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**Research on the Adjustment of
Radio Frequency
Charging Mechanism and Rate in Taiwan**

Executive Summary

Telecom Technology Center

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Executive Summary

I. Research Origin

The legal basis for the frequency utilization fee in our country is Article 48 Paragraph 2 of the “Telecommunications Act”, that “In order to effectively utilize the resources of radio waves, MOTC shall mandate the term of utilization of frequency, and establish a fee schedule to collect usage fees from radio frequency users.” The former telecommunication competent authority, the Directorate General of Telecommunications of MOTC, composed the frequency usage fee instructions by announcement in 1997, and the frequency usage fee began to be imposed starting from 1998. After NCC was established, the “Radio Frequency Usage Fee Charging Standard” was formulated in April 2007 according to the Charges and Fees Act and the Administrative Procedure Act. Later on, the charging formula was reviewed and modified multiple times from 2008 to 2017, and the charging standards were also regularly reviewed and modified to be in compliance with the spectrum management policy objectives of our country. In addition, the Executive Yuan has started the promotion of “Digital Nation • Innovative Economic Development Plan” ever since 2017, and the objectives are for the digital life service penetration rate of our citizens to reach 80%, broadband service to reach 2Gbps, and to guarantee the basic citizen right of 25Mbps broadband Internet access by 2025, which can drive the development of current national key industries such as IoT and medical care.

In coordination with aforementioned government policies, NCC has also actively promoted the improvement of broadband network coverage and adopted the mechanism for collecting radio frequency usage fees based on corresponding intervals in order to

prompt mobile broadband service providers to increase the installation of mobile broadband networks in remote areas and to optimize the network coverage in remote areas. Considering the obvious difference in wave propagation properties and degree of commercialization of Sub-1GHz, 1800MHz, 2100MHz, and 2600MHz frequency band granted to mobile broadband services or even the 2300MHz and 3600MHz which could be available in the future, there should be certain segmentation of spectrum value. As a result, the factor should be adjusted according to the newly added frequency band for the mobile frequency usage fees in order to reflect the spectrum values of high and low frequency bands.

The aforementioned conditions of policy development reveal that the style of frequency usage, the difference in frequency bands being used, the difference in geographical areas of use, and the correlation with the promotion of mobile broadband service are all deeply affected by the role of frequency usage fee. The planning and collection of frequency usage fee can reflect the spectrum value and bear the spectrum management cost, and they can also serve as the promotion incentives for mobile broadband infrastructure. The calculation and collection of frequency usage fees are no longer just for the purpose of telecommunication resources management.

Under the trend of digital convergence, the emerging communication technologies will continue to evolve, thus leading to a highly competitive communication market in response to the industrial development in the era of 5G and IoT. The background environment for the formulation of charging standards of existing frequency usage fees has been changed, so there is indeed the need for total examination of the structural adjustment mechanism and supporting measures of frequency fees. And the various calculation formula and standards of frequency usage fees should be further reviewed

such that the frequency charging standards can be more reasonable, the effective utilization of radio frequency can be enhanced, and the principle of user-pays can be implemented.

II. Research Methods and Process

The methods of this research are mainly literature analysis method, case study method, and comparative analysis method. Seminars have been organized for integrating the output of various work items. The draft of amendment of charging standards of our country's radio frequency usage fees and the recommended mid-to-long-term structural adjustment have been proposed according to the existing system of licensing via combination of business and frequency, and the converged spectrum management regulations of future telecommunication act based on licensing via frequency.

This study starts from the collection of international policies of frequency usage fees and clarifying the environments and requirements of frequency usage in various countries in order to further understand the thinking and policy consideration for the planning of frequency usage in various countries, and thoroughly understand the function of frequency usage fee as a policy tool. With different cultural backgrounds and society foundations in different countries, there could be special or exclusive planning for the requirement development of frequency usage fees under various business models. For better clarification of correlations and impacts caused by the different factors of various countries, the comprehensive comparative analysis of considerations and regulation architectures of various countries is required to actually

understand the focuses of policies of various countries. Later on, the comparative analysis should be conducted on aforementioned obtained data and future convergence regulatory structure. And the specific suggestions and responsive measures should be proposed considering the current status and infrastructure of the industries in Taiwan in order to improve the proper supervisory mechanism of radio frequency usage fees.

With the different development contexts of spectrum management architectures of various countries, the regulatory architecture, environmental properties, and the difference in policy direction all indicate that there are many different perspectives of the frequency use environment in Taiwan and international development situation to be clarified. Therefore, while collecting the information related to the charging mechanism of frequency usage fees in advanced countries, in this study experts and scholars have also been invited to participate in the seminars with industrial representatives to collect opinions from all sectors to serve as the reference for the proposed frequency usage fee calculation basis adjustment plan and relevant suggestions.

