

Appendix 1: 700MHz Spectrum Auction Details

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Asia-Pacific						
Malaysia (Planned Approach)	2019	Spectrum Assignment (SA) through a tender (beauty contest)	4 x 20 MHz in the 703 – 743 and 758 – 798 MHz band	Two licenses of 2 x 20 MHz OR Four licenses of 2 x 10 MHz	15 Years	SKMM
Australia	2013	Spectrum assignment through auction	9 National lots of 2 X 5 MHz in the 703 - 733 and 758 - 788 MHz band	2 x 10 MHz (20 MHz in total) OR 2 x 20 MHz (40 MHz in total)	15 Years	https://www.acma.gov.au/theACMA/auction-summary-700-mhz-digital-dividend-2013
Philippines	2016	Spectrum assignment through auction	-	2 x 10 MHz (20MHz)	15 Years	https://www.telegeography.com/products/commsupdate/articles/2016/11/10/ntc-outlines-details-of-third-licence-auction-for-philippines/
Japan	2012	Tender	30MHz x 2	3 blocks of 2 x 10 MHz (FDD)	15 Years	https://group.softbank/en/corp/d/annual-reports/2013/segmentinformation/marketdata/frequencyadministrationjapan.html
New Zealand	2013	Spectrum assignment through auction	90 MHz	One license of 2x10 MHz Two licenses of 2x 15 MHz 2x5 MHz (unsold)	20 Years	https://www.telegeography.com/products/commsupdate/articles/2014/05/23/new-zealands-telecoms-minister-confirms-details-of-700mhz-spectrum-allocation-options/
Australia	2018	Spectrum assignment through auction	733 – 748 MHz paired with 788 – 803 MHz	. Lot one: 2 x 10 MHz lot (738–748 MHz paired with 793–803 MHz) . Lot two: 2 x 5 MHz lot (733– 738 MHz paired with 788–793 MHz)	11 Years 8 Months	https://www.acma.gov.au/-/media/Spectrum-Licensing-Policy/Information/pdf/700-MHz-unsold-lots_Auction-guide-pdf.pdf?la=en

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Singapore	2017	Spectrum assignment through auction	Nine (9) 700 MHz Spectrum Lots	Starhub: 30 MHz of 700 MHz M1: 20 MHz of 700 MHz	14 Years	https://www.imda.gov.sg/~media/imda/files/regulation%20licensing%20and%20consultations/frameworks%20and%20policies/spectrum%20management%20and%20coordination/spectrum%20rights%20auctions%20assignment/final%20information%20memorandum.pdf
India	2016	Spectrum assignment through auction	703 -748 MHz and 758-803 MHz (FDD)	770 MHz remains unsold	-	https://main.trai.gov.in/sites/default/files/White_Paper_22022019.pdf http://www.careratings.com/upload/NewsFiles/Studies/TRAI%20Recommendation%20on%20Spectrum%20Auction%20August%202018.pdf
Taiwan	2013	Spectrum assignment through auction	2x45 MHz	3 licenses of 2x10 MHz 1 license of 2x15 MHz	17 Years	https://www.ncc.gov.tw/english/content.aspx?site_content_sn=370
Europe						
Germany	2015	Spectrum assignment through auction	703-733 and 758-788 MHz band	FDD: Three licenses of 2 x 10 MHz	15 Years	https://frankrayal.com/2015/06/20/german-spectrum-auction-overview/
Sweden	2018	Spectrum assignment through auction	2 X 20 MHz plus 20 MHz in the 703-733 and 738-788 MHz band	· FDD: Two licenses of 2 x 5 MHz, One license of 2 x 10 MHz · Four licenses of 1 x 5 MHz (SDL)	20-25 Years	https://www.pts.se/contentassets/58f801887d6e46f590ef2b846447bc9b/consultation-700mhz-feb2018.pdf
France	2015	Spectrum assignment through auction	Six blocks of 700 MHz	SFR: 2 x 5 MHz Orange: 2 x 10 MHz Bouyges: 2x 5 MHz Free Mobile: 2x 10 MHz	20 Years	https://www.fiercewireless.com/europe/france-raises-almost-eu3m-more-from-700-mhz-auction
Finland	2016	Spectrum assignment through auction	2x30 MHz	FDD: Six license of 2x5 MHz	17 Years	https://www.lvm.fi/lvm-site62-mahti-portlet/download?did=208928

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Iceland	2017	Spectrum assignment through auction	3 lots of 2 x 10 MHz 703-733 and 758-788 MHz band	Two licenses of 2x10 MHz	15 Years	https://www.telegeography.com/products/commsupdate/articles/2016/07/21/iceland-auctioning-700mhz-frequencies-by-year-end/
Italy	2018	Spectrum assignment through auction	(694MHz-790MHz)	FDD: Six licenses of 2x5 MHz	15 Years	https://5gobservatory.eu/italian-5g-spectrum-auction-2/
Switzerland	2019	Spectrum assignment through auction	FDD: 60 MHz SDL: 15 MHz	60 MHz (FDD) 10 MHz (SDL)	15 Years	https://www.news.admin.ch/newsd/message/attachments/55585.pdf
Denmark	2019	Spectrum assignment through auction	FDD: 2x30 MHz TDD: 20 MHz	2x10 MHz 2x5 MHz 2x15 MHz plus 20 MHz (FDD)	20 Years	https://5gobservatory.eu/denmark-completes-auction-of-the-700-mhz-band/
Norway	2019	Spectrum assignment through auction	6 blocks of 2 x 5 MHz (2 x 30 MHz)	Three licenses of 2 x 10 MHz	20 Years	https://5gobservatory.eu/5g-spectrum/national-5g-spectrum-assignment/#1549379848113-e71527cb-a1c0
Americas						
U.S.	2008	Spectrum assignment through auction	698–806 MHz	-12 MHz bandwidth (698–704 and 728–734 MHz) -12 MHz bandwidth (704–710 and 734–740 MHz) -6 MHz bandwidth (722–728 MHz) -22 MHz bandwidth (746–757 and 776–787 MHz) -10 MHz bandwidth (758–763 and 788–793 MHz)	-	https://www.ellipsis.co.za/wp-content/uploads/2012/10/SAPS-auction_2012.pdf
Chile	2014	Spectrum assignment through beauty contest	Offered operators 70 MHz out of a total of 90 MHz of available spectrum. (713-748MHz and 768 - 803MHz)	2 x 10 MHz (713-778) / 2 x 15 MHz (723 - 793) / 2 x10 (738 - 803)	-	http://www.5gamericas.org/files/8314/4051/7653/4G_Americas_700_MHz_Spectrum_Process_Lat_Am.pdf

