in Table 0-4.

Table 0-4: Recommended cost ranges for the termination of voice for the years 2015 – 2020

Year	Limit of lower range	Benchmark values for the years 2015 - 2020	Limit of upper range
	AU cents		
2015	1.37	1.61	1.85
2016	1.30	1.53	1.76
2017	1.22	1.44	1.66
2018	1.16	1.36	1.56
2019	1.08	1.27	1.46
2020	1.00	1.18	1.36

0.2 Derivation of the cost of terminating SMS

12. In relation to the second part of the terms of reference, we showed, first, that the cost of an SMS message consists of two components, (a) the cost of conveyance over the network, i.e. the part of the network that is used in common by voice, SMS and data, and (b) the cost of equipment dedicated specifically to the SMS service, i.e. the SMS centres. It is (a) relative to which we checked whether it can be set relative to the cost of mobile voice termination using a conversion factor

13. Given the above, we showed that the cost of conveyance of an SMS stands in a fixed relationship to that of carrying one minute of voice. The corresponding conversion factor is 0.00121, or that fraction of one minute of network usage needed for conveying one SMS. The corresponding cost of conveyance for one SMS is therefore this conversion factor times the per minute cost of 1.59 AU cents for voice, which for 2015 results in 0.002 AU cents.

14. We next derived the costs of SMS centres used in the network of the Australian hypothetical efficient operator. This calculation was based on information from the benchmark models, on the level of the WACC as applicable to Australia, and on experience values from the WIK data bank for opex, common cost and the economic lifetimes of such SMS centres. Dividing the resulting annual cost by the number of SMS messages in Australia projected for 2015, we arrived at a cost per SMS of 0.026 cents.

15. Our advice to the ACCC regarding the cost of terminating an SMS is to base it, as just discussed, on the sum of the two cost components for (a) conveyance and (b) SMS centres. For 2015 this calculation leads to a cost of termination of 0.028 AU cents per SMS.

1 Description of the consultancy

The Australian Competition & Consumer Commission (ACCC) has commissioned WIK-Consult (1) to provide an estimate of the costs of providing mobile voice termination in Australia by benchmarking against the costs of providing mobile terminations services in international markets, and (2) to provide advice on setting SMS termination rates relative to mobile voice termination rates.

1.1 Terms of reference

In the Order for Services it is specified that the required services are to be provided in accordance with the following terms of reference (ToR):

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A. The consultant will conduct an international benchmarking exercise to assess / estimate the cost of providing the mobile voice termination service in Australia. This requires the consultant to benchmark against cost of providing mobile termination services in international markets from the application of a cost model.

   Specifics of the service required:

   1. Selection criteria for the benchmark set

      The benchmark set should be selected based on the following selection criteria:

      a. The benchmarks used should be the outputs of cost models that are based on TSLRIC+ cost concept.

         The benchmark set should include TSLRIC+ rates calculated or published by international regulators even if they have adopted a pure LRIC methodology to determine the regulated termination rates. If feasible, the consultant may construct TSLRIC+ rates from pure LRIC models to add to the benchmark set.

      b. Benchmarking against costs rather than regulated mobile termination rates

         The ACCC considers that consultant should benchmark against the costs of providing mobile termination services in international jurisdictions, rather than the regulated termination rates ultimately adopted in regulatory decisions.

      If the consultant proposes additional selection criteria in deciding on the benchmark set, clear reasons should be provided.

2. Adjustment process for the benchmarks

   The consultant shall make appropriate adjustments to the outputs from international cost models to take into account country specific factors that may impact the costs of providing termination services in Australia. Such factors may potentially include:

   - Currency conversion
   - Geographic terrain
   - Population density
   - Network usage
   - Spectrum allocation
   - Mobile network technology
   - Scope of service offered (including 4G services)

   The consultant may make adjustments to take into account any of these or other factors if it considers it feasible and necessary to do so. All adjustments must be clearly explained with reasons.

3. Estimated costs of the MTS in Australia

   The consultant will provide advice and recommendations on a cost range that it considers reflects the estimated costs of providing the mobile voice termination service in Australia.

B. The consultant will provide advice on setting the SMS termination rate relative to the mobile voice termination rate.

The ACCC is contemplating setting the SMS termination rate relative to the mobile voice termination rate based on the number of SMS that can be sent using the capacity for one minute of voice call (i.e. a conversion factor). The ACCC seeks advice from the consultant on the following issues:

1. Whether this is a feasible approach to determine the regulated SMS termination rate.
2. If it is a feasible approach, how should the ACCC determine the appropriate conversion factor to use.
3. What adjustments should be made to refine a conversion factor solely based on the relative capacity requirements of voice and SMS services.

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WIK-Consult will implement the ToR within the limits of the degrees of freedom provided by them. In Chapter 2, we will for the purpose of clarification provide comments on a number of aspects in the ToR, in particular also on some of the country specific factors that may impact the costs of providing termination services.

1.2 Overview over steps for carrying out the consultancy

In Chapter 2, we provide, as just mentioned, clarifications and interpretations regarding some terms in the ToR, in particular regarding some of the factors expected to have an effect on the costs of terminating services. Chapter 3 will cover the process by which the applicable models were selected. In Chapter 4 we describe the adjustments made to the benchmarks discussing each time the approach used. Chapter 5 in turn covers the derivation of the cost of terminating SMS based on the cost for voice termination and taking into account the cost of dedicated SMS centres. Finally, Chapter 6 provides advice on the range of costs from which the ACCC may select the value for the MTAS rates.

2 Commentary on the criteria specified in the ToR

Three types of comments are provided, (a) clarifications as to what particular terms mean and imply, (b) critical discussion of some country specific factors in the ACCC's list, and (c) presentation of two additional country specific factors that are proposed by WIK-Consult.

2.1 Use of the term "Total Service Long-Run Incremental Cost Plus (TSLRIC+)"

The ToR specify that the benchmarks to be used should be determined on the basis of the TSLRIC+ cost standard. The ACCC had decided on this methodology[1] after considering the submissions to its discussion paper of August 2014[2] with which it had initiated a consultation with stakeholders on how it should approach the pricing of the MTAS.

This TSLRIC+ standard is characterised by the fact that (a) the total costs incurred to provide services are distributed to the different services on the basis of a matrix of factors reflecting the intensity with which these services use the various network elements (the routing matrix), (b) there is a mark-up on the so-derived cost of each of the services to cover organisational common cost and (c) that it covers all costs incurred for providing the service. This cost standard, referred to in Australia as TSLRIC+, is applied in other jurisdictions in Europe and elsewhere under different designations, either as "Long-Run Average Incremental Cost (LRAIC)", "Long-Run Incremental Cost Plus (LRIC+)" or "Long-Run Average Incremental Cost Plus (LRAIC+), where through the "A" it is emphasised that it is an average cost, averaged also over common cost, and the "+" indicates that also organisational common cost in addition to network common cost are included. It is here the matter of differences in terminology only and not of substance. In this consultancy, whenever a model that is otherwise applicable uses one of these standards, and it is assured that total costs are allocated using a routing matrix and there is a mark-up for organisational common cost so that all cost are covered, this is considered to be consistent with the TSLRIC+ approach as required by the ToR.

2.2 The requirement to use benchmarks

The costs of the MTAS are to be determined on the basis of benchmarks, where the benchmarks are for costs determined according to the TSLRIC+ (or comparable) cost standard and used by the NRA of the benchmark country.

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1 See Australian Competition & Consumer Commission (2015):
2 Australian Competition & Consumer Commission (2014.

It is generally recognised that benchmarks cannot be as precise as estimates that are based on an own model and that the use of benchmarks entails greater margins of error. Benchmarks may deviate from an appropriate estimate of the variable of interest due to two types of influences. The one is systematic in the sense that it derives from different values of important determinants applied in the models, the other is unsystematic or random in the sense that it derives from peculiarities of the concrete modelling approaches.

In the case of the unsystematic type of deviation, the components of the benchmark set may differ from one another due to reasons that are particular to the backgrounds from which the benchmarks come. For example, in our context, differences between the costs of termination found in the benchmark models may have come about, because the NRAs determining the costs have different concerns regarding the performance of mobile operators; they may be more concerned about users, more about producers, what politicians say or the European Commission wants them to do. Or, the institutional set-up requires them to heed more the claims of the one or the other stakeholder. Or, the levels of efficiency modelled by the consultants selected to construct the models may differ that would cause the results to be higher or lower than otherwise. Or, either too conservative or too optimistic assumptions were used in the parameterisation of the models. There is, however, a saving feature in this respect which lies in the statistical nature of the approach. Through the use of a sufficiently large number of observations the expectation is justified that these unsystematic differences in results are largely washed out through an appropriate statistical treatment of the observations.

As regards the systematic differences, these are differences in results due to known differences in cost-driving parameter values. One such important difference may be that in the one country, voice service is carried to X % over 2G technology and to (1-X) % over 3G, while in Australia the shares are Y % and (1-Y) %. In this case adjustments, as called for in the ToR, are possible whereby the benchmark value is changed in the appropriate direction on the basis of a known respective elasticity with which the cost of termination reacts to the percentage changes in technology use. Ideally, one would be able to compensate for all such systematic deviations, which, however, is not possible so that the focus is usually – as also in this study – on the most important ones.

Given the above discussion, the assumption is that, once the impact of country specific factors is accounted for, the correspondingly adjusted benchmarks provide the basis for deriving an essentially unbiased estimate of the costs of the termination services in Australia. At the same time it is recognised that there will remain a margin of error that is unavoidable with any estimate. This is a fact based on statistical reality and must be faced by the regulator when making its final decision. Given that regulators are in the obligation to keep regulated operators whole, this circumstance usually leads to a slight upward drift in the estimate to compensate for the chance that the error is on the negative side. The mechanism is usually being referred to as “being conservative”. While this is to the benefit of the regulated operators, demanders of the regulated service may object that this is to their unjustified disadvantage. There is, however, a justification in the sense that this is the part of the cost of regulation that demanders have to bear, their overall benefit being that they will enjoy regulated rates that generally are substantially lower than they would be without regulation. We make this comment, since there will be instances where we will also face situations where it appears to be appropriate to “be conservative” in this sense. We will point this out when this is the case.

The fact that the benchmarks will be subject to adjustments for country specific factors of sufficient importance, implies the obligation to include all benchmark models that fulfil the criteria stated earlier. Given these adjustments, there would be no reason, except in obvious cases, to exclude a benchmark model because of the existence of country specific factors. Proceeding otherwise would open the door to argue for the exclusion of some benchmark countries due to other irrelevant concerns and not be in the spirit of an unbiased approach.

2.3 What are the benchmarks for?

In the preceding section we discussed properties of the benchmarks that will be found in the benchmark models. They are (a) the benchmarks on which the adjustments are to be affected. The result of the adjustments will also be (b) a benchmarks, i.e. the benchmarks for the costs of providing MTAS in Australia. This means that in the course of the study, the expression “benchmark” will be used with different connotations. In the case of (a), “benchmarks” will be the observations from the benchmark models of which there are always as many as there are models. In case (b), “benchmarks” are the result of the study and stand for the estimates of the cost of the MTAS in Australia. It will be clear each time from the context, what connotation of “benchmark” is being referred to.