III. Review of Existing Radio Frequency Usage Fees Charging Mechanisms in Foreign Countries

We have collected the historical development, latest measures, and design of calculation models (including specific formula and standard of key parameters) of radio frequency usage fees charging mechanisms in ten countries/regions (US, Canada, Britain, Germany, France, Finland, Australia, Japan, Singapore, and Hong Kong). The comprehensive analysis and comparison of policy purpose, charging mechanism, charging subject, and charging models and formula of frequency usage fees in this study

are as shown below.

A. Comparison of purposes of charging policies

The comparison reveals that, among the purposes of charging policies of frequency usage fees in all countries in this study, most of them are for making up the costs of spectrum management except for promoting the effective utilization of spectrum, and they can properly reflect the opportunity cost of spectrum use value. The thinking of frequency usage fee in Canada has reflected its focus on frequency usage rate. The comparison table of charging policy purposes of the countries in this study is as shown in the following Table Table 2- 1.

Table 2- 1: Comparison of charging policy purposes of the countries

Countries	Purposes of charging policy
US	<ul style="list-style-type: none"> ● The spectrum management fee is for covering the costs of implementation of spectrum management, law enforcement activities, and activities stipulated by policies and rules. ● It is only limited to the management behaviors listed in the Communication Act, including the supervision of spectrum, formulation of policies and laws, information services for spectrum user, and international activities.
Canada	<ul style="list-style-type: none"> ● The charges imposed on limited rights or privilege, including the acquisition and use of natural resources under public control. ● It can reflect the economic value of consumption of spectrum resources, and promote the effective utilization or prevent the excessive use of public resources.

Britain	<ul style="list-style-type: none"> ● It can reflect the opportunity cost of use of spectrum, and reclaim the spectrum management cost. ● It can ensure the optimal spectrum utilization in order to maximize the benefits of citizens and consumers, including the general social value of spectrum use, specific consumers, and citizens' benefits.
Germany	<ul style="list-style-type: none"> ● It is for covering the administration, supervision, and execution costs required by frequency assignment, which include the planning and update of frequency usage, necessary measurement, research on inspection and compatibility, and assurance of frequency use efficiency and avoidance of interference; international cooperation, harmonization, and standardization.
France	<ul style="list-style-type: none"> ● Sharing all costs of this nation's management of radio frequency.
Finland	<ul style="list-style-type: none"> ● It can ensure the effective and interference-free use of radio frequency, promote competition, and maintain the quality, reliability, safety, and affordability of communication network and services. ● It can be used for covering the spectrum management cost.
Australia	<ul style="list-style-type: none"> ● Promoting the effective spectrum utilization and optimizing use benefits. ● Reflecting the spectrum management cost and spectrum value.
Japan	<ul style="list-style-type: none"> ● Public interest expenses for spectrum use. ● Spectrum monitoring, control, and investigation of illegal radio stations; summarizing the making and management of radio station supervisory system; others. ● The charging purpose newly added in recent years: in response to the talent cultivation of IoT equipment; in response to the preparation and support of satellite broadcast and reception environment after popularization of 4K and 8K; and preparation and support of wireless network environment in public area.

Singapore	<ul style="list-style-type: none"> ● Reclamation of administrative costs of spectrum management of competent authority.
Hong Kong	<ul style="list-style-type: none"> ● Reclamation of spectrum management cost. ● As for the spectrum not released via price bidding, the spectrum opportunity cost can be reflected by frequency usage fee. ● It can ensure that the spectrum is provided via economic and social approach with technology benefits, or allow companies to return the excessive spectrum, such that the entire society can acquire the public benefits of spectrum resources.

B. Charging mechanism

The comparison reveals that, in some countries like US, Canada and Japan, the charging approach of frequency usage fees is to determine the total amount of spectrum management expenditures first, and then divide it to fees to be shared by different businesses. Different charging mechanisms are formulated by other countries with respect to different business models. In some countries there will not be any additional frequency usage fee for the spectrum resources obtained via price bidding approach. Take the mobile communication business in Britain as an example, based on the payment of mobile communication management fee, the mobile communication management fee to be paid is calculated by the percentage of sales revenue. And there is no need to pay for the frequency usage fee with respect to the spectrum obtained via price bidding. The comparison table of charging mechanisms of frequency usage fees of the countries in this study is as shown in Table Table 2- 2 below.

Table 2- 2: Comparison of the charging mechanisms of frequency usage fees of the countries

Countries	Charging mechanism
US	<ul style="list-style-type: none"> ● Total budget allocation method ● The estimated value of actual direct cost related to the acceptance of spectrum license application implemented by FCC.
Canada	<ul style="list-style-type: none"> ● Total budget: the frequency usage fees are determined by the total amount of consumed spectra. ● The expenses of issuance, extension, or renewal of radio frequency permit include frequency license fees and the number of telephone channels. ● For the company who acquired spectrum license via price bidding, the bid bond will serve as the frequency usage fee. ● As for radio broadcast and wireless TV, it will be based on the collection of special license fees.
Britain	<ul style="list-style-type: none"> ● Administrative Incentive Pricing Method (AIP): it can reflect the spectrum management cost to cover the cost paid by competent authority for spectrum management; meanwhile, it can also reflect the opportunity cost (economic value) of spectrum use. ● The company acquired spectrum license via price bidding does not need to calculate the frequency usage fees by AIP method. The bidding can reflect the development of recent spectrum use market, and protect the competitiveness of future spectrum use. ● By object of collection, it can be divided into license fee and management fee. Management fee and license fee are calculated by the percentage of sales revenue generated by the business related to spectrum resources operation.