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Brazil	2014	Spectrum assignment through auction	9 lots of 700MHz band	2 x 5 MHz (703 -743MHz) (758-798MHz) (Comply with FDD)	-	Downloaded document.
British Virgin Island	2016	Tender	2x6 MHz (698-704 MHz) 2x10 MHz (788-798 MHz)	2 x 6 MHz (FDD) 11 MHz (TDD)	-	http://www.trc.vg/images/attachments/Consultations_2017/SMF%202018%20-%20Final%20Doc%20Post%20Consultation%20-%20050318%20-%20TRK%20%28004%29.pdf
Colombia	Expected 2019-2020	Tender	70 MHz split into seven blocks	-	20 Years	https://www.bnamericas.com/en/news/colombia-watchdog-welcomes-700mhz-tender-plans
Mexico	2016	Awarded to Wholesale network	two FDD blocks 45 + 45 MHz	2x45 MHz to network wholesaler	20 Years	http://www.ift.org.mx/sites/default/files/conocenos/pleno/presentaciones/adriana-sofia-labardini-inzunza-presidenta/spectrumsummit2017iftlabardinimexicooralfinale-170816174510.pdf
Peru	2016	Tender	90 MHz in 3 blocks	-	-	-
Canada	2014	Spectrum assignment through auction	108 MHz of spectrum	FDD: 3 Blocks of 12 MHz FDD: 2 Blocks of 10 MHz TDD: 2 Blocks of 6 MHz	-	https://en.wikipedia.org/wiki/700_MHz_auction_in_Canada
Argentina	2014	Spectrum assignment through auction	130 MHz	2x35 MHz + 2x10 MHz	15 Years	https://www.telegeography.com/products/commsupdate/articles/2014/11/03/argentina-spectrum-bids-total-usd2-23bn-13-above-floor-price/

25 countries excluding Malaysia and Colombia that will be awarding from 2020 onwards.

Appendix 2: 2300MHz Spectrum Auction Details

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Asia Pacific						
Malaysia (Planned Approach)	2019	Spectrum Assignment (SA) through a tender (beauty contest)	90 MHz (2300-2390 MHz)	Eight blocks of 2x5 MHz (3GPP Band 40)	15 Years	SKMM
Australia	2011	Spectrum assignment through auction	-	--	15 Years	https://www.acma.gov.au/theACMA/multiband-spectrum-auction-results-winning-prices-and-winning-bidders
Hong Kong	2012	Spectrum Assignment (SA) through a tender (beauty contest)	2x25 MHz or 50 MHz	Five frequency bands, each with a bandwidth of 2x 5 MHz (50 MHz)	15 Years	https://www.ofca.gov.hk/en/media_focus/press_releases/index_id_255.html
India	2016	Spectrum assignment through auction	320 MHz (20 MHz in 16 LSAs)	TDD	20 Years	https://main.trai.gov.in/sites/default/files/RecommendationsAuctionofSpectrum01082018.pdf
Singapore	2016	Spectrum assignment through auction	40 MHz (2300 MHz)	-	-	https://sbr.com.sg/telecom-internet/news/tpg-telecom-plagued-installation-challenges https://sbr.com.sg/telecom-internet/news/analysts-are-betting-tpg-fourth-telco
Europe						
United Kingdom	2018	Spectrum assignment through auction	40 MHz of spectrum at 2350-2390 MHz	8 x 5 MHz (TDD)	20 Years	https://www.ofcom.org.uk/_data/assets/pdf_file/0030/81579/info-memorandum.pdf
Denmark	2019	Spectrum assignment through auction	TDD: 100 MHz at 2300-2400 MHz	Six lots of 10 MHz spectrum (TDD)	22 Years	https://ens.dk/sites/ens.dk/files/Tele/information_memorandum_-_updated_feb_2019.pdf

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Americas						
Brazil	2020	Spectrum assignment through auction	100 MHz	National batch of 50 MHz and regional bundles of 40 MHz	-	http://www.southpartner.com/news/5g_auction_includes_four_frequency_bands_and_will_be_the_largest_in_brazil
Africa						
Nigeria	2014	Spectrum assignment through auction	30 MHz of unpaired spectrum (2360 – 2390 MHz) plus 10 MHz of guard band	1 x 30 MHz (TDD)	10 Years	https://www.ncc.gov.ng/documents/460-information-memorandum-on-2-3ghz-spectrum-auction-for-wholesale-wireless-access-service-wwasl/file

7 countries excluding Malaysia and Brazil that will be awarding from 2020 onwards

Appendix 3: 2600MHz Spectrum Auction Details

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Asia-Pacific						
Malaysia (Planned Approach)	2019	Spectrum Assignment (SA) through a tender (beauty contest)	i) 2x70 MHz (FDD) - 2500 MHz to 2570 MHz paired with 2620 MHz to 2690 MHz ii) 40 MHz (TDD) - 2575 MHz to 2615 MHz	Reassignment based on actual utilization	15 Years	SKMM
Hong Kong	2009	Spectrum assignment through auction	105MHz spectrum	FDD: Three 2x15MHz lots TDD: Three lots of 5 MHz	15 Years	https://www.dotecon.com/assets/images/dp1001.pdf
Myanmar	2016	Spectrum assignment through auction	2x20 MHz (2575-2595 MHz, 2595-2615 MHz)	TDD	15 years	https://www.ptd.gov.mm/Uploads/LawFP/Attach/22018/7527221022018_2.%202600MHz%20Auction%20Framework%20with%20Clarifications%20v%20Oct%2013%202016.pdf
Europe						
United Kingdom	2013	Spectrum assignment through auction	190 MHz spectrum	FDD: 2x5 MHz, 2x10 MHz, 2x20 MHz TDD: 9 generic lots of 5 MHz	20 Years	https://www.ofcom.org.uk/data/assets/pdf_file/0022/32872/im.pdf

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Sweden	2008	Spectrum assignment through auction	5 MHz blocks and national licenses	FDD: Three licenses of 2x 20 MHz & One license of 2x10 MHz TDD: 50MHz	15 Years	https://rysavresearch.files.wordpress.com/2017/08/2009_12_gsma_2_6_ghz_report.pdf
France	2011	Hybrid Tender	140 MHz	two lots of 2x15MHz and two lots of 2x20MHz	20 Years	https://www.ofcom.org.uk/_data/assets/pdf_file/0016/51208/spectrum-value.pdf
Belgium	2011	Single-Band Award	155 MHz	FDD: Two lots of 2x20 MHz, 2x15 MHz TDD: 45 MHz	15 Years	https://frankrayal.com/2011/11/29/analysis-of-the-2-6-ghz-spectrum-auction-in-belgium/
Spain	2011	Spectrum assignment through auction	5 national 2x10 lots	2x10 MHz 2x5 MHz	18 Years	https://www.ofcom.org.uk/_data/assets/pdf_file/0016/51208/spectrum-value.pdf
Portugal	2011	Spectrum assignment through auction	FDD: 14 lots of 2 × 5 MHz TDD: 2 lots of 25 MHz	FDD: 3 Lots of 2x20 MHz TDD: 1 Lot of 25 MHz	15 Years	https://www.anacom.pt/render.jsp?categoryId=344704
Norway	2007	Spectrum assignment through auction	2500-2690 MHz	FDD: 2x40 MHz FDD/TDD: 2x30 MHz TDD: 50 MHz	15 Years	https://www.ofcom.org.uk/_data/assets/pdf_file/0016/51208/spectrum-value.pdf