In the preceding paragraph it was said that the benchmark in the sense of (b) is for the cost of providing MTAS in Australia. As the ACCC advised us, there will not be three individual cost benchmarks, one for each of the three actual operators in Australia. This implies that the resulting benchmark will be for a hypothetical market situation in which a hypothetical operator has a market share of one third. Given that the cost benchmark will correspond to the TSLRIC standard, which is the cost of an efficient operator, It is also assumed that this hypothetical operator will be an efficient operator, as is also the case for the operators represented in the benchmark models.

2.4 The requirement to carry out adjustments

When adjustments for country specific factors are to be carried out, these adjustments must correct the outcomes of the benchmark models for the impact of the differences in cost driving country specific factors (parameters), holding (a) in the benchmark models and (b) in Australia. This implies, that the values of the corresponding parameters holding for Australia must be known. For this reason, WIK-Consult requested the ACCC to obtain this information from the operators, which was then provided. When discussing the adjustments in Chapter 4, the parameters to which this requirement applies will be apparent and their values for Australia will then be indicated.

One important aspect in this context is that the parameter values applicable to Australia will be averages of the values obtained from the three actual operators. These averages are considered to be the parameter values relevant for the assumed hypothetical efficient operator for whicht the benchmark cost for termination is to be derived, as discussed in the preceding section.

2.5 Country specific factor “Population density”

It can safely be assumed that this factor has already been subject of discussions in the Australian regulatory environment, with the strong implication that Australia’s low density has an upward impact on the cost. Those who refer to it appear to suggest that population may more or less be evenly distributed over the whole territory of Australia which would imply that there are many areas where demand is thin and therefore cell sites are coverage driven, which in turn implies that the number of users per cell site would be relatively low and therefore cost per unit of service high. This is an argument that without concrete information to verify it has the ring of plausibility.

Some doubt on the degree of plausibility is, however, already cast by the fact of Australia’s high rate of urbanisation. It is, with 89 %,[3] higher than that of most benchmark countries. This means that for 89 % of the population the notion that they live in low-density areas, where the cells of mobile network have few users, does not hold. Still, it might be that the remaining 11 % of the population live so dispersed in Australia that this may entail a relatively large number of coverage driven cells with very few users and therefore high cost per unit of service. Again, this remains an argument in the abstract which may or may not be true.

In the current study, we are not restricted to arguing in the abstract, given that we are using concrete information from operational models that allow the comparison of network statistics from these models with actual statistics for Australia. We will come to those statistics shortly. First we highlight the difference between arguing in the abstract, when concrete statistics are not available, and developing insights on the basis of concrete information.

Without doubt, Australia’s population density is extremely low and there are certainly areas that are served by base stations that are placed there to only provide coverage. And there may be proportionately more of these areas than in other countries. If

3 See World Bank (2015).

everything else were equal, this would lead to higher cost per unit of service in Australia, especially given that the cost of access usually makes up between 60 % and 70 % of total cost. Everything else, however, may not be equal. Note, first, that per-unit (for voice service: per-minute) cost is determined by taking the total cost of a network element (like the radio access network) and dividing it by the total volume of service provided by this network element. In particular, the per-unit (per-minute) cost of radio access is arrived at by taking the total cost of all radio access networks (those that are coverage-driven as well as the other ones, i.e. those that are traffic-driven) and dividing that cost by the total volume of service. Note, second, that, although there may be quite a number of coverage-driven cells, it may also be that in the other cells volumes of traffic are so high that as a result cost per unit (cost per minute) is very low, which overall would more than compensate the upward effect due to coverage driven cells.

What in the preceding paragraph has been portrayed as a possibility is a fact based on information regarding Australian networks and the networks of the benchmark models. Table 2-1 provides two series of statistics, each time both for the Australian hypothetical network (averages taken over the three networks) and for the networks from the benchmark models:

(a) The average number of users served from one site;

(b) The average volume of traffic delivered over one site.

Comparing the statistics in the Table, the following astonishing facts emerge: As far as the number of users served on average from one site is concerned (see column (2) of Table 2-1), the number for Australia Is lower than that of only three of the benchmark models and is higher than that of the other six. What does this mean? Even if there were relatively many coverage-driven cells in Australia with few users being served in them, this becomes irrelevant, given the large number of users served in the other sites. It is clear that the more users are served per site, the lower is the cost per unit of service, since the fixed cost of a site is spread over more and more users. Therefore, it follows already from this comparison that the cost of termination need not necessarily be higher in Australia due to low population density and the resulting prevalence of coverage-driven cells.

Table 2-1: Network usage in Australia and the models

(1)	(2)	(3)
Country	Number of users per site	Volume of traffic per site in GB
Australia	*1,344*	*15,569*
Denmark	636	3,596
Mexico	2,683	5,104
Netherlands	1,444	1,838
Norway	430	3,429
Portugal	1,392	3,759
Romania	729	1,323
Spain	1,013	6,016
Sweden	434	8,864
UK	877	6,440

Sources: ACCC regarding values for Australia, else benchmark models

This conclusion is dramatically confirmed by comparing the volumes of traffic that are shown on average to be delivered through one site (see column (3) of Table 2-1). Here, the figure for Australia is by far the highest, being almost double of the nearest one shown for Sweden. Again, since the higher the volume per site, the lower is the cost per unit of service, it follows forcefully from this comparison that the cost of termination will not be higher in Australia due to low population density.

One may wonder why the benchmark models show volumes of traffic per site that are so low in relation to that shown for Australia. A possible answer is that at the time of their construction, in some cases three years back, the expectation of the high growth of data was not yet so prevalent so that rather pessimistic forecasts were used. This will have led to relatively high costs per unit of service given today's volumes of service, which will have to be taken into consideration when the corresponding adjustments are to be made in Section 4.5. The observations just made lead to the consideration that for the purposes of this study, it is the reality of the benchmark countries as represented in the models, which is to be compared with the actual reality in Australia, not that now actually prevailing in these countries, since the benchmarks taken from the models are determined by that "model reality".

2.6 Country specific factors "Mobile network technology" and "Scope of services offered (including 4G services)"

Under this head, first the roles of 4G technology and of 4G services are to be considered. Among the benchmark models, only three consider 4G services and only one considers voice over 4G, and this only in the later periods covered by the model. We are advised by the ACCC that Australian operators report that besides offering data over 4G, they will start offering voice over 4G during the upcoming regulatory period. Given these circumstances, we will not adjust the benchmarks for any differences in the use of 4G technology for the provision of termination services for the year 2015. However, when projecting the development of the cost of termination over future years, we are going to factor in the anticipated effect of a forecast share of voice over 4G into this development (see Section 4.8).

In contrast to 4G, there is room for adjustment regarding the use of 2G and 3G technologies for conveying voice traffic. While in Australia a percentage of only about 6 % of voice is carried over 2G and the rest over the more efficient 3G technology, the models show higher degrees of use of 2G, ranging from 32 % to 69 %, and corresponding shares of 3G. Since 3G is substantially more efficient and therefore less costly than 2G, adjustments are to be carried out to account for the corresponding cost differences (see Section 4.3).

2.7 Country specific factor "Spectrum allocation"

In general, spectrum allocation may have an impact on the cost of providing services according to the relation of the size of the available spectrum to the volume of services to be delivered. If there is more spectrum in terms of bandwidth available then traffic driven cells can be larger which means fewer cells are needed which means that cost of hardware is saved and cost per unit of service is lower. Since we are here concerned with the cost of voice termination and SMS, we need to verify whether there are differences in spectrum availability for operators in Australia and the operators in the benchmark models that would warrant adjustments in the cost estimates for these services in the models. For this purpose we look at allocations of spectrum from those spectrum bands that are commonly used for voice and SMS, i.e. the 900 MHz and 1800 MHz bands for delivery over 2G technology and the 2100 MHz band for delivery over 3G technology.

These allocations are shown in Table 2-2.

Table 2-2: Spectrum allocations per operator in Australia and the benchmark models

(1)	(2)	(3)	(4)	(5)
Country	Spectrum band			Total spectrum
	900 MHz	1800 MHz	2100 MHz	
	MHz			
*Australia**	*8.3*	*21.7*	*20.0*	*50.0*
Denmark	8.8	18.8	15.0	42.6
Mexico**	5.0	21.7	-	26.7
Netherlands	11.6	18.2	20.0	49.8
Norway	11.0	8.4	15.0	34.4
Portugal	8.0	6.0	20.0	34.0
Romania	10.0	10.0	15.0	35.0
Spain	10.2	22.3	21.0	53.5
Sweden	7.2	10.0	15.0	32.2
UK	-	30.0	10.0	40.0

* Averages of allocations to the 3 Australian operators; the allocations for metropolitan areas are used; the 20 MHz shown for 2100 MHz are in the 2000 MHz band.

** Allocations in the 850 and 1900 MHz bands to be used in 2G.

We emphasize again that the spectrum allocations shown in Table 2-2 are for those spectrum bands that have commonly been used for voice and SMS. When spectrum in the bands below 900 MHZ and above 2100 MHz became available for mobile services, these were in general used for the new data services. Furthermore, we know that the 900 MHz and 1800 MHz bands, used in the past to a large extent for realizing voice and SMS over 2G technology, have with the decline of this technology been more and more deployed for the realization of services carried over both 3G and 4G technologies, i.e. the technologies that are more efficient than 2G. Therefore, with the shift of a larger and larger share of voice to 3G, any restriction due to limited availability of spectrum on the deployment of base stations for the realization of voice and SMS have been more and more relaxed.

Before this background, looking at the total available spectrum in column 5, it appears that each operator represented in Table 2-2, whether in Australia or any of the benchmark countries, appears to be liberally equipped with spectrum for the delivery of voice and SMS services. We note in particular large allocations in the 1800 MHZ band, which used to be needed when voice and SMS had to be delivered in traffic driven cells over 2G technology, and for the 2100 MHz band, which is used when voice and SMS are carried over the more efficient 3G technology. From this follows that spectrum for the delivery of voice and SMS services is for all these operators available in more than sufficiently large amounts and the degree of use of spectrum from these bands for these services is a result of management decisions that are taken according to the requirements of providing both voice/SMS services and data services over these bands. In other words, it is not the exogenously determined availability of spectrum that determines the use of particular amounts of spectrum for the one or other service, but these degrees of usage follow from operators' management decisions regarding how to best run their networks. From this follows that there would be no need to carry out adjustments to the benchmarks due to differential, exogenously determined, availabilities of spectrum.

2.8 Country specific factor proposed by WIK "Level of the WACC"

The intensive discussions in many jurisdictions in Europe and elsewhere on the level of the WACC witness to the relevance of this factor. This is so because the WACC directly affects annualised capex which is one of the most important cost components of a telecommunications network. A higher level of the WACC means a higher level of cost, and of course vice versa for a lower level. The values of the WACC applied in the benchmark models vary between 6 % and 11 % while we are advised by the ACCC that the one applicable in Australia is 5.43 %. From this follows that the level of the WACC is to be included as one of the country specific factors that may impact the costs of providing termination, and that also in respect of the WACC adjustments will have to be carried out (see Section 4.4).