Germany	<ul style="list-style-type: none"> ● It can be divided into one-time fee and annual fee; one-time fee is based on the equipment being used; the annual fee is for covering the spectrum management cost. ● As for the annual fee, there will be different base unit (serving as the calculation basis) set up according to the different frequency user groups corresponding to the frequency purposes. ● The annual fee calculation scope covers the manpower expenses and business expenses required by spectrum management and electromagnetic compatibility management.
France	<ul style="list-style-type: none"> ● Frequency usage fee and administrative management fee should be paid.
Finland	<ul style="list-style-type: none"> ● License fee and frequency usage fee should be paid.
Australia	<ul style="list-style-type: none"> ● Spectrum license frequency usage fees include: management fee, annual license fee, and spectrum reception fee. ● Management fee: the direct cost generated by reclamation of spectrum management. ● License fee: it is for reclamation of indirect cost. ● Spectrum reception fee: The price is determined by bidding in order to reflect the opportunity cost of spectrum. ● Equipment license frequency usage fee: management fee and annual license fee.
Japan	<ul style="list-style-type: none"> ● Total budget allocation method.
Singapore	<ul style="list-style-type: none"> ● Administrative Cost Pricing Method = annual spectrum management fee plus one-time application processing fee. ● As for the spectrum resources released via bidding, the annual spectrum management fee and one-time application process fee should be paid in addition to the bidding price.

	<ul style="list-style-type: none"> ● The Administrative Incentive Pricing method is introduced by competent authority.
Hong Kong	<ul style="list-style-type: none"> ● As for the spectrum resources released via bidding, the bidding price is the frequency usage fee. ● As for the spectrum resources released via administrative assignment, the minimum cost replacement method should be used for calculation of frequency usage fee.

C. Charging object

In most countries all companies acquiring spectrum resources are set to be the charging objects of frequency usage fees. The frequency usage fees can be waived for the objects of emergency rescue, police, or government use in some countries. The comparison table of frequency usage fee charging mechanism of the countries in this study is as shown in Table 2- 3 below.

Table 2- 3: Comparison of frequency usage fee charging objects in the countries of this study

Countries	Charging objects
US	<ul style="list-style-type: none"> ● All permitted radio businesses. ● Exclusive telecommunication, microwave, radio, airline radio, mobile communication service, broadband wireless service, AM station, FM station, commercial digital TV, satellite TV station, lower power TV station, cable TV relay, and satellite live broadcast business.
Canada	<ul style="list-style-type: none"> ● Radio frequency equipment user; ● Spectrum license user;

	<ul style="list-style-type: none"> ● Broadcast license user. (with business revenue higher than a certain ratio) ● Wireless communication service providers.
Britain	<ul style="list-style-type: none"> ● Management fee is applicable to companies running telecommunication business, and license fee is applicable to companies running broadcast and TV businesses.
Germany	<ul style="list-style-type: none"> ● Those assigned with radio frequencies. ● Those exempt from frequency usage fee: Federal government and affiliated public corporation, and the agency and organization with all or part of regulatory expenditures covered by federal budget, or with national security mission.
France	<ul style="list-style-type: none"> ● Charging objects: exclusive telecommunication, fixed communication, mobile communication, satellite communication, and wireless regional service providers. ● Objects exempt for frequency usage fees: emergency medical care of public hospital, policy administration, and firefighting rescue and broadcast.
Finland	<ul style="list-style-type: none"> ● All radio frequency license holders.
Australia	<ul style="list-style-type: none"> ● Spectrum license holding companies ● Equipment license holding companies ● Objects exempt from equipment license fee: diplomatic agency, coastal and remote area emergency rescue agency, and human life protection and emergency rescue agency.
Japan	<ul style="list-style-type: none"> ● Permitted spectrum direct users include broadcasters, telecommunication companies, power companies, railway companies, highway, airlines, gas companies, national

	<p>corporation, local public organization, and common corporation.</p> <ul style="list-style-type: none"> ● Objects with reduced frequency usage fees: the use purposes of citizen safety (such as national defense and fire protection), and the security maintenance purposes (such as policy, maritime security, and drug bans) are all exempt from frequency usage fees. The businesses of fire protection and floor prevention purposes of local county/city governments will also be exempt from frequency usage fees. The disaster prevention administration purposes only need to pay half of the frequency usage fee.
Singapore	<ul style="list-style-type: none"> ● It can be divided into exclusive frequency, shared frequency, and temporary experimental frequency users. ● Exclusive frequencies include public mobile communication, radio broadcast, fixed communication, exclusive communication, and others.
Hong Kong	<ul style="list-style-type: none"> ● Non-government purpose spectrum users.