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Netherlands	2012	Spectrum assignment through auction	11 licenses of 1x5 MHz	TDD: 1 x 30 MHz , 1 x 5 MHz , 1x25MHz FDD: Two licenses of 2 x 10 MHz , 2 x 20 MHz , 2x20 MHz , 2x5 MHz	17 Years	https://www.telegeography.com/products/commsupdate/articles/2012/12/17/4g-auction-raises-usd5bn-for-dutch-coffers/
Finland	2009	Spectrum assignment through auction	FDD: 14 lots of 2x5MHz (2500MHz-2570MHz and 2620MHz-2690MHz) TDD: 50MHz (2570MHz-2620MHz)	FDD: 2 X 20 MHz(2500 – 2520 MHz), 2 X 25 MHz (2520-2545 MHz), 2 X 25 MHz (2545-2570 MHz) TDD: 1 x 50 MHz (2570-2620 MHz)	-	https://www.telegeography.com/products/commsupdate/articles/2009/11/24/finland-completes-2-6ghz-spectrum-auction/ https://rysavyresearch.files.wordpress.com/2017/08/2009_12_gsma_2_6_ghz_report.pdf
Austria	2010	Spectrum assignment through auction	Bandwidth of 2x70 MHz and consists of 14 paired 5 MHz frequency blocks	FDD : 14 (2x70MHz) TDD: 10 (50MHz)	16 Years	https://www.rtr.at/en/tk/FRQ_2600MHz_2010_AE
Switzerland	2019	Spectrum assignment through auction	-	None of the TDD spectrum at 2600 MHz was sold	15 Years	https://www.telecomtv.com/content/5g/swiss-land-334-million-for-5g-licences-34011/
Romania	2019	Spectrum assignment through auction	-	2x40 MHz (FDD)	10 Years	http://www.ancom.org.ro/en/mobil/january-31-2019_6074
Denmark	2010	Spectrum assignment through auction	2x70MHz	3 licenses of 2 x 20 MHz 1 license of 2 x10 MHz	20 Years	https://www.ofcom.org.uk/_data/assets/pdf_file/0028/74359/annex_8.pdf

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
Greece	-	-	-	2 x 10MHz blocks (TDD)	15 Years	https://www.telegeography.com/products/commsupdate/articles/2014/10/14/800mhz-2600mhz-auction-results-announced/
Germany	2010	Multiband Award	2 500.0-2 570 MHz/2 620-2 690.0 MHz 2 570-2 620 MHz	14 blocks of 2x5 MHz (FDD) 10 blocks of 1x5 MHz (TDD)	15 Years	https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/FrequencyAward2010/PresentationOutcomeAuction101015.pdf?__blob=publicationFile&v=2
Italy	2011	Multiband Award	240 MHz	2 blocks of 2x15 MHz, 2x10 MHz, 2x20 MHz (FDD) 30 MHz (TDD)	15 Years	https://books.google.com.my/books?id=vDQ5BAAAQBAJ&pg=PA106&lpg=PA106&dq=italy+2011+2.6ghz+auction+results&source=bl&ots=giCaBy3Ejs&sig=ACfU3U136pE9GhJ84rib6eb4NLIGuiCmAQ&hl=en&sa=X&ved=2ahUKEwiWhZPluoHkAhXU7XMBHT9eDNUQ6AEwBnoECAkQAQ#v=onepage&q=italy%202011%202.6ghz%20auction%20results&f=false
Americas						
Argentina	2017	Spectrum assignment through auction	2500 -2690 MHz	80 MHz (FDD) 20 MHz (TDD)	15 Years	https://www.telegeography.com/products/commsupdate/articles/2017/05/17/argentina-enacom-invites-bidders-for-2-5ghz-spectrum/

Country	Auction Date (Year)	Award Mechanism	Available Spectrum	Spectrum Allocated (TDD or FDD)	Timeline for Assignment	Source
British Virgin Island	-	-	FDD: 2500 MHz – 2570 MHz/ 2620 MHz – 2690 MHz TDD: 2570 MHz – 2620 MHz/ 2570 MHz – 2620 MHz	TDD	-	-
Mexico	2018	Spectrum assignment through auction	130 MHz	Four blocks of 2×10MHz (FDD) Two blocks of 20MHz (TDD)	20 Years	https://www.telegeography.com/products/commsupdate/articles/2018/07/11/mexican-2-5ghz-auction-date-looms-two-bidders-authorized/

21 countries excluding Malaysia that will be awarding from 2020 onwards

Appendix 4: Spectrum Band Allocation and Pricing for Mobile Operators in the 700MHz Spectrum

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
Asia - Pacific								
Philippines (108,315,639)	64%	3	PLDT	-	US\$660 Million	No conditions available	Coverage for 4G/LTE	https://www.rappler.com/business/industries/172-telecommunications-media/135644-globe-pldt-700-megahertz-cell-sites (2016)
			Globe	-	US\$660 Million			
Japan (126,808,064)	93%	3	NTT DoCoMo	2 x 10 MHz	Frequency band users are required to pay radio utilization fees to MIC of ¥200 (US\$1.90) a year for every base station and approximately ¥95.15 million (US\$ 902,878) a year for every 1 MHz of bandwidth used (5- 10 Years)	No conditions available	Coverage for LTE	https://group.softbank/en/corp/d/annual-reports/2013/segmentinformation/marketa/frequencyadministrationjapan.html (2012)
			KDDI					https://group.softbank/en/corp/d/annual-reports/2013/segmentinformation/marketa/frequencyadministrationjapan.html (2012)
			e-Mobile					https://www.mobileworldlive.com/latest-stories/japanese-carriers-issued-700mhz-airwaves/ (2012)
Singapore (5,877,979)	84%	4	Singtel	4 x 10MHz	SG\$376 Million	No conditions available	Use of spectrum to enhance network	https://www.gov.sg/~sgpcmedia/media_releases/imda/press_release/P-20170404-1/attachment/175%20MHZ%20OF%20SPECT

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
								RUM%20ALLOCATED%20TO%20FOUR%20WINNING%20BIDDERS%20THROUGH%20THE%20GENERAL%20SPECTRUM%20AUCTION.pdf (2017)
			M1	2 x 10MHz	SG\$188 Million			https://www.gov.sg/~sgpcmedia/media_releases/imda/press_release/P-20170404-1/attachment/175%20MHZ%20OF%20SPECTRUM%20ALLOCATED%20TO%20FOUR%20WINNING%20BIDDERS%20THROUGH%20THE%20GENERAL%20SPECTRUM%20AUCTION.pdf (2017)
			StarHub	3 x 10MHz	SG\$282 Million			https://www.gov.sg/~sgpcmedia/media_releases/imda/press_release/P-20170404-1/attachment/175%20MHZ%20OF%20SPECTRUM%20ALLOCATED%20TO%20FOUR%20WINNING%20BIDDERS%20THROUGH%20THE%20GENERAL%20SPECTRUM%20AUCTION.pdf (2017)
New Zealand (4,788,783)	69%	3	2degrees	2 x 10 MHz	US\$36.3 Million+ GST	No conditions available	4G-LTE cellular use	https://www.telegeography.com/products/commsupdate/articles/2014/05/23/new-zealands-telecoms-minister-confirms-details-of-700mhz-spectrum-allocation-options/ https://www.rsm.govt.nz/projects-and-
			Spark	2 x 15 MHz	US\$54.5 Million + GST			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
			Vodafone	2 x 15 MHz	US\$54.5 Million + GST			auctions/auctions/about-spectrum-auctions/ (2014)
Australia (25,133,932)	87%	3	Telstra	2 x 20 MHz	-	-	-	--
			Vodafone	-	-	-	-	
			Optus	2 x 10 MHz	AUD\$649.13 Million	-	-	
Taiwan (23,766,937)	87%	4	Ambit Microsystems Corp	2 x 10 MHz	TWD6.81 Billion	-	-	https://www.ncc.gov.tw/english/content.aspx?site_content_sn=370 (2013)
			Asia Pacific Telecom Co Ltd	2 x 10 MHz	TWD6.415 Billion	-	-	
			FET Co Ltd	2 x 10 MHz	TWD6.81 Billion	-	-	
			Taiwan Co Ltd	2 x 15 MHz	TWD10.485 Billion	-	-	
India (1,370,739,632)	82%	3	Airtel	-	-	-	-	-
			Jio	-	-	-	-	
			Vodafone	-	-	-	-	
Europe								
Sweden (10,053,135)	87%	5	Telia	One lot of 2 x 10MHz blocks	US\$143 Million (15 Years)	Minimum coverage requirement.	Coverage	https://www.pts.se/contentassets/58f801887d6e46f590ef2b846447bc9b/consultation-700mhz-feb2018.pdf (2018)
			Net4Mobility	Two lots of 2x5MHz	US\$150 Million (15 Years)	No coverage obligation		