2.9 Country specific factor proposed by WIK "Cost of spectrum"

Also in respect of the cost of spectrum, there have been intensive discussions in many jurisdictions regarding the share of that cost that should be recovered through regulated rates. The importance of spectrum fees becomes apparent when one considers that in the benchmarks they make up cost shares ranging from 0 % to 16 %. As will be shown in Section 4.7, the corresponding share for Australia is 1 %, from which follows again that adjustments will have to be carried out to make the benchmarks consistent with the level of spectrum fees in Australia.

3 Selection of models

The criteria for selecting the models have been that they have been used by the national regulatory authorities (NRAs) of the given countries to determine the cost of voice termination and that they are publicly available. In order to identify models that complied with this criterion, we carried out research on the websites of NRAs that were likely to have used such tools. This search was carried out in a methodical way as described below.

First we scrutinized the websites of NRAs of all OECD countries where the "calling party pays (CPP)" principle is applied.[4] These are the countries the most likely to be similar to Australia in terms of economic development, types of networks and level and structure of demand. The countries next in line were the countries of the EU that were not members of the OECD. We then checked whether models were available from countries where we knew that the NRA uses a cost model. Here we disregarded the countries from the Caribbean (where cost models are being used), on the basis that the networks of these small island countries are too dissimilar to those in Australia. Finally, we searched the websites of the NRAs of the largest remaining countries which are applying CPP. This search we stopped after not identifying any available model after we had checked the ten largest countries of this remaining category. This was done on the realistic assumption that further search would not lead to the identification of any further useable model. The websites from which the models can be downloaded are shown in the appendix.

The benchmarks to be obtained from the models are the costs calculated on the basis of the TSLRIC or a comparable standard, even if the model was in the end used for another, e.g. the Pure LRIC, cost determination, as long as the models had carried out the relevant calculations and also provided the information on the basis of the appropriate standard. Table 3-1 shows the list of countries for which models fulfilling the criteria could be identified. Besides the names of the countries, the table also shows the cost standard eventually applied by the NRA and the one also provided and used in this study.

4 In countries in which the principle of "receiving party pays (RPP)" is applied, no regulation is needed and one would therefore find there no cost models.

Table 3-1: Selected benchmark countries

Country	Cost standard applied by the NRA	Standard also provided in the model and used here
Denmark	Pure LRIC	LRAIC+
Mexico	Pure LRIC	Plus LRAIC
Netherlands	Pure BULRIC*,§	Plus BULRAIC
Norway	Pure LRIC	LRIC+
Portugal	Pure LRIC	LRAIC+
Romania	Pure LRIC	LRAIC+
Spain	Pure LRIC	LRIC+
Sweden	LRAIC+	LRAIC+
UK	Pure LRIC	LRIC+

* BULRIC ≡ bottom-up LRIC, i.e. LRIC determined on the basis of a bottom-up model.
§ A court later overturned the regulator's decision and required that a rate based on LRIC plus be applied..

The models for these countries are all of recent vintage, none is older than 3 years and all contain estimates for the year 2015. We also consider that a number of nine models is adequate to obtain a range of benchmarks that sufficiently closely encompass the appropriate estimate for Australia. We note here that the New Zealand Commerce Commission, in its report on whether the mobile termination access services should become designated or specified services, uses a benchmark set composed of one more country, but for which the relative range of values is larger than for the present data set.[5]

There are a number of countries in which the NRAs use models that, however, cannot be used for various reasons. The countries and the reasons for the non-applicability of the models are listed in Table 3-2:

5 See Commerce Commission (2010). The normalized standard deviation of the benchmark set used by the NZ Commerce Commission is 0.355, while that of the present benchmark set is 0233.

Table 3-2: Models that could not be used

Country	Reason for non-applicability of model
France	Cost of termination cannot be computed according to the TSLRIC or comparable standard
Lithuania	Model is populated with dummy parameter values
Slovakia	Model is not populated with parameter values
Austria	Models are not in the public domain
Bahrain	
Belgium	
Germany	
Greece	
Israel	
Luxembourg	
Malaysia	
Turkey	

From Table 3-2 it appears that seven of the nine benchmark models are from member countries of the European Union. A criticism has already be levelled against this selection arguing that this “data set may contain correlated features that are driven by membership of the European Union and decisions that have been at EU level”. This criticism must be rebutted as irrelevant. First, while the European Commission specifies particular ground rules for determining rates for the termination of mobile services, these rules do not extend to prescribing the concrete approach to model construction. Second, something that we referred to above as the operation of unsystematic effects can be observed in the benchmark results, when one country (Denmark) shows a benchmark value of 2.11 AU cents and another (Portugal) one of 4.362 AU cents (after conversion into AU currency on the basis of a purchasing power parity adjusted exchange rate). When the rate of one country is more than double that of another country, it is hard to argue that they reflect some kind of correlated features.

4 Adjustments to the benchmarks for voice

Table 4-1 presents the benchmarks for the cost of voice termination as shown in the benchmark models. They are expressed in local currency and are those calculated for the year 2015.

Table 4-1: Original benchmark values

Benchmark country	Currency of benchmark country	Cost of voice termination for 2015 (nominal values)
Denmark	DK øre	9.069
Mexico	US cent	1.727
Netherlands	€ cent	1.844
Norway	NO øre	15.882
Portugal	€ cent	1.925
Romania	€ cent	1.166
Spain	€ cent	1.417
Sweden	SE öre	12.210
UK	pence	1.129

The following seven sections will deal with the implementation of the adjustments according to the ToR and as commented on in Section 1-2. They are carried out in the following order:

(1) Conversion into Australian currency

(2) Step 1 of adjusting for spectrum fees: Elimination of the spectrum fees from the benchmark figures; spectrum fees applicable to the benchmark to reflect those in Australia to be added as a last step

(3) Adjusting for network technology: Appropriately blending 2G/GSM and 3G/UMTS costs

(4) Adjusting for differences in the WACC

(5) Adjusting for differences in network usage

(6) Adjusting for differences in geographic terrain

(7) Step 2 of adjusting for spectrum fees: Adding spectrums fees relevant for Australia

As will be remembered, some of the factors suggested by the ACCC are not represented in above list, i.e. “Population density”, “Scope of service” and “Spectrum allocation”. In Chapter 2 we argued that the effect of the first mentioned is covered by “Network usage”, that of the second by “Network technology”, while for the last one there exists no reason to carry out an adjustment.

Except for the adjustments under (1), (2) and (7), which according to their logic come either at the beginning or at the end, the order of the adjustments is determined by the importance of the effects due to them. In the methodological note below, we show that the order in which these adjustments are carried out do not have any influence of the final outcome.

After having carried out the adjustments to obtain benchmarks for the year 2015, Section 4.8 then uses information regarding the future development of the cost of termination in order to derive benchmarks for the years 2016 through 2020.

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Methodological note

It must be shown that the order in which adjustments are carried out do not influence the result of the exercise.

Let

B_0 ≡ initial value of the benchmark of a country

B_1 ≡ value of the benchmark after 1st adjustment

B_2 ≡ value of the benchmark after 2nd adjustment

Δ_1 ≡ change in factor used for the 1st adjustment, exogenously given

Δ_2 ≡ change in factor used for the 2nd adjustment, exogenously given

$€_1$ ≡ elasticity with which the cost of the benchmark reacts to Δ_1, the change in the cost driving factor used for the 1st adjustment, exogenously given

$€_2$ ≡ elasticity with which the cost of the benchmark reacts to Δ_2, the change in the cost driving factor used for the 2nd adjustment, exogenously given

Then it holds that

(1) $B_1 = (1 + €_1\Delta_1)\, B_0$

(2) $B_2 = (1 + €_2\Delta_2)\, B_1$

Equation (1) represents the first adjustment, starting from B_0, and equation (2) the second one, starting from B_1, the result of the first adjustment. Now, by substituting the right side of the first equation into the second one, we obtain

(3) $B_2 = (1 + €_2\Delta_2)\,(1 + €_1\Delta_1)\, B_0$

By the rules of algebra, we can rewrite equation (3) in the form

(4) $B_2 = (1 + €_1\Delta_1)(1 + €_2\Delta_2) B_0$

which on would have obtained if the initially second adjustment is carried out first and the initially second one thereafter.

The above holds for all of the adjustments carried out. It follows that the order of performing the adjustments will have no influence on the final result. The reason is that the changes in the cost driving factors, and the elasticities with which the benchmarks are made to react to these changes, are all exogenously given.

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4.1 Conversion into Australian currency

The benchmarks are converted into Australian currency on the basis of a combination of (a) the relevant exchange rate of the Australian dollar to the foreign currency, and (b) this exchange rate adjusted to reflect differences in purchasing power parity (PPP).

For the exchange rate, the average of the values over the past ten years is used, given that the current rate at any given moment of time reflects momentary world economic and financial conditions and are not necessarily reflective of the basic value of the other currency in terms of Australian dollars. An average over ten years is a better indicator of this value than the current rate. This ten-year average of the nominal exchange rate is applied to that portion of the benchmarks of which it is assumed that it has been caused by the assets of a mobile network that are traded in international markets at world market prices, e.g. radio and other electronic equipment. The fact of world market prices for these assets justifies the use of the nominal exchange rate for determining the Australian currency value of that portion of the benchmarks.

The PPP adjusted exchange rate is used for the cost component due to those assets and activities that use local resources for which prices in the domestic market have to be paid. Australia is one of the more expensive countries in terms of PPP, so that the putting in place of network elements like towers and trenches and operating a mobile network is relatively more expensive there than in some of the benchmark countries, if the comparison is made using the nominal exchange rate. Using instead the PPP adjusted exchange rate for the corresponding portion of the benchmark cost compensates for the bias that otherwise would occur.

The above approach regarding exchange rates and application of PPP corresponds to that used by the Commerce Commission of New Zealand in its 2011 determination for mobile termination rates in New Zealand.[6] WIK-Consult was at the time a consultant to

6 See Commerce Commission (2011).

the Commerce Commission and participated in developing the approach. Thus, relying on this approach represents for us a degree of continuity, in particular also, since the ACCC referred in its 2011 MTAS FAD to the Commerce Commission's benchmark TSLRIC+ estimates when justifying its own decision.[7]

The blending of the nominal and the PPP-adjusted exchange is done on a 50/50 basis, which represents an empirically observed approximate relation between the shares of a mobile operator's cost derived from tradable goods and services and from local resources, and which was also used by the New Zealand Commerce Commission. Table 4-2 below shows both the details and the results of this conversion process.

Table 4-2: Benchmark values in Australian currency

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						Benchmark in AU cents	
Country	Benchmark in local currency	Exch. rate (10 year average)	PPP AU/local currency	Exch. rate adjusted for PPP	Weighted average of exch. rate and PPP	Exch. rate only	PPP-adjusted exch. Rate
Denmark	9.069	0.209	1.231	0.257	0.233	1.894	2.113
Mexico	1.727	1.127	2.667	3.006	2.067	1.947	3.569
Netherlands	1.844	1.511	1.455	2.197	1.854	2.786	3.420
Norway	15.882	0.198	1.067	0.211	0.204	3.137	3.241
Portugal	1.925	1.511	2.000	3.022	2.266	2.908	4.362
Romania	1.166	1.511	3.200	4.834	3.173	1.762	3.699
Spain	1.417	1.511	1.778	2.686	2.098	2.141	2.973
Sweden	12.210	0.164	1.231	0.202	0.183	1.999	2.230
UK	1.129	1.895	1.455	2.757	2.326	2.141	2.627
					Average:	2.302	3.137

Sources: Reserve Bank of Australia (2015) and XE (2015) for exchange rates, The World Bank (2015) for PPP relations.