D. Charging model and formula

The comparison table of charging models and formula of frequency usage fees in the countries in this study is as shown in Table 2- 4 below. However, due to the different degrees of disclosure by competent authorities of various countries, the data is rather limited for some countries.

Table 2- 4: Comparison of charging models and formula of frequency usage fees in the countries in this study

Countries	Charging models and formula
US	<ul style="list-style-type: none"> ● Total budget allocation system ● The spectrum management expenses table will be submitted annually according to the total expenditures of spectrum management to be reviewed and approved by the Congress before being publicly announced. After it is confirmed, the charging rate will be determined.
Canada	<ul style="list-style-type: none"> ● Radio frequency user: the frequency usage fees will be calculated by considering the parameters such as type of station, type of service, amount of spectra, and geographical location. ● Different charging rates are differentiated according to different categories of business. ● Radio and TV operators: the payment to be submitted by the operators with sales revenues exceeding a certain ratio should be calculated by considering the management cost of competent authority (CRTC).
Britain	<ul style="list-style-type: none"> ● Management fee and license fee are calculated by the percentage of business revenues generated by the businesses related to the operation of spectrum resources. ● AIP method: considering frequency, geographical properties, bandwidth, and geographical coverage.
Germany	<ul style="list-style-type: none"> ● The calculation standard will be determined according to the different frequency users corresponding to frequency purposes. ● Calculating the business expenses and HR expenses required by competent authority, and the compensation of public interests of interference avoidance and effective use of frequency.

France	<ul style="list-style-type: none"> ● It can be divided into frequency usage fee and management fee.
Finland	<ul style="list-style-type: none"> ● Calculation standard is set according to the frequency purpose.
Australia	<ul style="list-style-type: none"> ● Annual license fee = basic fee x population coverage x amount of license bandwidth
Japan	<ul style="list-style-type: none"> ● It is calculated based on the accumulation of expense of every radio station.
Singapore	<ul style="list-style-type: none"> ● It is divided into frequency use management annual fee and one-time application fee.
Hong Kong	<ul style="list-style-type: none"> ● The base value of the alternative of this service should be calculated by minimum cost alternative method, and then the frequency usage fee can be calculated by considering the base value, bandwidth, frequency band, type of business license, and degree of exclusiveness.

IV. Comparison of charging mechanisms and charging rates of frequency usage fees of our country and foreign countries

We have investigated the rates and mechanisms of radio frequency purposes (such as mobile communication, radio broadcast, wireless TV, fixed communication, exclusive telecommunication, and satellite communication) in US, Canada, Britain, Germany, France, Finland, Australia, Japan, Singapore, and Hong Kong. The investigation reveals that there are different radio wave supervisory systems in these countries and regions, and the definitions, charging mechanisms, and degrees of disclosure of frequency usage fees are rather different. So it is difficult to conduct

comparative analysis even for countries adopting fixed rate. There are no general rules for the determination of rates in various countries and regions. There are several criteria of: fixed rate (single fee), number of radio stations, ratio of business revenues, and factor product.

V. Suggested adjustment of frequency usage fee of mobile broadband of our country

A. Suggested measure of converting the collection nature of frequency usage fee to management cost

In principle, the charging methods of spectrum management costs of many countries are based on annual charge of spectrum users to reclaim the direct or indirect costs of competent authorities generated by spectrum management activities. As for the collection of spectrum fee, it means the fee collected from specific users who borrow spectrum resources from the government. This charging principle is mainly for promoting the effective utilization of spectrum resources, so usually it is collected by market mechanism (such as bidding price), or the fee collection can reflect the opportunity cost¹ of spectrum acquisition.

The direct cost of spectrum management refers to the cost involving specific supervisory procedure or event, such as the cost of application for specific frequency

¹ITU (2016), Guidelines for the review of spectrum pricing methodologies and the preparation of spectrum fees schedules, p.10.

during license release, the manpower and time costs possibly consumed during frequency assignment process, the interference analysis required by frequency clearing, and the costs required by international or regional coordination; indirect cost refers to the cost possibly generated when supervisory agency carries out spectrum management mechanism, such as the costs of spectrum planning, spectrum monitoring, spectrum preparation, interference investigation, spectrum research, and relevant personnel, equipment, and building.

After comparative research on the charging modes of mobile communication (mobile broadband) frequency usage fees of various countries, the management costs which could be included in the charging mechanism of frequency usage fee can be divided into spectrum direct management cost and indirect management cost. For example, when US determines the rates of frequency usage fees, it has been specified that only the costs and expenses required by implementation of spectrum management, law enforcement activity, and formulation of policies and rules can be included as the consideration of frequency usage fee.