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
Germany (82,438,639)	66%	5	TEF DE	2 x 10MHz (703- 773MHz)	€166.40 Million + €166.85 Million Total: €333.25 Million (15 years) - US\$373 Million	No coverage obligation	Coverage	https://frankrayal.com/2015/06/20/german-spectrum-auction-overview/ (2015)
			Vodafone	2 x 10MHz (708 - 788MHz)	€165.5 Million + €163.5 Million Total: €329 Million (15 Years) - US\$368 Million			
			Telekom	2 x 10MHz (718- 783MHz)	€166.7 Million + €171.6 Million Total:€338.3 Million (15 Years) - US\$378 Million			
Norway (5,400,916)	92%	3	Telia	2 x 10MHz	NOK 2,176,000 Million (US\$243 Million)	Coverage obligations for designated railway section	Coverage / Mobile services	https://eng.nkom.no/technical/frequency-auctions/auctions/planned-completed-auctions/allocation-of-the-700-mhz-band (2019)
			Telenor	2 x 10MHz	NOK180, 000,000 (US\$ 20.1 Million) - Didn't have to pay for placement in the 700MHz band	Coverage obligation for main highways		
France (65,480,710)	68%	4	Orange	2 x 10MHz	€933 Million	No coverage obligation	Coverage / Mobile services	https://www.fiercewireless.com/europe/france-raises-almost-eu3m-more-from-700-
			SFR	2 x 5MHz	€466 Million			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
			Bouygues Telecom	2 x 5MHz	€467 Million			mhz-auction (2015)
			Free Mobile	2 x 10MHz	€932 Million			
Finland (5,561,389)	83%	5	Telia	4 x 5MHz	€22.33 Million (17 years)	No coverage obligation	Coverage	https://www.telegeography.com/products/commsupdate/articles/2016/11/25/finlands-three-largest-cellcos-win-700mhz-licences-at-minimum-prices/ (2016)
			Elisa	4 x 5MHz	€22 Million (17 years)			
			DNA	4 x 5MHz	€22 Million (17 years)			
Iceland (339,031)	61%	4	Siminn	4 x 10 MHz	ISK 35 Million	Technologically neutral	Used for high- speed network services	https://www.telegeography.com/products/commsupdate/articles/2017/06/02/iceland-concludes-auction-for-lte-spectrum-in-four-bands/ (2017) http://www.lya.com/index.php/2017/05/08/spectrum-auction-in-iceland-moves-ahead-in-may/
Italy (59,216,525)	70%	4	Vodafone	4 x 5 MHz	€683.2 Million	No coverage obligation	Coverage	https://blog.telegeography.com/italian-5g-auction-causes-concern (2018)
			TIM	4 x 5 MHz	€680.2 Million			
			Lliad	2 x 10 MHz	€676.5 Million			
Switzerland (8,616,785)	74%	3	Swisscom	2 x 15 MHz	CHF 195.6 Million (inclusive of other spectrum) (15 years)	No coverage obligation	Coverage for 5G services	https://www.telegeography.com/products/commsupdate/articles/2019/02/08/switzerland-completes-5g-auction/ (2019) https://www.news.admin.ch/newsd/message/attachments/55585.pdf
			Sunrise	2 x 10 MHz	CHF 89.2 Million (inclusive of other spectrum) (15 years)			
			Salt	2 x 5 + 1 x	CHF 94.5 Million			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
				10 MHz	(inclusive of other spectrum) (15 years)			
Denmark (5,775,224)	81%	5	TDC	2 x 15 MHz + 20 MHz	DKK 1.62 Billion (inclusive of other spectrum) (20 years)	79 Areas, Minimum down/uplink of 30Mbps/3Mbps	Coverage	https://www.telegeography.com/products/commsupdate/articles/2019/03/29/hi3g-tdc-tt-netvaerket-winners-in-spectrum-auction/ (2019) https://5gobservatory.eu/denmark-completes-auction-of-the-700-mhz-band/
			Telenor	2 x 5 MHz	DKK 107.6 Million (inclusive of other spectrum) (20 years)	66 Areas, Minimum down/uplink of 30Mbps/3Mbps		
			Telia					
			3 (Tre)	2 x 10 MHz	DKK 485.233 Million (inclusive of other spectrum) (20 years)	67 Areas, Minimum down/uplink of 30Mbps/3Mbps		
Americas								
Chile (18,355,533)	69%	4	Entel	2 x 15MHz	CLP6880 Million (US\$12.3 Million)	Mobile voice connectivity, data transmission, Internet access for remote areas (1281 districts in all) and 500 municipal schools subsidized by	Coverage particularly in rural areas	http://www.5gamericas.org/files/8314/4051/7653/4G_Americas_700_MHz_Spectrum_Process_Lat_Am.pdf (2014)
			Movistar	2 x 10 MHz	CLP4249 Million (US\$7.6 Million)			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator that won the license	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
			Claro	2 x 10 MHz	CLP404.2 Million (US\$723,000)	the government.		
Brazil (212,599,530)	55%	9	Telmex (Claro)	1 lot of 2 x10 MHz	US\$724.6 Million	Does not include mandatory coverage obligation	Digitalization of television networks, improve mobile broadband with high speeds, expand fibre networks and improve national technology development	Downloaded document
			Telcom Italia (TIM)	2 lots of 2 x 10 MHz	US\$724.5 Million			
			Telefonica (Vivo)	3 lots of 2 x 10 MHz	US\$716.6 Million			
			Algar (CTBC)	5 lots of 2 x 10 MHz	US\$10.99 Million			

Appendix 5: Spectrum Band Allocation and Pricing for Mobile Operators in the 2300MHz Spectrum