Column (3) of Table 4-2 shows the ten year average of the exchange rate for the Australian dollar relative to each of the benchmark countries' currencies. Column (4) in turn indicates the relationship between the PPP indicator for Australia and that for the benchmark country, i.e. the factor by which the corresponding exchange rate must be multiplied in order to take account of the higher price level in Australia and thus for the higher prices of local resources used. The effect on the exchange rate is then shown in column (5) which is the product of (3) and (4). The evenly weighted average of the straight and PPP-adjusted exchange rate is shown in column (6) and the benchmark in Australian cents on the basis of this average is shown in column (8). Column (7) shows for comparison the value of the benchmark if the straight exchange rate were applied.

Applying the PPP adjustment has a substantial effect on the benchmark values. This is obvious from the comparison of columns (7) and (8), in particular the average values shown at the bottom. We note that in each case the PPP adjusted value is higher than the one based on an unadjusted exchange rate, in some cases substantially. This

7 See Australian Competition & Consumer Commission (2011), p. 14.

confirms the observation made earlier that, when comparing local price levels with international ones, Australia is one of the more expensive countries in the world.

4.2 Adjusting for spectrum fees – Step 1

Spectrum fees vary substantially between the benchmark countries and therefore also in relation to those applicable in Australia. From this follows that adjustments will have to be carried out to make the benchmarks consistent with the corresponding cost level in Australia. In a first step, the approach consists in eliminating from the country benchmarks the components due to the spectrum fees; in a second step, carried out as the last adjustment to the benchmarks, the cost per minute that Australian operators on average incur on account of spectrum fees are added. This adjustment will be carried out in Section 4.7. Here the results of the first step are reported.

Note that eliminating the spectrum fees is the first adjustment after the currency conversion because, depending on the size of this fee, without its removal it would make the cost appear larger than the cost justified on the basis of the production relationships. The adjustments to be carried out in the following, however, represent in each case the impact of factors that work through such production relationships, so it is appropriate that the share in total cost due to spectrum fees be taken out before these adjustments are made.

Table 4-3 shows in the third column the benchmarks excluding the share of spectrum fees, while in the fourth column indicating the percentage that this fee made up in the original benchmark.

Table 4-3: Benchmarks without spectrum fees

(1)	(2)	(3)	(4)
Country	Original benchmarks in AU cents from Table 4-2	Benchmarks with spectrum fees eliminated	
		AU cents	Reduction
Denmark	2.113	1.973	7%
Mexico	3.569	3.112	13%
Netherlands	3.420	2.865	16%
Norway	3.241	3.058	6%
Portugal	4.362	4.289	2%
Romania	3.699	3.364	9%
Spain	2.973	2.777	7%
Sweden	2.230	2.229	0%
UK	2.627	2.328	11%
Average:	3.137	2.888	

Noting that the percentages due to the spectrum fees range between 0 % and 16 %, we observe that if they were not removed this would indeed introduce a bias in the subsequent adjustments. The impact is most visible in the difference between the averages of the original and the adjusted benchmarks, shown at the bottom of the table.

4.3 Appropriately blending 2G/GSM and 3G/UMTS costs

Since the adjustments in this section will be separately made on the cost figures for 2G and 3G, we present in Table 4-4 the benchmarks without spectrum fees separately for these two technologies.

Table 4-4: Benchmarks without spectrum fees for 2G and 3G

(1)	(2)	(3)
Country	Benchmarks with spectrum fees eliminated for	
	2G	3G
	AU cents	
Denmark	2.825	1.573
Mexico	4.150	2.474
Netherlands	3.448	2.216
Norway	5.308	1.619
Portugal	4.353	4.190
Romania	4.135	1.728
Spain	3.420	2.303
Sweden	3.223	1.412
UK	2.405	2.278
Average:	3.695	2.198

Note that the average for 2G lies above and the average for 3G below the average shown in Table 4-3 for the combined benchmark, which was to be expected, given that 3G is the more efficient technology.

The 2G and 3G technologies are used to substantially different degrees in Australia and in the models of the benchmark countries. 3G technology is used in Australia much more extensively and 2G correspondingly less. Since 3G is more efficient than 2G, adjusting the benchmarks to correspond to the Australian use of 2G and 3G will entail a decrease in the benchmarks. This is obviously so, because the lower per-minute cost of voice traffic carried by 3G will after adjustment be weighted by a higher share of traffic, and, vice versa, the higher per-minute cost of voice traffic carried by 2G will be weighted by a lower share of traffic.

A necessary input for carrying out the adjustments are the average shares with which voice is carried over the two technologies in Australia. The ACCC obtained this information from the three operators. According to it, an average of 6 % of voice is carried over 2G and an average of 94 % over 3G. We considered these average shares to be the relevant ones for the hypothetical efficient operator in 2015 and thus will use them for the adjustments as shown in Tables 4-5 through 4-7.

The adjustments will be carried out in two steps. First, the benchmark models' costs for each technology will be adjusted to reflect the effect of greater economies of scale on cost in the case of traffic over 3G, and of lower economies of scale on cost in the case of traffic over 2G. The second step will then consist in calculating the weighted average of the new benchmark costs for 2G and 3G using the weights applicable to Australia. The results of the first step are separately produced for 2G and 3G in Table 4-5 and Table 4-6.

Important parameters for these adjustments are the elasticities with which the benchmarks react to changes in the share of the technology. An elasticity as used here expresses the fact that, if for example 2G technology is used for only 6 % of the volume instead of 32 %, then 2G facilities are used less intensively and diseconomies of scale become effective so that the per unit cost of providing the service over 2G increases. The opposite holds for the increase in the share of 3G. If for example 3G technology is used for 94% of the volume instead of 68 %, then 3G facilities are used more intensively and economies of scale become effective so that the per unit cost of providing the service over 3G decreases. For determining the increase in the costs of delivering service over 2G due to the reduction in the use of this technology, we use an elasticity of -0,5, which is larger than the one of -0.3 for determining the decrease in the cost of delivering service over 3G due to the increase in the use of this technology. The reasons for this are described in the methodological note below.

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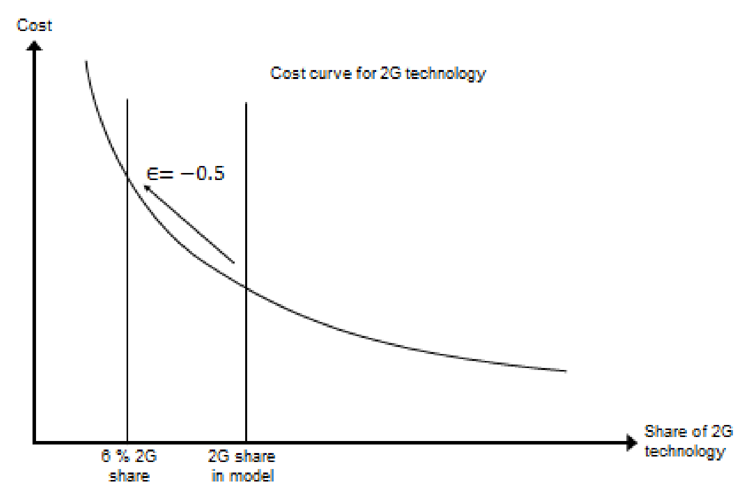
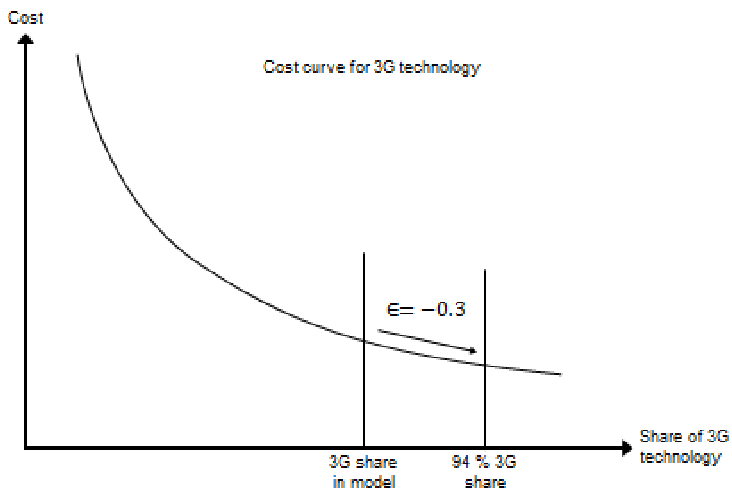
Methodological note

It must be shown that along the range of a cost curve, the elasticity of cost in reaction to a change in volume is – in absolute value – relatively high when utilisation is relatively low, and relatively low when utilisation is relatively high. The low utilisation case applies in the case of 6% of voice being realised over 2G, and the high utiliisation case in the case of 94 % of voice being carried over 3G.

The two figures below present typical cost curves showing the cost of a minute of voice as a function of the intensity of use of a technology, 2G being the technology in the figure on top and 3G in the figure at the bottom. The curves are downward sloping with slopes that become less steep with increasing volume being provided. It is assumed that the 2G and 3G shares with which voice is provided in one of the benchmark models are like those correspondingly marked on the axes of the figures. The share for 2G is lower than that for 3G. At the same time the 2G share is higher than the 6 % share holding for Australia and the 3G share is lower than the 94 % holding for

Australia. If now adjustmens have to be made to the model benchmarks to the effect that production take place at the technology levels of Australia, cost of a minute of 2G voice will “ride” up its cost curve to the point where it corresponds to a share of 6 %, while cost of a minute of 3G voice will “ride” down its cost curve to the point where it corresponds to a share of 94 %. It is easy to verify that a shift in share of about equal magnitude downwards to a 6 % share for 2G and upwards to a 94 % share for 3 G will entail a change in cost for the 2G case that – in absolute magnitude – is larger than the change in the cost for the 3G case. This difference in impact is taken into account by assigning an elasticity of -0.5 to the 2G case and of -0.3 to the 3G case.





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The elasticity values in the methodological note are experience values that WIK-Consult has observed in its own models and in other consultants' models that it has analysed. In this context, we refer to the study that WIK-Consult has carried out for the New Zealand Commerce Commission in 2008, in which it reported corresponding elasticity values.[8] It should be noted that the values reported there have larger magnitudes than the ones used here. Selecting lower values than those we have observed in other models eflects a conservative approach, given that the overall result of the adjustments carried out are decreases in the benchmarks (because of the shift from 2G to 3G technology) which would have been larger if the magnitudes of the elasticities had been higher.

Turning to the derivation of results in Tables 4-5 and 4-6, we observe that column (2) shows each time the starting benchmarks values, as already known from Table 4-4, and column (7) shows each time the resulting change in the benchmark. In column (3) the models share of the technology is indicated, in column (4) the one for Australia, in column (5) the percentage difference in that share as shown in the model and holfing for Australia, in column (6) the value of the elasticity applied. We note that on average the increase in the per minute cost of 2G technology is higher than the decrease in the

8 See WIK-Consult (2008).

cost of 3G, reflecting the effect of cost reactions at different ends of the scale of utilisation discussed in the methodological note.