Table 4- 1: Management costs planned by various countries which could be included in the frequency usage fee charging mechanism

Countries	Charging
US	<ul style="list-style-type: none"> ● The collection of spectrum management cost is emphasized on direct management cost. ● The collection of frequency usage fee is mainly for covering the costs of implementation of spectrum management, law enforcement activities, and policies and rules formulation activities. These costs are limited to the management behaviors stipulated in Communication Act such as the execution of spectrum supervision, formulation of policies and regulations,

	<p>providing information services to spectrum users, and international activities.</p>
Canada	<ul style="list-style-type: none"> ● The frequency usage fee will not be repeatedly imposed on bidding-based business. Only the radio station will be charged. ● The license fees to be paid by telecommunication operators should be calculated according to Telecommunication Surcharges Management Rules based on the business revenue.
Britain	<ul style="list-style-type: none"> ● The purpose of frequency usage fee is to reclaim spectrum management cost, and making up for the costs paid by administrative agency for spectrum management. The Administrative Incentive Pricing Method will reflect the opportunity cost of spectrum use. ● Mobile service operators must pay one-time application fee while applying for spectrum resources in order to reflect the cost of application operation.
Germany	<ul style="list-style-type: none"> ● Frequency usage fee is for covering the administration, supervision, and execution costs required by frequency assignment, which include: (1) Planning and renewal of frequency use, including necessary measurement, inspection, and compatibility research, in order to ensure the frequency use efficiency and to avoid interference; (2) international cooperation, reconciliation and standardization. ● During the calculation of frequency usage fee, the competent authority will consider the business expense and manpower expense required by execution. A portion of it is for compensation of public interest targets such as interference avoidance, promotion of effective spectrum use, and assurance of electromagnetic compatibility.

France	<ul style="list-style-type: none"> ● Sharing all costs of national management of radio frequency.
Finland	<ul style="list-style-type: none"> ● Frequency usage fees should be paid by all base stations and equipment using frequencies. ● The purpose of frequency usage fee is to promote the frequency use efficiency.
Australia	<ul style="list-style-type: none"> ● Frequency usage fee is for reclamation of administrative cost of competent authority, and spectrum reception fee can reflect the opportunity cost. ● Management fee: it can reclaim the direct cost of spectrum management by the government. ● Annual license fee: it can reclaim the indirect cost of spectrum management.
Japan	<ul style="list-style-type: none"> ● The initial charging purpose of frequency usage fee: (1) spectrum monitoring, control, and investigation of illegal radio station; (2) production and management of comprehensive radio station supervision system; (3) others (matters which can benefit all radio stations). ● Newly added charging purposes in recent years: (1) in response to the talent cultivation of IoT equipment; (2) in response to the preparation and support of satellite broadcast reception environment after popularization of 4K and 8K; (3) preparation and support of wireless network environment in public areas. ● The use purposes of frequency usage fees can be divided into 9 categories of implementation objects, including: (1) implementation operation of wireless spectrum monitoring; (2) establishment and utilization of comprehensive radio station supervisory system; (3) expanded research and development in response to radio spectrum resources; (4) survey and assessment technology related to security of radio spectrum; (5)

	<p>emission of standard radio frequency; (6) popularized service supporting wireless system; (7) measures for dealing with shielding of radio spectrum; (8) enhancement of security and knowledge of correct use of radio spectrum; (9) and analysis and planning related to charging mechanism of frequency usage fee.</p>
Singapore	<ul style="list-style-type: none"> ● It is for reclamation of administrative cost of spectrum management by competent authority. ● Frequency usage application and processing fee: it is the cost of activities required by competent authority's assessment of feasibility during one-time reclamation of frequency applied for by the company. ● Frequency management fee: it is for annual reclamation of costs of activities resulted from protection of safe frequency use.
Hong Kong	<ul style="list-style-type: none"> ● The charging principles of frequency usage fee are for reclamation of spectrum management cost, and reflecting the opportunity cost of spectrum. ● As for the spectrum released by non-bidding approach (referring to the fixed link released by administrative assignment, electronic news interview and field broadcast link, and satellite link), the opportunity cost of frequency usage can be reflected by frequency usage fee. ● It is ensured that the spectrum is provided by the method with the optimal economic, social, and technical benefits, or the operators are allowed to return the excessive spectrum such that the entire society can acquire the public interest of spectrum resource.

By comparing and investigating the consideration factors of national competent authorities with respect to spectrum management cost, we can clarify that which are the cost factors resulted from spectrum management that should be included in the scope of frequency usage fee. After further comparison of charging systems of various countries with respect to mobile communication (mobile broadband) use frequency, they can be divided into three types as described below:

1. The fee includes direct management cost and indirect management cost

As for frequency usage fees of mobile communication spectrum of most countries in this study, the charging purposes include direct management cost and indirect management cost. In some countries, such as US, the frequency usage fee is emphasized on the reclamation of direct management cost; as for the mobile communication spectrum frequency usage fees in some countries, the charging will take into consideration the interference avoidance, promoting effective frequency use, and assuring the public interest of electromagnetic compatibility, such as Germany; there are also some countries, like France and Singapore, where the charging purposes of frequency usage fees are mainly for sharing all costs of spectrum management conducted by the government.