Country (Population in Year)	4G Penetration Rate	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source (Year)
Asia-Pacific								
Singapore (5,877,979)	84%	4	TPG	8x5 MHz	-	-	-	https://www.zdnet.com/article/tpg-spends-sg23-8m-on-more-singapore-mobile-broadband-spectrum/ (2005)
Hong Kong (7,490,776)	84%	4	21 ViaNet Group Limited	1 x 30 MHz	US\$ 19.34 Million	No coverage obligations	LTE Coverage	https://frankrayal.com/2012/11/06/summary-of-select-spectrum-auction-results/ (2012)
			China Mobile Hong Kong Company Limited	1 x 30 MHz	US\$ 19.34 Million			
			Hutchinson Telephone Company Limited	1 x 30 MHz	US\$ 19.34 Million			
India (1,370,659, 594)	86%	4	Bharti Airtel	160 MHz	INR 7,895 crore	-	-	https://www.medianama.com/2016/10/223-2016-spectrum-auctions-telcos/ (2016)
			Reliance Jio	130 MHz	INR 7,000 crore			
			Vodafone	-	-			

Country (Population in Year)	4G Penetration Rate	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source (Year)
Europe								
United Kingdom (66,959,016)	77%	4	O2	40 MHz	£205,896,000	No coverage obligations	Coverage	https://www.ofcom.org.uk/about-ofcom/latest/features-and-news/results-auction-mobile-airwaves (2018)
Denmark (5,775,224)	81%	5	TDC	60 MHz	DKK 1.62 Billion	No coverage obligations	Coverage	https://www.telegeography.com/products/commsupdate/articles/2019/03/29/hi3g-tdc-tt-netvaerket-winners-in-spectrum-auction/ (2019)
Africa								
Nigeria (201,585,657)	44%	-	Bitflux	1x30 MHz	Reserve price, USD 23.25 Million	-	-	https://static1.squarespace.com/static/52246331e4b0a46e5f1b8ce5/t/5982efa959cc688aefded7f/1501753262055/Parallel+1B_Genna+Robb_Acacia+Economics.pdf (2014)

Appendix 6: Spectrum Band Allocation and Pricing for Mobile Operators in the 2600MHz Spectrum

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
Asia-Pacific								
Hong Kong (7,490,776)	90%	3	Genius Brand Limited	30 MHz (2500-2515 paired with 2620-2635 MHz)	HK\$ 518 million	-	-	https://rysavvyresearch.files.wordpress.com/2017/08/2009_12_gsma_2_6_ghz_report.pdf (2009)
			CSL Limited	30 MHz (2540-2555 paired with 2660-2675 MHz)	HK\$ 523 million	-	-	
			China Mobile Hong Kong Company Limited	30 MHz (2555-2570 paired with 2675-2690 MHz)	HK\$ 494.7 million	-	-	
Myanmar (54,399,531)	63%	9	Fortune International Ltd	2 x 20 MHz	\$6.09 Million (15 years)	-	-	http://www.vdb-loi.com/mlw/client-alert-motc-announces-2600-mhz-spectrum-auction-winners (2016)
			Global Technology Co Ltd	2 x 20 MHz	\$7.03 Million (15 years)	-	-	
			Amara Communications Co Ltd	2 x 20 MHz	\$120.36 Million (15 years)	-	-	

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
			Yatanarpon Teleport Public Co Ltd	2 x 20 MHz	\$107.99 Million (15 years)	-	-	
Europe								
United Kingdom (66,959,016)	77%	6	Vodafone Limited	2 x 20MHz (2500 - 2640Mhz) 1x25MHz (2570- 2595MHz)	€790.7 Million	No coverage obligation	-	https://www.ofcom.org.uk/_data/assets/pdf_file/0031/74893/4g-final-results.pdf (2013)
			Niche Spectrum Ventures Limited	2x 15MHz (2520- 2655MHz) 1 x 25MHz (2595 - 2620MHz)	€201.5 Million			
			Everything Everywhere Limited	2 x 35MHz (2535 - 2690MHz)	€588.8 Million			
Austria (8,766,201)	73%	4	Orange	4 lots of 2 x 10MHz	€4.1 Million (16 years)	Coverage obligations include 25% of population and have to be fulfilled with a data rate of 1Mbps in downlink and 256 kbps in uplink	Coverage	https://www.rtr.at/en/tk/FRQ_260_0MHz_2010_AE (2010)
			T-Mobile	4 lots of 2 x 20MHz	€11.2 Million (16 years)			
			A1	4 lots of 2 x 10MHz	€13.2 Million (16 years)			
			H3G Austria	4 lots of 2 x 20MHz	€11.1 Million (16 years)			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
Denmark (5,775,224)	81%	5	H3G	2 x 10MHz (Unpaired - 25MHz)	€953k (20 years)	No coverage obligations	-	https://www.ofcom.org.uk/_data/assets/pdf_file/0028/74359/annex_8.pdf (2010)
			TDC	2 x 20 MHz	€44.8 Million (20 years)			
			Telenor	2 x 20 MHz (Unpaired-10MHz)	€44.8 Million (20 years)			
			Telia	2 x 20 MHz (Unpaired-15MHz)	€45.3 Million (20 years)			
Greece (11,122,134)	66%	3	Cosmote	2 x 30 MHz	€28.2 Million	No coverage obligations	Coverage for LTE services	https://www.telegeography.com/products/commsupdate/articles/2014/10/14/800mhz-2600mhz-auction-results-announced/ (2014)
			Vodafone	2 x 20 MHz	€18.8 Million			
			Wind Hellas	2 x 20 MHz	€18.8 Million			
Sweden (10,053,135)	84%	4	Telia	2 x 20 MHz	\$93 Million (15 years)	No coverage obligations	Coverage	https://www.eetimes.com/document.asp?doc_id=1250889 (2008)
			Tele2	2 x 20 MHz	\$93 Million (15 years)			
			Telenor	2 x 20 MHz	\$93 Million (15 years)			
			Three (Tre)	20 MHz	\$49 Million (15 years)			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
France (65,480,710)	58%	4	Orange	2 x 20 MHz	€287 Million (20 years)	No coverage obligations	Coverage	https://www.telegeography.com/products/commsupdate/articles/2011/09/23/french-lte-auction-nets-eur936m-for-government/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%253A+telegeography%252Fcommsupdate+%2528TeleGeography+CommsUpdate%2529&utm_content=Google+Reader (2011)
			SFR	2 x 15 MHz	€150 Million (20 years)			
			Bouygues Telecom	2 x 15 MHz	€228 Million (20 years)			
			Free Mobile	2 x 20 MHz	€271 Million (20 years)			
Belgium (11,571,385)	70%	4	Belgacom	2 x 20 MHz	€20.22 Million (15 years)	No coverage obligations	Coverage	https://frankrayal.com/2011/11/29/analysis-of-the-2-6-ghz-spectrum-auction-in-belgium/ (2011)
			KPN Group	2 x 15 MHz	€15.04 Million (15 years)			
			Mobistar	2 x 20 MHz	€20.02 Million (15 years)			
			BUCD	45 MHz	€22.51 Million (15 years)			
Italy (59,216,525)	70%	4	Vodafone	2 x 15 MHz	€1260 Million (18 years)	No coverage obligations	LTE Coverage	https://books.google.com.my/books?id=vDO5BAAQBAJ&pg=PA106&pg=PA106&dq=italy+2011+2.6ghz+auction+results&source=bl&ots=giCaBy3Ejs&sig=ACfU3U136pE9GhJ84rib6eb4NLIGuiCmAQ&hl=en&sa=X&ved=2ahUKEwiWhZPluoHkAhXU7XMBHT9eDNUQ6AEwBnoECAkQAQ#
			Wind Tre	2 x 20 MHz	€1120 Million (18 years)			
			TIM	2 x 15 MHz	€1260 Million (18 years)			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
			Hutchison	2 x 10 MHz + 30 MHz	€231 Million (18 years)			v=onepage&q=italy%202011%202.6ghz%20auction%20results&f=false (2011)
Spain (46,441,049)	84%	4	Telefonica	2 x 20 MHz	€49.3 Million (18 years)	No coverage obligations	LTE Coverage	https://frankrayal.com/2011/08/03/spanish-spectrum-auction-results-as-expected/ (2011)
			Orange	2 x 20 MHz	€49.3 Million (18 years)			
			Vodafone	2 x 20 MHz	€49.3 Million (18 years)			
Portugal (10,254,666)	76%	3	MEO	2 x 20 MHz	€12 Million (15 years)	No coverage obligations	LTE Coverage	https://www.anacom.pt/render.jsp?categoryId=344704
			Vodafone	2 x 20 MHz	€12 Million (15 years)			
			NOS	2 x 20 MHz	€12 Million (15 years)			
Germany (82,438,639)	66%	3	Telekom	9 x 5 MHz	€84.8 Million (15 years)	No coverage obligations	LTE Coverage	https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Area%20Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/FrequencyAward2010/PresentationOutcomeAuction101015.pdf;jsessionid=EDED00DA2CAF4A9883FFC230AE9447CB?blob=publicationFile&v=2
			O2	16 x 5 MHz	€141.1 Million (15 years)			
			Vodafone	13 x 5 MHz	€118.4 Million (15 years)			