Table 4-5: Adjusting 2G benchmarks for the share of 2G in Australia

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country	Benchmark with spectrum fees eliminated (AU cents)	Original 2G share in model	2G share in AU	Percentage difference in share in the model vs. AU	Elasticity with which 2G costs react to technology share	Change in benchmark due to difference in 2G share (AU cents)
Denmark	2.825	32%	6%	-81%	-0.5	+1.148
Mexico	4.150	38%	6%	-84%	-0.5	+1.748
Netherlands	3.448	53%	6%	-89%	-0.5	+1.528
Norway	5.308	39%	6%	-85%	-0.5	+2.246
Portugal	4.353	61%	6%	-90%	-0.5	+1.961
Romania	4.135	68%	6%	-91%	-0.5	+1.885
Spain	3.420	42%	6%	-86%	-0.5	+1.468
Sweden	3.223	45%	6%	-87%	-0.5	+1.397
UK	2.405	39%	6%	-85%	-0.5	+1.018
					Average:	+1.600

Table 4-6: Adjusting 3G benchmarks for the share of 3G in Australia

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country	Benchmark with spectrum fees eliminated (AU cents)	Original 3G share in model	3G share in AU	Percentage difference in share in models vs. AU	Elasticity with which 3G costs react to technology share	Change in benchmark due to difference in 3G share (AU cents)
Denmark	1.573	68%	94%	38%	-0.3	-0.180
Mexico	2.474	62%	94%	52%	-0.3	-0.384
Netherlands	2.216	47%	94%	99%	-0.3	-0.656
Norway	1.619	61%	94%	54%	-0.3	-0.263
Portugal	4.190	39%	94%	139%	-0.3	-1.742
Romania	1.728	32%	94%	194%	-0.3	-1.003
Spain	2.303	58%	94%	63%	-0.3	-0.436
Sweden	1.412	55%	94%	71%	-0.3	-0.302
UK	2.278	61%	94%	55%	-0.3	-0.373
					Average:	-0.593

Note the algebraic signs in Tables 4-5 and 4-6, indicating – as was to be expected from the methodological note – that the changes for 2G benchmarks have gone up, due to lower economies of scale by shifting to a 6 % share, and that the changes for 3G benchmarks have decreased, due to this time greater economies of scale by shifting to a 94 % share. In Table 4-7, the changes in the 2G and 3G cost figures, shown in Tables 4-5 and 4-6, are added to those which we started with at the beginning of this adjustment. The old values are shown in columns (2) and (3) and the newly adjusted ones in columns (6) and (7). The newly blended results, based on weights of 6% for GSM and 94 % for UMTS, are shown in column (8).

Table 4-7: Deriving blended 2G/3G benchmarks based on adjusted benchmarks from Tables 4-5 and 4-6

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Country	Benchmark before the adjustment for …		Change in benchmark due to difference in share of ...		Adjusted benchmark for …		New blended 2G/3G bench-mark
	2G	3G	2G	3G	2G	3G	
Denmark	2.825	1.573	1.148	-0.180	3.972	1.392	1.547
Mexico	4.150	2.474	1.748	-0.384	5.897	2.090	2.318
Netherlands	3.448	2.216	1.528	-0.656	4.976	1.560	1.765
Norway	5.308	1.619	2.246	-0.263	7.554	1.356	1.728
Portugal	4.353	4.190	1.961	-1.742	6.313	2.448	2.680
Romania	4.135	1.728	1.885	-1.003	6.020	0.725	1.042
Spain	3.420	2.303	1.468	-0.436	4.888	1.867	2.048
Sweden	3.223	1.412	1.397	-0.302	4.620	1.109	1.320
UK	2.405	2.278	1.018	-0.373	3.424	1.905	1.996
				Average:	5.296	1.606	1.827

Note that the average of the blended results decreased from 2.888 AU cents, shown at the bottom of Table 4-3, to a value of 1.827 AU cents. This reduction should not be surprising as the shares of the relative inefficient 2G technology are in the benchmark models substantially higher than the 6 % that hold in Australia.

4.4 Adjusting for differences in the WACC

We are advised by the ACCC that the WACC applicable to mobile network operators in Australia is 5.43 %. The values of the WACC applied in the benchmark models vary between 6.29 % and 11.28 %. Given that the WAAC directly affects annualised capex, the most important primary cost component of a telecommunications network, there is a clear need for adjustments of the country benchmarks.

The procedure is similar to the one applied in the preceding section for the adjustments due to differences in the use of 2G and 3G technologies. First, for each benchmark country, the percentage difference between its WACC level and that for Australia is determined. Then an average elasticity with which the cost of termination reacts to changes in the level of the WACC is applied to determine the impact on the cost. Of the empirically observed range of elasticities we select a conservatively low value of 0.2. Here, we refer again to the study for the New Zealand Commerce Commission in which we reported elasticities that show the reaction of costs to changes in the WACC.[9] The impact will be negative if the difference between the Australian WACC and that of the benchmark country is negative, which is always the case. The resulting (negative) changes will then be added to the levels of the so far adjusted benchmarks (as derived in the preceding section). The several steps are represented in Table 4-8.

Table 4-8: Adjustments for differences in the WACC

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Country	WACC in Bench-mark countries	WACC in AU	Percent-age difference in level of WACC	Elasticity of reaction of cost to WACC	Percent-age change in bench-mark	Change in bench-mark	Adjusted benchmark (AU cents)
Denmark	6.29%	5.43%	-14%	0.2	-3%	-0.042	1.505
Mexico	12.95%	5.43%	-58%	0.2	-12%	-0.269	2.049
Netherlands	6.60%	5.43%	-18%	0.2	-4%	-0.062	1.703
Norway	11.28%	5.43%	-52%	0.2	-10%	-0.179	1.549
Portugal	11.05%	5.43%	-51%	0.2	-10%	-0. 273	2.408
Romania	11.10%	5.43%	-51%	0.2	-10%	-0.106	0.936
Spain	10.87%	5.43%	-50%	0.2	-10%	-0.206	1.843
Sweden	7.61%	5.43%	-29%	0.2	-6%	-0.076	1.244
UK	9.04%	5.43%	-40%	0.2	-8%	-0.159	1.837
						Average:	1.675

Column (2) shows the different levels of the WACC in the benchmark countries, column (4) the percentage differences between those levels and that of Australia. In column (6), the percentage change in the benchmark by applying the elasticity of 0.2 is indicated and in column (7) the corresponding change in the benchmark applied to the values shown in Table 4-5 as result of the preceding adjustment. Finally, column (8) presents the resulting benchmark after this adjustment. By comparing the average shown at the bottom of Table 4-8 with the average shown in Table 4-5, this adjustment has led to an average decrease of the benchmark of 0.153 AU cents, i.e. from 1.827 AU cents to 1.675 AU cents.

4.5 Adjusting for differences in network usage

We have discussed this factor already in Section 2.5, where we showed that the network usage of operators in Australia, according to the information reported by them, is substantially larger than that in any of the benchmark models. We pointed out that on the basis of these differences in the degrees of network usage, the argument that

9 See WIK-Consult (2008).

because of Australia's population density costs should be higher in Australia is not valid. On the contrary, given the high network usage shown for Australian networks relative to that in the benchmark models, the per unit cost of services in Australia must be considered to be substantially lower than that in the models. It was thus pointed out that on account of the relatively low network usages shown by the models, the benchmarks needed to be adjusted downward to reflect the cost that would hold if corresponding network usage degrees had been implemented in these models.

The lower cost of the voice and therefore termination service due to a higher degree of network usage follows from the following relationships. The large network usage shown for Australian networks is primarily due to the large growth in the demand for data services to an extent that by now – measured in a common dimension, i.e. gigabyte – they make up about 98 % of total traffic. From this expansion in the demand for data services benefit voice services in so far as their share of the costs of commonly used facilities (sites of base stations and controllers, links for conveyance of traffic between nodes) gets smaller, as a larger and larger share of these costs are being now borne by data services. The causal relationships are complex and may be somewhat different for each benchmark model. In recognition of this, we apply a pronouncedly conservative low elasticity according to which costs are made to react to the change in network usage. We put the value of the elasticity at 0.02, which is a twentieth of the average of elasticities with which costs were made to react to changes in volume due to changes in the shares of 2G and 3G technologies (see Section 4.3). Simulations with the WIK cost model specified for a hypothetical European operator – with however a substantially lower level of data induced overall network usage than observed for Australia – exhibited corresponding elasticities between 0.05 and 0.1. The choice of a value of 0.02 thus for one expresses a concern for being conservative. It also reflects the fact that at a high level of overall network usage, as in Australia, the share of voice is much smaller than in the specification of the WIK model, resulting in a lower elasticity with which the cost of voice reacts to overall network usage.

The adjustments are carried out in Table 4-9. As in respect of the parameter differences handled in the preceding two sections, first the degrees of network usage (in terms of volume per site) for the benchmark models and for Australia are presented in columns (2) and (3), then the percentage differences in column (4) are shown. We observe the in some cases huge percentage differences, which is also a reason for using the conservative value of 0.02 for the elasticity with which cost is made to react to them, shown in column (5). Columns (6) and (7) present the results.

Table 4-9: Adjustments for differences in network usage

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country	Network usage in terms of GB per site in …		Percentage difference relative to usage in AU	Elasticity of reaction of cost to degree of network usage	Change in benchmark	Adjusted benchmark
	Models	Australia				
Denmark	3,596	15,569	-333%	0.02	-0.100	1.405
Mexico	5,104	15,569	-205%	0.02	-0.084	1.965
Netherlands	1,838	15,569	-747%	0.02	-0.254	1.448
Norway	3,429	15,569	-354%	0.02	-0.110	1.439
Portugal	3,759	15,569	-314%	0.02	-0.151	2.256
Romania	1,323	15,569	-1077%	0.02	-0.201	0.734
Spain	6,016	15,569	-159%	0.02	-0.059	1.785
Sweden	8,864	15,569	-76%	0.02	-0.019	1.226
UK	6,440	15,569	-142%	0.02	-0.052	1.785
				Average:	-0.115	1.560

Comparing the average shown at the bottom of Table 4-9 with the average benchmark resulting from the preceding adjustment in Table 4-8, we observe an average decrease of the benchmark of 0.115 AU cents, i.e. from 1.675 AU cents to 1.560 AU cents.

4.6 Adjusting for differences in geographic terrain

This factor catches the effect of features of the terrain that make it more difficult to get radio signals in appropriate quality to all areas of the territory to be served. These difficulties are caused by obstacles to the propagation of the radio waves, preventing the signals to travel as far as they otherwise would. The obstacles consist primarily of elevations such as mountains and hills. If such obstacles are recognised by the cell size determining mechanism, cell sizes in affected areas will be smaller, thus the number of such cells will be higher and total cost as well as cost per unit of service will also be higher.

This effect would manifest itself in areas that have relatively low demand which at the same time are hilly and mountainous. This would be so because in such areas the propagation properties of the radio waves determines the ranges of cells, and it is in these areas that the propagation properties are obstructed by this kind of terrain. Despite the on average high degree of network usage, such areas are likely to exist in Australia, i.e. rural areas and also not so densely populated suburban areas and small towns, where population density is so low that even with a high demand per user total demand does not exceed the spectrum capacity of one base station, which would be the situation giving rise to propagation property driven cells.