2. Charging includes spectrum management cost, policy objectives, and spectrum value

In Japan the spectrum resources are released under the review system. Therefore, the charging of frequency usage fee in this country will take into consideration the affairs which could benefit all radio stations in addition to the management costs resulted from spectrum supervision. Therefore, the charging

purpose of frequency usage fees in Japan covers a wider scope than the reclamation of spectrum management costs in other countries in this study. It further covers the costs of technology R&D, research and development of spectrum security technology, emission of standard radio wave, popularized services supporting wireless system, measures dealing with spectrum shielding, enhancement of spectrum security and knowledge of correct use, and analysis and planning of frequency usage fee system.

Some countries, such as Britain, will promote the policy goals to be achieved by competent authority while calculating annual spectrum license fees. For example, when Ofcom was implementing license renewal operation with respect to 900MHz and 1800MHz, for urging operators to enhance the incentives for mobile network deployment range, the costs of joint investment by operators will be taken into consideration during calculation of annual license fees of these two frequency bands in order to improve the willingness of operators to improve the total coverage of mobile network and coverage in remote villages.²

3. There will be no frequency usage fee for the spectrum released via price bidding mechanism

The investigation of this study reveals that, among charging policies of frequency usage fees of some countries in this study, there will be no frequency usage fee for the spectrum released via price bidding mechanism. For example, similar measures were adopted in Canada and Britain. The charge is only

² TTC (2015), Ofcom in Britain changed license conditions of mobile operators to improve the coverage of mobile network. For details please refer to: <https://www.ttc.org.tw/mobile/index.php?apps=news&action=more&id=108> ◦

applied to radio stations in Canada. In Britain, only a one-time application fee needs to be paid by the operator during application for spectrum resources in order to reflect the cost of operation process. In addition, a specific percentage of annual business revenue is collected as the license management fee. As for the spectrum resources released via price bidding in Hong Kong, the bidding price is the frequency usage fee.

The comparison among other countries in this study reveals that, if the mobile communication spectra of most countries were released via price bidding, there is not any additional charge of spectrum value (opportunity cost) with respect to frequency usage fees. Instead, it is mainly for reclamation of management cost. In some countries like Canada, there will not be any frequency usage fees for mobile communication spectrum released via price bidding. The comparison of frequency usage fee charging systems of mobile broadband service frequencies in our country and the countries in this study is as shown below.

Table 4- 2: Charging mechanisms of mobile broadband frequency usage fees in various countries

Research mechanism	Applicable country	Details
The charges include direct management cost and indirect management cost	US	Emphasized on direct management cost
	Germany	Covering the execution cost required by spectrum assignment and the compensation for public interests required by policy implementation.
	Australia	Reclamation of administrative management cost.
	France	Reclamation of administrative management cost.
	Singapore	Reclamation of administrative management cost.

The charges include spectrum management cost, policy purpose, and spectrum value	Japan	The frequency release is based on review system, and the frequency usage fee is applicable to six major charging purposes and nine major implementation fields
	Our country	The frequency release is based on bidding system
	Finland	The frequency release is based on bidding system, and the charging purpose is for promoting frequency use efficiency
There is no frequency usage fee for the spectrum released via price bidding mechanism	Canada	Only the use by radio station will be charged
	Britain	There will be a certain management fee (based on a certain percentage of business revenue)
	Hong Kong	The bidding prices is the frequency usage fee

In summary, the charging principle of mobile broadband frequency usage fee in our country should follow the international trend, that the nature of collection should be converted to covering the actual government expenses of businesses related to spectrum management. In addition to the direct costs such as manpower expense of relevant departments, possible indirect costs such as spectrum R&D and spectrum sharing database establishment and operation can also be included together with the consideration of realization of spectrum social value. If the competent authority believes that the collection of frequency usage fee can contribute to achieving the public interest required by policy, then the expenditure of such policy expense should be properly included.

It is suggested by this research that in the future the management cost factors of mobile broadband business frequency usage fee can be included, and we can learn from Japan, Germany, or Britain, that the measures of government administration

expenditure or administration purpose can be properly reflected by the collection of frequency usage fee, including:

- Direct cost and indirect costs of spectrum assignment and management by competent authority:
 - Direct costs include the costs of spectrum policy formulation, frequency monitoring system and management, and human resources;
 - Indirect costs refer to costs of spectrum technology R&D, R&D of spectrum coexistence and interference technology, application and processing operation of spectrum bidding, spectrum cross-field cooperation, R&D of transmission technology, network security assessment and inspection, and enhancement of Internet data security.
- The policy objectives formulated by the government for realizing public interests, including popularized service, broadband network performance measurement, communication equipment talent cultivation, and enhancement of mobile broadband network coverage in remote villages.