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
Norway (5,400,916)	87%	3	Telenor	-	-	-	-	-
			Telia	-	-	-	-	
			Ice.net	-	-	-	-	
Netherlands (17,139,467)	86%	3	KPN	1 x 30 MHz + 2 x 10 MHz	€1.35 Billion	No coverage obligations	LTE Coverage	https://www.telegeography.com/products/commsupdate/articles/2012/12/17/4g-auction-raises-usd5bn-for-dutch-coffers/ (2012)
			Vodafone	2 x 10 MHz	€1.38 Billion			
			T-Mobile	1 x 25 MHz + 2 x 5 MHz	€911 Million			
Finland (5,561,389)	83%	5	Telia	50 MHz	€819,200	No coverage obligations	Coverage	https://www.telegeography.com/products/commsupdate/articles/2009/11/24/finland-completes-2-6ghz-spectrum-auction/ (2009)
			Elisa	50 MHz	€834,700			
			DNA	40 MHz	€675,700			
Iceland (339,031)	61%	4	Siminn	2 x 20 MHz	ISK 10 Million	Technologically neutral	Used for high-speed network services	https://www.telegeography.com/products/commsupdate/articles/2017/06/02/iceland-concludes-auction-for-lte-spectrum-in-four-bands/ (2017)
			Vodafone	2 x 20 MHz	ISK 10 Million			
			Nova	4 x 10 MHz	ISK 12 Million			
			Yellow Mobile	2 x 10 MHz	ISK 6.3 Million			
Switzerland (8,616,785)	74%	3	Swisscom	-	-	-	-	https://www.telecomtv.com/content/5g/swiss-land-334-million-for-5g-licences-34011/ (2019)
			Sunrise	-	-	-	-	
			Salt	-	-	-	-	

Country (Population in Year)	4G Penetration Rate (2018)	Total Mobile operators in Country	Mobile Operator	Allocated Band	Price paid for Band (License term)	License Conditions	Planned Use	Source
Romania (19,469,760)	73%	4	Orange	-	-	-	-	https://www.telegeography.com/products/commsupdate/articles/2019/06/11/romania-to-grant-5g-licences-by-end-of-2019/ (2019)
			Vodafone	-	-	-	-	
			Telekom	-	-	-	-	
			Digi.Mobil	-	-	-	-	

Appendix 7: Data Points for 700 MHz Spectrum Pricing

Country	Year	Population (2019)	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
Germany	2012	82,438,639	66%	Telefonica	2 x 10 MHz	15 years	USD	373 Million	https://frankrayal.com/2015/06/20/german-spectrum-auction-overview/
				Telekom	2 x 10 MHz			368 Million	
				Vodafone	2 x 10 MHz			378 Million	
U.S.	2000	329,408,795	87%	-	-	-	USD	0.600 / US\$ / MHz /Population	http://atu-uat.org/wp-content/uploads/2016/06/day-1-session-4-presentation-1-by-scott-mckenzie-coleago-for-gsma-english-version.pdf
	2002							0.060 / US\$ / MHz /Population	
	2003							0.040 / US\$ / MHz /Population	
	2005							0.090 / US\$ / MHz /Population	
	2008							0.086 / US\$ / MHz /Population	
Australia	2013	25,133,932	87%	Telstra	2 x 20 MHz	11 years 8 months	AUD	1.3 Billion	-
				Vodafone	-			-	
				Optus	2 x 10 MHz			649.1 Million	
New Zealand	2013	4,788,783	69%	2degrees	2 x 10 MHz	20 years	USD	36.3 Million	https://www.telegeography.com/products/commsupdate/articles/2014/05/23/new-zealands-telecoms-minister-confirms-details-of-700mhz-spectrum-allocation-options/
				Spark	2 x 15 MHz			54.5 Million	
				Vodafone	2 x 15 MHz			54.5 Million	
Singapore	2017	5,877,979	84%	M1	2 x 10 MHz	14 years	SGD	188 Million	https://www.zdnet.com/article/tpg-spends-sg23-8m-on-more-singapore-mobile-broadband-spectrum/
				Singtel	4 x 10 MHz			376 Million	
				StarHub	3 x 10 MHz			282 Million	
				Net4Mobility	2 x 10 MHz	15 years		150 Million	

Country	Year	Population	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
Norway	2019	5,400,916	87%	Telia	2 x 10MHz	20 Years	USD	243 Million	https://eng.nkom.no/technical/frequency-auctions/auctions/planned-completed-auctions/allocation-of-the-700-mhz-band
				Telenor	2 x 10MHz			20.1 Million	
Japan	2012	126,808,064	93%	NTT DoCoMo	2 x 10 MHz	15 years	Yen	¥95.15 Million	https://group.softbank/en/corp/d/annual-reports/2013/segmentinformation/marketingdata/frequencyadministrationjapan.html
				KDDI	2 x 10 MHz				
				e-Mobile	2 x 10 MHz				
Chile	2014	18,355,533	69%	Entel	2 x 15MHz	-	USD	12.3 Million	http://www.5gamericas.org/files/8314/4051/7653/4G_Americas_700_MHz_Spectrum_Process_Lat_Am.pdf
				Movistar	2 x 10 MHz			7.6 Million	
				Claro	2 x 10 MHz			723,000	
Brazil	2014	212,599,530	55%	Telmex (Claro)	1 lot of 2 x10 MHz	-	USD	724.6 Million	Downloaded Document
				Telcom Italia (TIM)	2 lots of 2 x 10 MHz			724.5 Million	
				Telefonica (Vivo)	3 lots of 2 x 10 MHz			716.6 Million	
				Algar (CTBC)	5 lots of 2 x 10 MHz			10.9 Million	
Switzerland	2019	8,616,785	74%	Swisscom	2 x 15 MHz	15 Years	CHF	195.6 Million (inclusive of other spectrum)	https://www.news.admin.ch/news/message/attachments/55585.pdf
				Sunrise	2 x 10 MHz			89.2 Million (inclusive of other spectrum)	
				Salt	2 x 5 + 1 x 10 MHz			94.5 Million (inclusive of other spectrum)	