If it is then observed that Australia has in general more hilly and mountainous areas than some of the benchmark countries, and if there are no reasons to believe that Australia has a smaller number of propagation driven cells than these countries, then the corresponding benchmarks need to be adjusted correspondingly.

We would like to point out that the effects of network usage, on the one hand. and of the terrain features, on the other, are independent of each other. This can be seen on the basis of the following thought experiment. Consider that in respect of network usage a benchmark country and its benchmark operator are like Australia and the Australian hypothetical operator, while in Australia the propagation driven cells are mountainous and in the benchmark country they are flat. Then in Australia, sizes of propagation driven cells would be smaller and their number wound tend to be higher while the number of traffic driven cells would be smaller. This would mean that, despite the same degree of network usage, average cost in Australia would be higher.

There do not appear to exist statistics that measure the degree of mountainousness of a country. One would have to rely on verbal descriptions of the geographical features of a country or own visual inspection of maps showing the topographical profiles of the countries. For completeness sake, we report in Table 4-10 the verbal descriptions from the one available source regarding countries’ terrain, including the benchmark countries used in this study, which we however do not consider as very illuminating. We take this stance, since the assessments in the table do not appear to have been arrived at on an internally consistent set of criteria, as is revealed by the different categories by which the terrain features are described, which means that they do not seem to be providing reliably discriminating criteria for comparison.

Table 4-10: Description of topographical features of benchmark countries' terrain

Country	Description of terrain
Australia	*Mostly low plateau with deserts; fertile plain in southeast*
Denmark	Low and flat to gently rolling plains
Mexico	High, rugged mountains; low coastal plains; high plateaus; desert
Netherlands	Mostly coastal lowland and reclaimed land (polders); some hills in southeast
Norway	Glaciated; mostly high plateaus and rugged mountains broken by fertile valleys; small, scattered plains; coastline deeply indented by fjords; arctic tundra in north
Portugal	Mountainous north of the Tagus River, rolling plains in south
Romania	Central Transylvanian Basin is separated from the Moldavian Plateau on the east by the Eastern Carpathian Mountains and separated from the Walachian Plain on the south by the Transylvanian Alps
Spain	Large, flat to dissected plateau surrounded by rugged hills; Pyrenees Mountains in north
Sweden	Mostly flat or gently rolling lowlands; mountains in west
UK	Mostly rugged hills and low mountains; level to rolling plains in east and southeast

Source: CIA (2015)

Lacking better sources, we relied on visual inspection of the countries' maps showing their topographical profiles. On the basis of their comparison, we were able to operationalise the terrain features of the benchmark countries by classifying them either as more or as less mountainous than Australia. On this basis, it appears that Mexico, Portugal, Romania, Spain and UK have a profile roughly similar to that of Australia, while Denmark, the Netherlands and Sweden appear to be less and Norway to be more mountainous. Correspondingly, in Table 4-11 we will increase the benchmarks of Denmark, the Netherlands and Sweden, and decrease that of Norway to make them more comparable in this regard to the cost that would obtain in Australia.

Although we pointed out above that there are effects of these topographical features on costs, it should be noted that this effect is not very large. When carrying out simulations with ACCC's model for Australia used in its previous decisions, where for the purpose of the simulation we artificially set all areas of Australia to "flat", the effect on cost was a decrease of 2.59 % relative to the reference scenario of the actual terrain structure. In other words, the presumed better propagation properties due to an all-out flat territory caused the sizes of coverage driven cells to increase only to a small extent, so that the number of sites decreased also only to a small extent, and therefore the cost decreased only by this small percentage. Rounding the measured percentage value, we use a percentage of 3 % for both the upward and downward adjustments carried out in Table 4-11. The value used being thus higher than the estimated value. Proceeding this way is conservative, since there are more increases than decreases. With thus an downward adjustment in one case (for Norway) and three upward adjustments (for Denmark, the Netherlands and Sweden), the average effect is 0.009 AU cent per minute, increasing the averaged benchmark to 1.569 AU cents.

Table 4-11: Adjustments for differences in terrain

Country	Benchmark after preceding adjustment	Percentage change due to greater or less mountainous territory	Benchmark after current adjustment
Denmark	1.405	3%	1.447
Mexico	1.965	0%	1.965
Netherlands	1.443	3%	1.492
Norway	1.439	-3%	1.396
Portugal	2.256	0%	2.256
Romania	0.734	0%	0.734
Spain	1.791	0%	1.785
Sweden	1.226	3%	1.262
UK	1.785	0%	1.785
Average:	1.560		1.569

4.7 Adjusting for spectrum fees – Step 2

In Section 4.1 we had eliminated from the benchmarks the local spectrum fees, varying substantially from one country to the other, in order to be able to make unbiased adjustments for the production-related parameter differences. As last adjustment to the 2015 benchmarks, the values emerging from the preceding round of adjustments need now to be marked-up for the share of spectrum fees due to termination that are relevant for Australia.

The first step in this process is the determination of the annual amount of spectrum fees paid on average by the Australian operators for the various spectrum bands. We present in Table 4-12 the corresponding derivation. We abstain from deriving the average capacities in the various spectrum bands that would devolve to the hypothetical efficient operator. We showed in Section 2.6 that the available spectrum would not constrain the design of the radio access network for the delivery of voice and SMS services, and that therefore the benchmarks need not be adjusted on account of the availability of spectrum. From this follows that we do not need to know the quantities of spectrum that the hypothetical efficient operator would have.

Column (2) of Table 4-12 shows the average amount paid by the operators at auctions for each of the various spectrum bands (except for the 900 MHz band, see below); columns (3) and (4) indicate the values of the parameters “WACC” and “Period of assignment", column (5) the annuity formula to transform an one-off payment into an annuity, and column (6) the corresponding annual amount for each spectrum band. The entries for the 900 MHz band differ as for this band there is no one-off payment, but there are annual payments that, averaged here over the three operators, are shown in column (6). Turning to the lower part of the table, we observe in line (a) the sum of expenses for all spectrum bands. In line (b) we add 2 % for opex. In this respect, we differ from the benchmark models and also from the WIK model for the ACCC in 2006/07, where no opex on account of spectrum is recognised. In our opinion, the control of proper use of spectrum requires some expense that justifies the inclusion of a mark-up for opex.[10] In line (c) a common cost, put at 10 % of the subtotal in line (c) is added, where this mark-up is an experience value based on WIK's knowledge of other cost models and operators' cost accounting records. The entry in line (e) represents the total amount paid for spectrum by the hypothetical efficient operator in Australia.

Table 4-12: Derivation of total cost of spectrum for the hypothetical efficient operator

(1)	(2)	(3)	(4)	(5)	(6)
Band	Amount paid in AUD (average over 3 AU operators)	Period of assign-ment in years	WACC	Formula for annuity A	Annuity
700/2500 MHZ	975,576,701				96,740,790
800 MHZ	586,884,568				58,197,040
1800 MHz	150,149,949	15	5.43 %	$A = \frac{5.43\ \%}{\left[1-\left(\frac{1}{1+5.43\%}\right)^{15}\right]}$	14,889,270
2000 MHz	386,514,500				38,327,810
2300 MHz	21,287,615				2,110,937
900 MHz	Determined on the basis of annual payments, shown here as average for the 3 operators; implied capitalisation on basis of the investment/annuity relation for the other frequencies: 274,314,934				27,201,801
(a)	Sum of annuities based on amounts paid for spectrum plus expenses for 900 MHz band:				237,467,647
(b)	Opex = 2 % of total investment in spectrum (see column (2), including the capitalised expenses for 900 MHZ):				47,894,565
(c)	Subtotal:				285,362,213
(d)	Common cost = 10 % of subtotal:				28,536,221
(e)	Total:				313,898,434

Source: ACCC for amounts paid by operators, the WACC, period of assignment

The next step consists in deriving a measure of the volume of traffic for each service and for the total traffic, deemed to be carried by the hypothetical efficient operator in Australia in 2015. This volume will be expressed in gigabytes (GB), the measure for data, the predominant part of traffic. Before presenting in Table 4-13 the in GB transformed volumes of voice and SMS, we show in the methodological note, how this transformation is carried out.

10 Opex are expenses to keep assets in working condition. There is no question that opex arises for facilities like base stations and transmission systems. Opex has typically not been taken into account for spectrum, although it is without question also an asset for which opex arises due to its administration and the control over its proper use. While we deem that a value of 10 % of the investment value, which is the experience opex value for the hardware assets, must be considered as too high, we believe that an "over the thumb" estimate of 2 % would be appropriate.

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Methodological note

For transforming minutes of voice into gigabytes (GB), we proceed as follows:

- We assume the bitrate for voice to be 12.2 kbit/s.
- The conversion factor for GB into kbit is 8,388,608, arrived at by multiplying the number of bits in one byte, which is 8, by the number of kbits in 1 gigabit, which is 1,024*1,024.
- Let V be the volume of voice in minutes
- The first step is the transformation of minutes into seconds which leads to V*60.
- Next the volume in seconds is multiplied by the bitrate of voice to obtain the volume of voice in kbits, which leads to V*60*12.2 kbit.
- The result of the preceding step is divided by the conversion factor between GB and kbit arrived at above, ie. 8,388,608.
- The result is the desired volume of voice expressed in the dimension of GB.

For transforming the number of SMS into GB, we proceed as follows:

- We assume an SMS size of 140 bytes (including overhead)
- Let Q be the number of SMS.
- The conversion factor between GB and byte is 1,073,741,824, arrived at by recognising that 1 kbyte has 1,024 bytes and 1 megabyte has 1,024 kbytes and 1 gigabyte has 1,024 megabytes.
- The transformation consists in multiplying Q by the SMS size to obtain volume of SMS in bytes i.e. Q*140.
- Next the volume in bytes is divided by the conversion factor shown above of 1,073,741,824.
- The result is the desired volume of the number of SMS expressed in the dimension of GB.

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Table 4-13: Total traffic of hypothetical efficient operator measured in gigabytes (GB) and shares of the three different services of voice, SMS and data

Service	Volume in 2014 of traffic in …		Projected growth rate	Forecast traffic volumes in GB for 2015	Shares
	Original units	in GB			
Voice	30,226,567,092 minutes	2,637,607	5%	2,769,487	1.639%
SMS	15,974,697159 m	2,083	4%	2,166	0.001%
Data	118,710,269 GB	118,710,269	40%*	166,194,377	98.360%
			Total:	168,901,120	100.000%

* The projected growth rates are based on the three operators' average growth rates for 2013/2014, all slightly scaled down to allow for some possible slackening of growth.

Source: ACCC for volumes of traffic and, derived from them, projected growth rates.

From Table 4-13 follows that 1.6 % of the annual cost of spectrum is to be borne by voice services. In Table 4-14 we derive the corresponding mark-up that needs to be added to the model benchmarks to make them comparable with the corresponding cost figure in Australia.

Table 4-14: Determination of per minute mark-up for spectrum fees

Object of consideration	Unit	Relevant quantity
Total cost of spectrum	AUD	313,898,434
Share assigned to voice	%	1.64
Fees assigned to voice	AUD	5,145,044
Volume of voice projected for 2015	minutes	31,737,895,446
Spectrum fee per minute of voice	AU cents	0.016

We are now in a position to carry out the last adjustment to the 2015 benchmarks. Table 4-15 shows in column (2) the benchmarks derived after the preceding round of adjustments, in column (3) the amount to be added for spectrum fees and in column (4) the resulting benchmark including spectrum fees as relevant for Australia.