B. Suggestion for setting band adjustment factor

Current charging mechanism of mobile communication frequency usage fee in our country can be traced back to as early as 2000. The competent authority at that time, Directorate General of Telecommunications of MOTC, determined the basis for charging rate by referring to the result of spectrum bidding price in US. After all these years, the mobile communication market has undergone significant changes. So in this study the international spectrum bidding results from 2015 to 2018 have been collected, including the results of international biddings under 1GHz in 11 countries including US, France, Germany, and Norway. After consideration of currency exchange rate and Purchase Power Parity (PPP) and conversion to USD/MHz/pop, the average value is

calculated as USD 0.7237/MHz/pop.

Except for spectrum below 1GHz, in this study the results of international biddings of 1-3GHz, 3-6GHz, and 6GHz have also been summarized to calculate the average price of spectrum bidding in recent years. The band of 1-3GHz is USD 0.4615/MHz/pop, the band of 3-6GHz is USD 0.1318/MHz/pop, and the band above 6GHz is USD 0.003/MHz/pop.

The existing band adjustment factor is based on the consideration of the differences in wave physical properties and eco system, and the measures in advanced countries, and the band is divided into three sections: below 1GHz, 1GHz to 2.2GHz, and 2.2GHz and above, which are granted the weighting factor of 1, 0.9, and 0.8 respectively.

However, the analysis of bidding prices of various 4G/license release bands in our country reveals that the economic benefits assessments of frequency bands below 1GHz by operators are not any higher than the economic benefits of other bands. And practically, there is not much difference in the amount of base stations built for the band of 1GHz~2.2GHz by operators.

At the initial stage of development of 5G band, the development of equipment related eco system is not yet matured, thus leading to higher initial equipment cost. This phenomenon is especially obvious among high frequency bands. In this study it is suggested that the future release of higher frequencies can be based on multiple-stage “weighting factor”, that the ratio gets lower for higher frequency, to be in compliance with the fairness of burden of frequency usage fee.

In this study we refer to the experience of international bidding from 2015 to 2018

and compare the proportional relationship among average values of bidding prices of various bands as shown in the table below. These values can serve as the references for modification of band factor.

Table 4- 3: Ratio relationship among international spectrum bidding prices

	Below 1GHz	1-3GHz	3-6GHz	6GHz and above
Average spectrum fee (USD) per MHz/pop	0.7237	0.4615	0.1318	0.003
Ratio	1	0.64	0.18	0.004

Compared to band adjustment factor of existing mobile communication frequency usage fee in our country, the existing band factors can be divided into three categories, which are below 1GHz, 1GHz to 2.2GHz, and 2.2GHz and above. However, the initial cost of high frequency band equipment is rather high, and the assigned bandwidth is expected to exceed 400MHz. If there is not any additional band factor, it could result in reduced willingness of operators bidding for the high frequency bands, thus indirectly affecting the promotion of 5G innovative application services and the development of communication market in our country. Therefore, it is suggested in this study that we can refer to the current international practice to divide 5G spectrum into below 1GHz, 1GHz to 3GHz, 3GHz to 6GHz, and 6GHz and above. And the modification of band adjustment factor can be based on the conversion ratio of international bidding results. This is plan No.1 for band adjustment factor in this study as shown in Table 4- 4.

Table 4- 4: Comparison between the band adjustment factor plan No.1 proposed in this study and existing regulations

Modification plan No.1 proposed in this study		Existing charging regulation	
Frequency range	Band adjustment factor	Frequency range	Band adjustment factor
Below 1GHz	1	Below 1GHz	1
1-3GHz	0.64	1-2.2GHz	0.9
3-6GHz	0.18	2.2GHz and above	0.8
6GHz and above	0.004	-	-

The amount of frequency usage fee will have significant impact on annual revenue of government. Due to the consideration of the impact on government revenue by adjustment of frequency usage fee, plan No.2 of band adjustment factor has been proposed in this study. In this plan, the architecture of existing charging regulation is maintained with addition of bands of 2.2-3GHz, 3-6GHz, and 6GHz and above. And the adjustment factor 0.8 of existing band of 2.2GHz and above is modified as the adjustment factor 0.64 of 2.2GHz to 3GHz. The numerical values of plan No.2 of band adjustment factor proposed in this study is as shown in the table below.

Table 4- 5: Comparison between the band adjustment factor plan No.2 proposed in this study and existing regulations

Modification plan No.2 proposed in this study		Existing charging regulation	
Frequency range	Band adjustment factor	Frequency range	Band adjustment factor
Below 1GHz	1	Below 1GHz	1
1-2.2GHz	0.9	1-2.2GHz	0.9
2.2-3GHz	0.64	2.2GHz and above	0.8
3-6GHz	0.18	-	-
6GHz and above	0.004	-	-

C. Assessment and suggestion for adjustment of existing frequency usage fee per MHz

In this study the international bidding results from 2015 to 2018 have been investigated, and the conversion of relevant numerical values has led to the average value of USD 0.7237/MHz/pop. After referring to the calculation steps of frequency usage fee per MHz by the competent authority in 2000, the Directorate General of Telecommunications of MOTC, the average value is converted to NTD, divided by the 15-year validation period of regular license, and then multiplied by the total population of our country (the value in August, 2018) and the frequency usage fee factor to obtain the frequency usage fee per MHz suggested in this study to be NTD 9.08 million.