Appendix 8: Data Points for 2300 MHz Spectrum Pricing

Country	Year	Population	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
United Kingdom	2018	66,959,016	77%	O2	40 MHz	-	GBP	205.8 Million	https://5g.co.uk/guides/5g-uk-auction/
Australia	2011	21,133,933	87%	Telstra	-	-	AUD	-	https://www.acma.gov.au/theACMA/multiband-spectrum-auction-results-winning-prices-and-winning-bidders
				NBM Co	-			-	
				Optus	-			-	
India	2016	1,370,659,594	86%	Reliance Jio	160 MHz	20 years	INR	78.95 Billion or 7,895 crore	https://www.medianama.com/2016/10/223-2016-spectrum-auctions-telcos/
				Bharti Airtel	130 MHz			70.00 Billion Or 7,000 crore	
Singapore	2005	5,877,979	84%	TPG	8 x 5 MHz	-	SGD	<u>F&S estimate:</u> 39 Million	https://www.zdnet.com/article/tpg-spends-sg23-8m-on-more-singapore-mobile-broadband-spectrum/
Hong Kong	2011	7,490,776	84%	21 ViaNet Group Limited	1 x 30 MHz	15 Years	USD	19.34 Million	https://frankrayal.com/2012/11/06/summary-of-select-spectrum-auction-results/
				China Mobile Hong Kong Company Limited	1 x 30 MHz			19.34 Million	
				Hutchinson Telephone Company Limited	1 x 30 MHz			19.34 Million	

Country	Year	Population	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
Denmark	2005	5,775,224	81%	TDC	60 MHz	20 years	DKK	1.62 Billion	https://www.telegeography.com/products/commsupdate/articles/2019/03/29/i3g-tdc-tt-netvaerket-winners-in-spectrum-auction/
Nigeria	2014	201,585,657	44%	Bitflux	1 x 30 MHz	10 Years	USD	23.25 Million	https://static1.squarespace.com/static/52246331e4b0a46e5f1b8ce5/t/5982efa959cc688aecfded7f/1501753262055/Parallel+1B_Genna+Robb_Acacia+Economics.pdf

Appendix 9: Data Points for 2600 MHz Spectrum Pricing

Country	Year	Population	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
Denmark	2010	5,775,224	81%	H3G	2 x 10MHz (Unpaired - 25MHz)	20 Years	EUR	953,000	https://www.ofcom.org.uk/__data/assets/pdf_file/0028/74359/annex_8.pdf
				TDC	2 x 20 MHz			44.8 Million	
				Telenor	2 x 20 MHz (Unpaired-10MHz)			44.8 Million	
				Telia	2 x 20 MHz (Unpaired-15MHz)			45.3 Million	
Sweden	2008	10,053,135	84%	Telia	2 x 20 MHz	15 Years	USD	93 Million	https://www.eetimes.com/document.asp?doc_id=1250889
				Tele2	2 x 20 MHz			93 Million	
				Telenor	2 x 20 MHz			93 Million	
				Three (Tre)	20 MHz			49 Million	
France	2012	65,480,710	58%	Orange	2 x 20 MHz	20 years	EUR	287 Million	https://www.telegeography.com/products/commsupdate/articles/2011/09/23/french-lte-auction-nets-eur936m-for-government/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%253A+telegeography%252Fcommsupdate+%2528TeleGeography+CommsUpdate%2529&utm_content=Google+Reader
				SFR	2 x 15 MHz			150 Million	
				Bouygues Telecom	2 x 15 MHz			228 Million	
				Free Mobile	2 x 20 MHz			271 Million	

Country	Year	Population	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
Austria	2010	8,766,201	73%	Orange	4 lots of 2 x 10MHz	16 years	EUR	4.1 Million	https://www.rtr.at/en/tk/FRQ_2600MHz_2010_AE
				T-Mobile	4 lots of 2 x 20MHz			11.2 Million	
				A1	4 lots of 2 x 10MHz			13.2 Million	
				H3G Austria	4 lots of 2 x 20MHz			11.1 Million	
Germany	2010	82,438,639	66%	Telekom	9 x 5 MHz	15 Years	EUR	84.8 Million	https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/Telecommunications/Companies/TelecomRegulation/FrequencyManagement/ElectronicCommunicationsServices/FrequencyAward2010/PresentationOutcomeAuction101015.pdf;jsessionid=EDED00DA2CAF4A9883FFC230AE9447CB?__blob=publicationFile&v=2
				O2	16 x 5 MHz			141.1 Million	
				Vodafone	13 x 5 MHz			118.4 Million	
Netherlands	2010	17,139,935	86%	KPN	1 x 30 MHz + 2 x 10 MHz	17 Years (2012)	EUR	1.35 Billion	https://www.telegeography.com/products/commsupdate/articles/2012/12/17/4g-auction-raises-usd5bn-for-dutch-coffers/
				Vodafone	2 x 10 MHz			1.38 Billion	
				T-Mobile	1 x 25 MHz + 2 x 5 MHz			911 Million	

Country	Year	Population	4G Penetration	Mobile Operator	Spectrum Allocation	License Duration	Currency	Spectrum Price	Source
Finland	2009	5,561,389	83%	Telia	50 MHz	-	EUR	819,200	https://www.telegeography.com/products/commsupdate/articles/2009/11/24/finland-completes-2-6ghz-spectrum-auction/
				Elisa	50 MHz			834,700	
				DNA	40 MHz			675,700	
Hong Kong	2009	7,490,776	84%	Genius Brand Limited	30 MHz (2500-2515 paired with 2620-2635 MHz)	15 years	HK\$	518 Million	https://rysaviresearch.files.wordpress.com/2017/08/2009_12_gsm_2_6_ghz_report.pdf
				CSL Limited	30 MHz (2540-2555 paired with 2660-2675 MHz)			523 Million	
				China Mobile Hong Kong Company Limited	30 MHz (2555-2570 paired with 2675-2690 MHz)			494.7 Million	
United Kingdom	2013	64,700,000	77%	Vodafone Limited	2 x 20MHz	20 Years (2013)	EUR	790.7 Million	https://www.ofcom.org.uk/__data/assets/pdf_file/0031/74893/4g-final-results.pdf
					1x25MHz				
				Niche Spectrum Ventures Limited	2x 15MHz			201.5 Million	
					1 x 25MHz				
Everything Everywhere Limited	2 x 35MHz	588.8 Million							