Table 4-15: Adding a mark-up for Australian spectrum fees to the benchmarks

(1)	(2)	(3)	(4)
Country	Benchmark after preceding adjustment	Mark-up for spectrum	Benchmark after current adjustment
	AU cents		
Denmark	1.447	0.016	1.463
Mexico	1.965	0.016	1.981
Netherlands	1.492	0.016	1.508
Norway	1.396	0.016	1.412
Portugal	2.256	0.016	2.272
Romania	0.734	0.016	0.751
Spain	1.785	0.016	1.801
Sweden	1.262	0.016	1.279
UK	1.785	0.016	1.801
Average:	1.569		1.585

The mark-up for expenses of spectrum is with 0.016 AU cents per minute and therefore about 1 % of the average of the benchmarks in the low range of that observed in the benchmark models. Also, it makes up less than 10 % of the amount in the cost estimate obtained in the 2006/2007 modelling exercise. Nevertheless, there is no doubt that this value is still conservative. The reasons are as follows:

- Within the various frequency bands, spectrum can now be used for any of the relevant services, in particular for data services which have actually become the greatest devourer of spectrum resources. This already implies that the cost of spectrum should be allocated to per unit cost of each service on the basis of a common mark-up.
- As we know from our discussion in Section 4.3, only a share of 6 % of the volume of voice is currently still being carried by 2G technology, the technology for which spectrum in the 900 and 1800 MHz band is used. In these bands, operators are actively re-farming spectrum from the use for 2G to the use for 3G and 4G.[11] Much of the re-farmed spectrum is used for data services. Also, the concurrent shift of voice volume from 2G to 3G technology implies a more efficient use of spectrum for voice by a factor of approximately two. Both observations points to the circumstance that a relatively small share of the spectrum in these bands is still being used for voice and SMS.
- The total cost of spectrum (bottom line of Table 4-12) is allocated to the various services on the basis of the shares in total traffic. The alternative approach would be to allocate the cost of the 900 and 1800 MHz bands according to the relative uses of this spectrum by these services. This calculation is, however, not possible, since the relative uses for these bands are not known. By the approach actually used, voice is getting a larger share of cost allocated to it than would be the case if the alternative

11 See Whirlpool (2015).

approach could be applied, because the amounts per MHz that were paid for the other bands were higher than for the 900 MHz and 1800 MHz bands.

4.8 Three statistics for expressing the expected central value from the set of adjusted benchmarks

The adjustments reported in the preceding section brought us to the final country benchmarks for 2015, the average of which is 1.59 AU cents. While the average (mean) is the most often used statistic for expressing the expected value of a common characteristic of a given data set, it is not necessarily the least biased one. Other candidates that statistically are preferable are the mean with extreme values removed and the median. Extreme values can often be traced to inappropriate underlying assumptions or other mistakes in the process creating them, and depending on their weight may then strongly bias the mean upwards or downwards, which would be the justification for removing them. The median, i.e. the value that lies precisely in the middle, with as many values above and as many values below, is not subject to the influence of any extreme values and can therefore be considered as the least biased one; if there are deviations, however, they may also be in any direction. We show the three statistics for our set of adjusted benchmarks in Table 4-16.

Table 4-16: Means and median of adjusted benchmarks

Statistic	Value (AU cents)
Mean (average)	1.59
Mean with extreme values removed	1.61
Median	1.50

In our case, the mean with extreme values eliminated is a bit higher than the mean of the whole data set, because the lower extreme value is farther away from the mean than the upper extreme, (We discuss the reasons for the extreme values at the end of the section.) The median, in turn, is lower than the mean without extreme values, which reflects the fact that it is completely unaffected by any values above or below and also means that, if it were biased, that bias could be upwards or downwards.

According to the ToR we are to provide advice and recommendations on a cost range that reflects our view on the cost of providing voice termination service in Australia. The derivation of this cost range recommendation in Chapter 6 will be based on the mean with extreme values removed. Its advantage vis-à-vis the other preferred statistic, i.e. the median, is that it has a well defined second moment, the standard deviation, which will be useful in defining the relevant cost range. It is also the more conservative one.

The reasons for removing from the benchmark set the extreme values (2.272 cents for Portugal and 0.751 cent for Romania) lie in particular aspects of their derivation. The high value for Portugal is due to a cost shown for 3G technology that is almost as high as that for 2G, which, given the greater efficiency of 3G, appears to be an artefact. The low value for Romania appears to be due to the fact that in the Romanian model all the important cost driving factors have extreme values in the sense that they belong to those farthest away from the Australian values, which meant that the adjustments to get the benchmark to reflect the cost corresponding to the parameter values relevant for Australia pushed this benchmark relatively stronger down than was the case for the other benchmarks, despite the choice of conservative values for the relevant elasticities. We observed these unlikely cost driver / ouput relationships in the process of carrying out the adjustments and did not correct for them at this stage. Here we are allowed to make a correction because these artefacts clearly bias the mean of the benchmarks, as an estimate of the expected cost of termination in Australia, downwards.

4.9 Benchmarks for the years 2016 through 2020

Beside determining the benchmark value for the cost of terminating a call in 2015, WIK-Consult's brief consists also in deriving corresponding benchmarks for the years 2016 through 2020. For this we are advised by the ACCC that it is expected that voice over 4G will become a reality in Australia, and it is therefore necessary to factor into the forecasts for these future years the effect on cost of the use of this most recent technology, which in relation to UMTS will again represent a substantial improvement in efficiency and therefore entail a decrease in cost.

Now, of the benchmark models, only one, the one for the UK, shows the cost of termination for these years with part of voice traffic having been realised over 4G technology, so that the benchmarks for the years 2016 through 2020 show the effect of lower cost due to this technology. The overall percentage decreases in cost (both due to 4G as well as due to general cost decreases) are shown for the individual years in column (2) of Table 4-17. An obvious approach to deriving a forecast of the future level of the cost of termination is to use the cumulative rate of 26.8 % and apply it to the benchmark for 2015 to arrive at a value for 2020 and then interpolate values on a linear basis to obtain values for the intervening years. In Table 4-17 is shown that proceeding this way we arrive for the year 2020 at a value of 1.18 AU cents.

Table 4-17: UK model cost trends 2016 – 2020 applied to benchmark for 2015

(1)	(2)	(3)
Year	Change in benchmark	Benchmarks for years 2015 through 2020 according to trend in UK model (AU cents)
2015		1.61
2016	-5.1%	1.53
2017	-5.5%	1.44
2018	-6.8%	1.36
2019	-6.6%	1.27
2020	-6.2%	1.18
Compound rate:	-26.8%	1.18

Further information regarding the role of voice over 4G in the UK model is presented in Table 4-18. We observe that the shares of voice being carried during the years 2016 through 2020 over 4G rises from 1 % to 24 % and that the relation of the cost of voice over 4G to that of voice over 3G is on average 0.30. We use this information for another approach to determining the forecast of the cost of termination in 2020.

Table 4-18: Production relationships regarding voice over 4G in the UK model

Year	Share of voice being carried over 4G	Relation of the cost for 4G to that of UMTS
2016	1%	0.28
2017	5%	0.28
2018	12%	0.30
2019	19%	0.31
2020	24%	0.32
	Average:	0.30

The approach is presented in Table 4-19 and discussed in the following.

Table 4-19: Benchmark for the cost in 2020 based on the component costs of 3G and 4G

No.	Object of consideration	Unit	Relevant quantity
(1)	Average of the cost of carrying termination over UMTS as derived from Table 4-7	AU cents	1.61
(2)	Cost of carrying termination over UMTS after application of the same adjustments (from Table 4-7 onwards) as for the blended benchmark*, §	AU cents	1.40
(3)	Relation of cost of voice over 4G to that over 3G on the basis of the relation shown in the UK model	cents/cents	0.3
(4)	Derived cost of voice over 4G accordingly	AU cents	0.42
(5)	Shares of 4G in the provision of voice in the UK model	%	24 %
(6)	Blend 3G and 4G costs according to the weights of the two technologies in the UK model	AU cents	1.16

* We leave the level of this cost as that for 2015 on the assumption that general decreases in cost for using 3G technology due to less expensive equipment is cancelled through the diseconomies of scale of lower volumes being provided over this technology.

§ This is the average of the 3G cost for the set benchmarks with extreme results removed.

In line (1) we start with the average cost of providing termination using 3G technology. The value in line (2) has undergone the same adjustments (for differences in the WACC, network usage and terrain) as were applied to the blended cost of 2G and 3G. These two values are thus based on information from all benchmark models. Line (3) shows the relation between the cost of delivery of voice over 4G to that of 3G in the UK model, which in line (4) is applied to the value in line (2) to obtain an estimate of the cost of providing termination service over 4G. This value is 0.42 AU cents instead of 1.41 AU cents. Line (5) then shows the share of 4G in the provision of termination in 2020 in the UK model, which we interpret here to mean in relation to Australia that the remaining 76 % are delivered over 3G, the technology of 2G not being used anymore by Australian operators. Blending the 3G and 4G costs using the just mentioned two percentages as weights leads to an estimate of the cost of termination in 2020 of 1.16 AU cents which must be compared with 1.18 AU cents in Table 4-17 that we obtained by applying the yearly cost decreases shown in the UK model.

From a methodological point of view, the second approach is the one to be preferred, as it is based on clear productive relationships: estimates of the cost per minute delivered over 3G and 4G plus shares with which termination is provided over these two technologies. As disadvantage may be considered that it needs more assumptions for deriving the components making up the estimate than needed for the first approach, for which the only assumption is that due to the impact of also using 4G in the next five years there will be annual decrease in the cost of 6 % on average. Nevertheless the two approaches lead to almost identical results, where however that from the first approach is slightly more conservative. We will therefore base our recommendation for the benchmarks for the years 2016 through 2020 in Chapter 6 on this latter value.

5 Derivation of a benchmark for the cost of SMS

According to the ToR, WIK-Consult is requested to advise the ACCC on whether it is feasible to determine the cost of an SMS in relation to the cost of the capacity of one minute of voice call, i.e. on the basis of a conversion factor. In the paragraphs below we show that this is the logical way to determine the cost for the conveyance part of the cost of an SMS. To this cost component must, however, be added the cost of special equipment that is dedicated to the handling of SMS messages, which, because it is dedicated, is not included in the benchmark for voice and must therefore be determined in a separate calculation. It turns out that this is the more important component of the cost of an SMS.

As regards the first conveyance part of SMS cost, this concerns the cost due to the carriage of SMS messages through the network, from the radio access network to the server locations in the core network, and vice versa. For this conveyance service, the same network elements are used for the conveyance of SMS as are used for the conveyance of voice traffic. Furthermore, the capacity used for the conveyance of one SMS stands in a fixed relation to the capacity used for one minute of voice. From this follows that the cost of one SMS message can be determined by multiplying the cost of one minute of voice by a fixed conversion factor. The derivation of the benchmark for the conveyance of SMS messages according to this approach is shown in Table 5-1.

Table 5-1: Derivation of the benchmark for the conveyance of SMS messages

Object of consideration	Unit	Applies to …	
		2G	3G
Channel rate of the two technologies used for SMS	bits/s	6,144	16,000
Multiplication by 60	bits/minute	368,640	960,000
Division by 8	bytes/minute	46,080	120,000
Length of one SMS	bytes	140	140
Capacity in number of SMS per minute of voice call	number/minute	329	857
Blended according to 6 % 2G and 94 % 3G	number/minute	825	
Conversion factor	minute/number	0.00121	
Cost per minute of termination of voice (from Table 4-16, mean value with extreme results removed)	AU cents / minute	1.61	
Cost per SMS	AU cents / 1 SMS	0.0020	

When considering the numbers in Table 5-1, and in particular the low cost of conveyance per SMS that result from them, it should nevertheless be noted that this result is still conservative in the sense that the assumed length of 140 bytes for one SMS is the maximum length that such a message can take, and that if a more realistic lower figure were used the number of possible messages per minute would be larger and the cost per message correspondingly lower. It is further to be noted that the total capacity needed for the SMS service altogether is so small in relation to the capacity needed for voice (see Table 4-13), that it can be presumed that this capacity is never explicitly considered when planning the network, and is in fact being provided out of spare and/or signalling capacity, which means that the cost of making this capacity available is actually zero. This holds in particular also, because SMS messages have low priority and can in the busy hour be delayed if there were capacity constraints. There may be the rare instance where capacity made available for SMS messages impair the quality of services of the other services (voice and data) which would then be the justification for also assigning a cost component for the conveyance part of the service. It should, however, not be considered to be higher than the cost shown in Table 5-1.

The second cost component for the termination of SMS messages is due to the SMS centres (SMSCs), the dedicated equipment needed for handling the messages through the network. Although only one of the benchmark models indicates a TSLRIC+ cost figure for SMS messages, all models include in their overall calculations the cost of SMSCs. In Table 5-2 we pick up the investment shown in these models for an SMSC as well as the number of such centres, and use this information as basis for arriving at our own benchmark for this cost component.

Table 5-2: Investment into SMS centres in the benchmark models

Country	Investment into one SMSC	Number of SMSCs in the network
Denmark	330,920	3
Mexico	2,930,945	2
Netherlands	2,788,014	2
Norway	4,255,727	1
Portugal	2,381,992	2
Romania	1,041,527	2
Spain	854,998	2
Sweden	1,395,360	4
UK	5,229,858	3
Average:	2,356,593	2.33

Given the (anticipated) heterogeneity of the investment figures as revealed in Table 5-2, and in the expectation that more precise information could be obtained from the Australian operators, we asked the ACCC early in the course of the study to request the operators to provide that information as it applies to their networks. It appeared from their responses that they were not in a position to provide information in the form as presented in the models and shown in Table 5-2. Some information was provided, but for confidentiality reasons we refrain from describing it in any detail, except to point out that, if converted into a suitable form, it would probably result on average in a higher investment figure than the average shown in Table 5-2. Further to mention that the figures provided appear to also include investments, like for development of the service, that are needed for retail activities, which would not be applicable to be included here. As a consequence of this situation, we rely on information from the benchmark models, using, however, for “investment” and for “number of SMSCs” figures from the upper ranges in the table which means that we are deriving a conservative benchmark. The corresponding calculation is provided in Table 5-3.

Table 5-3: Derivation of the benchmark for the SMS centres

Object of consideration	Unit	Relevant quantity
Investment per SMS centre	AUD	5,000,000
Number of SMS centres	Number	3
Total investment	AUD	15,000,000
WACC	%	5.43
Length of economic life of SMSC	years	8
Annuity (formula as in Table 4-12)	AUD	2,361,335
Opex = 10 % of investment*	AUD	1,500,000
Subtotal of annuity and opex	AUD	3,861,335
Common cost = 10 % of subtotal*	AUD	386,133
Total cost of SMSCs	AUD	4,247,468
Number of SMSs projected for 2015	Number	16,613,685,045
Cost per SMS	AU cent	0.0256

* The rate of 10 % on the investment value for opex as well as the 10 % mark-up for common cost are experience values that WIK knows from the analysis of cost accounting records of actual operators. We also applied these rates in the 2006/07 cost model for the ACCC.

In Table 5-4 we add the two cost components from Table 5-1 and Table 5-3 together.

Table 5-4: Benchmark cost per SMS

Cost component	AU cent per SMS
Cost due to conveyance	0.002
Cost due to SMS centres	0.026
Total cost per SMS	0.028

As appears from the above derivation, the bulk of the cost of providing SMS services is due to the dedicated equipment needed to handling them. Based on information from the benchmark models, we have made conservative assumptions for deriving the cost of these centres. Altogether, the two components lead to a cost for terminating one SMS that is lower than three hundredth of one AU cent. We obtained a similar result in the study carried out for the ACCC in 2006/2007.

The very low benchmark for terminating an SMS, which are presumably magnitudes below commercially negotiated rates in Australia,[12] needs further comment. These are in particular also called for, given that the benchmark in the one benchmark model that also shows the cost of terminating an SMS, i.e. the Denmark model, is with about 1 øre, or about 0.25 AU cents, still more than eight times higher than the cost arrived at here. Also the range of benchmarks between 0.06 and 0.48 NZ cents in the 2011 determination of the New Zealand Commerce Commission is substantially higher than the one obtained here. The same is true for the range of benchmarks reported in the ACCC's discussion paper of August 2014, where the range is between 0.04 AU cents and 1.74 AU cents, the lowest value of 0.04 AU cents being that for India.[13] The higher cost in the Danish case is primarily due to a – in our view – disproportionate cost for wholesale overhead. This cost component amounts, as determined by the Denmark model, to more than half of the cost of terminating an SMS. We are at a loss in identifying the type of wholesale activities that on account of terminating SMS traffic would generate such a relatively high cost. The provision of termination services does not require wholesale activities of the usual kind, since they are brought to one's points of interconnection unsolicited. There is no question that there is billing and some degree of customer care to assure frictionless interfaces with the interconnection partners at the SMS centres, but this type of cost is covered by the opex and common cost components included in the cost of these facilities. Our – not exhaustive – search for statements of regulatory agencies explicitly facing the very low cost of terminating SMS services led to the 2010 determination by the Communications Commission of Kenya, who recognises a pure LRIC cost for terminating an SMS of less than KES 0.01 or about 0.02 AU cents (taking PPP into consideration).[14] Given that pure LRIC costs tend to be half that of LRAIC costs, this would imply a cost of about 0.04 AU cents, which, beside the benchmark from India noted above, comes close to the benchmark obtained in this study. On the basis of these observations, we have no reason to question our above result simply because it is so much lower than most other benchmarks.

12 See Australian Competition & Consumer Commission (2014). In the table shown on page 10 of this document, the highest of seven benchmarks for SMS termination rates is shown to be 1.74 AU cents. The then following comment states that the regulated termination rates in the table are significantly lower than the current commercially negotiated SMS termination rates in Australia.

13 See Australian Competition & Consumer Commission (2014).

14 See Communications Commission of Kenya (2010).

6 Advice and recommendations

The ToR require us to provide advice and recommendations on

- a cost range that reflects the estimated costs of providing the mobile voice termination service in Australia, and
- whether, how and with what adjustments it is feasible to base SMS termination rate relative to the mobile voice termination rate

Below we present our recommendations which are based on the results of our analyses carried out in Chapters 4 and 5.

6.1 Cost range for the mobile voice termination service in Australia

Our recommendation regarding the cost range for the termination of voice derive from the results presented in Table 4-17 summarising our analyses carried out in Chapters 4. The recommended range for this service is based on the average benchmark with extreme values removed, i.e. 1.61 AU cents for the year 2015 and 1.18 AU cents for the year 2020, the values for the years in between having been linearly interpolated. The standard deviation around the 2015 value is 0.25 AU cents or 15 %. Following statistical practice, we define the cost range around the selected mean values on the basis of this standard deviation. The results are presented in Table 6-1.

Table 6-1: Recommended cost ranges for the termination of voice for the years 2015 - 2020

(1)	(2)	(3)	(3)
Year	Limit of lower range	Benchmark values for the years 2015 - 2020	Limit of upper range
	AU cents		
2015	1.37	1.61	1.85
2016	1.30	1.53	1.76
2017	1.22	1.44	1.66
2018	1.16	1.36	1.56
2019	1.08	1.27	1.46
2020	1.00	1.18	1.36

According to our analysis, we believe that the cost for terminating voice on the network of an efficient hypothetical operator in Australia lies within the ranges shown in Table 6-1. When assessing these ranges, the reader should take into consideration that we derived the benchmarks in column (3) of the table always with the concern in mind to be conservative rather than progressive, in particular when carrying out the adjustments.

6.2 Approach to determining the cost of terminating SMS

In Chapter 5 we demonstrated that the cost of conveyance of an SMS over the network can straightforwardly be derived from the cost of a minute of voice termination, using a conversion factor that is based on the relative capacity requirements of the two services. It was, however, also shown that there is a second component in the cost of SMS termination, i.e. the cost of the dedicated SMS centres necessary to handle the SMS on the network, which is actually the more important of the two components.

We derived cost estimates for both cost components, in the one case based on the conversion factor corresponding to the relative capacity requirements, and in the other case based on information regarding the expenses for SMS centres, for which benchmarks from the benchmark models were used. The resulting, conservatively derived, cost per SMS, as shown in Table 5-4, is 0.028 AU cent (in words: 2.8 hundredth of one AU cent) per SMS.

As this cost estimate is presumably below commercially negotiated rates by magnitudes, we then engaged in a discussion to the effect that there are no reasons to doubt the level of the cost that we derived. Our advice to the ACCC is therefore to seriously consider that the cost of terminating an SMS on the network of an efficient hypothetical operator in Australia corresponds to the one referred to in the preceding paragraph.

Appendix Links to benchmark models

Country	Year of development	Link
Denmark	2012	http://danishbusinessauthority.dk/lraic
Mexico	2015	http://www.ift.org.mx/iftweb/industria-2/unidad-de-prospectiva-y-regulacion/modelo-de-costos-utilizado-para-determinar-las-tarifas-de-interconexion-aplicables-al-ano-2015/
Netherlands	2013	https://www.acm.nl/nl/publicaties/publicatie/11645/Notificatie-ontwerpbesluit-marktanalyse-vaste-en-mobiele-gespreksafgifte-2013-2015/
Norway	2013	http://eng.nkom.no/market/market-regulation-smp/cost-model/lric-for-mobile-networks
Portugal	2012	http://www.anacom.pt/render.jsp?contentId=1125452&languageId=0#.VORavOaG9D0
Romania	2013	http://www.ancom.org.ro/en/lric-2011-2013_4348
Spain	2012	http://www.cnmc.es/es-es/telecomunicacionesyaudiovisuales/regulaci%C3%B3n/an%C3%A1lisisdemercados/an%C3%A1lisisdemercados-revisi%C3%B3n2013.aspx
Sweden	2014	http://www.pts.se/sv/Bransch/Telefoni/Konkurrensreglering-SMP/SMP---Prisreglering/Kalkylarbete-mobilnat/Gallande-prisreglering/
United Kingdom	2014	http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/

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