Appendix 10: Data Points for 700 MHz Spectrum Pricing

Country	Population	Population Density - 2019	GDP (Per Capita) - 2019	4G Penetration	Year	License Duration	Price (US\$/MHz/Population)	ARPU (US\$)
Europe								
Spain	46,441,049	92/km ²	\$31,906	84%	2011	-	\$ 0.490	15.2
Italy	59,216,525	201/km ²	\$34,784	70%	2011	15 Years	\$ 0.810	12.5
Portugal	10,254,666	111/km ²	\$23,731	76%	2011	-	\$ 0.560	8.9
France	65,480,710	118/km ²	\$47,112	58%	2011	20 Years	\$ 0.880	17.8
France	65,480,710	118/km ²	\$47,112	58%	2015	15 Years	\$ 0.770	17.8
Denmark	5,775,224	133/km ²	\$62,041	81%	2012	20 Years	\$ 0.370	17.2
Sweden	10,053,135	22/km ²	\$54,135	84%	2011	15 Years	\$ 0.580	20.0
Sweden	10,053,135	22/km ²	\$54,135	84%	2018	15 Years	F&S Estimate: \$ 0.491	20.0
Norway	5,400,916	16/km ²	\$76,621	87%	2019	20 Years	F&S Estimate: \$ 1.575	F&S Estimate: 32.0
Germany	82,438,639	233/km ²	\$49,692	66%	2012	15 years	\$ 0.910	15.8
Germany	82,438,639	233/km ²	\$49,692	66%	2015	17 years	\$ 0.224	15.8
United Kingdom	66,959,016	276/km ²	\$42,036	77%	2013	-	\$ 0.650	22.8
Americas								
U.S.	329,408,795	35/km ²	\$65,062	87%	2000	-	\$ 0.600	42.9
U.S.	329,408,795	35/km ²	\$65,062	87%	2002	-	\$ 0.060	42.9
U.S.	329,408,795	35/km ²	\$65,062	87%	2003	-	\$ 0.040	42.9
U.S.	329,408,795	35/km ²	\$65,062	87%	2005	-	\$ 0.090	42.9
U.S.	329,408,795	35/km ²	\$65,062	87%	2008	-	\$ 0.860	42.9
Canada	37,459,147	4/km ²	\$48,601	82%	2005	20 years	\$ 2.020	65.3
Chile	18,355,533	25/km ²	\$24,747	69%	2014	-	\$ 0.017	F&S Estimate: 15.0
Chile	18,355,533	25/km ²	\$24,747	69%	2014	-	\$ 0.024	F&S Estimate: 15.0
Brazil	212,599,530	25/km ²	\$15,553	61%	2014	-	\$ 0.063	F&S Estimate: 21.0

Asia-Pacific									
Australia	25,133,932	3/km ²	\$57,204	87%	2018	11 years 8 months	\$	1.390	35.7
New Zealand	4,788,783	18/km ²	\$42,009	69%	2013	20 years	\$	0.340	34.7
Singapore	5,877,979	8,109/km ²	\$102,027	84%	2017	14 years	F&S Estimate: \$	0.504	50.9
Singapore	5,877,979	8,109/km ²	\$102,027	84%	2017	14 years	\$	0.490	50.9
Japan	126,808,064	337/km ²	\$41,418	95%	2012	15 years	\$	0.010	52.8
Taiwan	23,268,087	643.8/ km ²	\$25,448	87%	2013	16 years	\$	0.563	F&S Estimate: 18.0

Note: The only data points available for tender were for Japan and Chile.

Appendix 11: Data Points for 2300 MHz Spectrum Pricing

Country	Population	Population Density - 2019	GDP (Per Capita) - 2019	4G Penetration	Year	License Duration	Price (US\$/MHz/Population)	ARPU (US\$)
Europe								
United Kingdom	66,959,016	276/km ²	\$42,036	77%	2018	20 years	\$ 0.093	22.8
United Kingdom	66,959,016	276/km ²	\$42,036	77%	2018	20 years	F&S Estimate: \$ 0.095	22.8
Denmark	5,775,224	133/km ²	\$62,041	81%	2005	20 years	\$ 0.310	17.2
Denmark	5,775,224	133/km ²	\$62,041	81%	2019	22 years	F&S Estimate: \$ 0.522	17.2
Asia Pacific								
South Korea	51,363,324	511/km ²	\$32,766	97%	2005	-	\$ 0.080	38.9
India	1,370,659,594	411/km ²	\$2,041	86%	2010	20 years	\$ 0.120	2.8
Australia	25,133,932	3/km ²	\$57,204	87%	2011	15 years	\$ 0.002	35.7
Singapore	5,877,979	8,109/km ²	\$102,027	84%	2005	-	\$ 0.025	50.9
Singapore	5,877,979	8,109/km ²	\$102,027	84%	2005	-	F&S Estimate: \$ 0.119	50.9
Hong Kong	7,490,776	6,677/km ²	\$50,567	84%	2012	15 years	\$ 0.110	30.2
New Zealand	4,788,783	18/km ²	\$42,009	58%	2016	-	\$ 0.017	34.7
Americas								
Canada	37,459,147	4/km ²	\$48,601	84%	2005	-	\$ 0.028	65.3
Africa								
Nigeria	201,585,657	212/km ²	\$2,450	44%	2014	10 years	\$ 0.002	4.1

Note: The only data point available for tender was for Hong Kong.

Appendix 12: Data Points for 2600 MHz Spectrum Pricing

Country	Population	Population Density - 2019	GDP (Per Capita) - 2019	4G Penetration	Year	License Duration	Price (US\$/MHz/Population) - 2019 Exchange rate	ARPU (US\$)
Europe								
Denmark	5,775,224	133/km ²	\$62,041	81%	2010	20 years	\$ 0.140	17.2
Denmark	5,775,224	133/km ²	\$62,041	81%	2019	20 years	\$ 0.152	17.2
Sweden	10,053,135	22/km ²	\$54,135	84%	2008	15 years	\$ 0.140	20.0
France	65,480,710	118/km ²	\$47,112	58%	2011	20 years	\$ 0.110	17.8
Italy	59,216,525	201/km ²	\$34,784	70%	2011	15 years	\$ 0.062	12.5
Norway	5,400,916	16/km ²	\$76,621	87%	2007	15 years	\$ 0.037	F&S Estimate: 32.0
Austria	8,766,201	106/km ²	\$52,474	73%	2010	16 years	\$ 0.028	16.0
Germany	82,438,639	233/km ²	\$49,692	66%	2010	15 years	\$ 0.026	15.8
Spain	46,441,049	92/km ²	\$31,906	84%	2011	18 years	\$ 0.026	15.2
Finland	5,561,389	16/km ²	\$50,879	83%	2009	-	\$ 0.004	15.2
Asia Pacific								
Hong Kong	7,490,776	6,677/km ²	\$50,567	84%	2009	15 years	\$ 0.270	30.2
Hong Kong	7,490,776	6,677/km ²	\$50,567	84%	2009	15 years	\$ 0.240	30.2
Hong Kong	7,490,776	6,677/km ²	\$50,567	84%	2017	15 years	F&S Estimate: \$ 0.211	30.2
Singapore	5,877,979	8,109/km ²	\$102,027	84%	2005	-	\$ 0.010	50.9

Note: The only data point available for tender was for France where a hybrid tender was carried out.