The calculation approach for the modification price of frequency usage fee per

MHz proposed in this study is as shown in the table below.

Table 4- 6: Calculation approach for the frequency usage fee per MHz proposed in this study

Average international bidding price of the band of below 1GHz (USD)	0.7237
<i>Multiplied by the currency exchange rate from USD to NTD</i>	30.695
<i>Divided by the validation period of regular international mobile communication license</i>	15 years
<i>Multiplied by the total population of our country(August 2018)</i>	23,577,271
<i>Multiplied by the factor of frequency usage fee</i>	0.26
<i>Obtained frequency usage fee per MHz (NTD/10,000)</i>	908

The frequency usage fee factor proposed in this study is based on the consideration that the spectrum value has been reflected in the bidding price during the bidding for spectrum. To avoid the spectrum value factor being repeatedly reflected in the frequency usage fee, in this study the average budget of frequency usage fee of the 5 previous years of our country has been summarized as around NTD 3.5 billion per year. The bidding prices of mobile broadband divided by average validation period of license is around NTD 9.83 billion per year, so the frequency usage fee factor is 0.26. The calculation formula for frequency usage fee factor is as shown below:

$$\frac{\text{Annual average of usage fee}}{(\text{Annual average of usage fee} + \text{annual average of bidding prices divided by validation period of license})} = \text{usage fee coefficient}$$

By referring to the international mobile broadband frequency usage fees by the unit of MHz, it can be found that the amount of NTD 10.675 million per MHz is obviously higher than other countries while being similar to Japan. However, in Japan the spectrum resources are released via the review system, so the spectrum value is reflected by the frequency usage fee. In our country the spectrum resources are released via bidding, such that the bidding price has already fully reflected the opportunity cost of spectrum.

If we conduct in-depth investigation of charging mechanisms of mobile broadband frequency usage fee, we will find that the charging mechanisms in Australia and Singapore are mainly for reflecting the spectrum administrative management cost. The charging content in Japan also includes spectrum value and the expenditure of policy purpose (such as technology R&D, popularized service subsidy, and talent cultivation) in addition to the reflection of management cost. Therefore, the German charging mechanism of frequency usage fee which includes both reclamation of spectrum management cost and reflection of public interest should serve as the reference for subsequent revision of mobile broadband frequency usage fee in our country.

D. Suggestion for coverage factor in remote areas

For further improvement of mobile broadband network coverage, and increasing the amount of high speed base stations built in remote areas by mobile broadband operators in order to optimize the village population coverage by high speed base station in remote areas, NCC reviewed the “Radio Frequency Usage Fee Charging Standard” in the 731st committee meeting on January 11th, 2017 and passed the addition

of “Remote Area Coverage Factor”. With the level 4 administrative area (village) serving as the basis for calculation of population coverage, the operators are encouraged to establish mobile broadband in 84 remote villages in the entire country, and the 5%, 10%, and 15% discounts of frequency usage fee are provided respectively when the coverage reaches 85%, 90%, and 95%.

Even though this design of adjustment factor is equipped with policy incentive, the population difference and geographical environment are special in remote areas of our country. After considering the user distribution and challenges of network construction, the effectiveness of active coordination by operators remains to be seen. The three major mobile broadband operators in our country will most likely set the target as more than 95% of coverage to obtain the highest discount of frequency usage fee; as for the operators with smaller scale of user base, it is rather difficult to achieve the lower target of 85% coverage under the economic consideration of expected investment far greater than the discount of frequency usage fee.

Moreover, the nature of collection of frequency usage fee will be converted to covering the administrative cost of frequency management in the future, so the purpose of collected fee should ensure complete reclamation of spectrum management cost. Therefore, there should be other forms of incentives or subsidies in the future to better benefit the operators with active constructions in remote villages.

During the transition adjustment period before complete conversion to covering the spectrum management cost, if the mobile broadband coverage in remote areas needs to be further enhanced, the existing approach of establishing one network for each operator cannot contribute to the reduction of construction cost in remote villages, and it could easily lead to repeated investment and energy consumption. In light of this, in

this study it is suggested to adopt the coverage under mobile infrastructure active sharing³ architecture to reduce the difference in the incentive of this factor between the market dominator and smaller scale operator; in addition, we can also refer to the promotion methods in other countries based on the enhancement of flow and transmission speed in order to simultaneously improve the coverage and quality of mobile broadband in remote villages.

E. Feasibility study of cancelling the Progressive Sunrise

Promotion Period of existing business adjustment factor

The third wave of mobile broadband business license release was completed in 2017, and the bandwidth of 120MHz was released in the band of 2100MHz, and the bandwidth of 10 MHz was released in the band of 1800MHz. These bands are applicable to the existing business adjustment factor of 0.7 in 2019.

During the past 5 years, the average annual income budget of frequency usage fee has been around NTD 3.5 billion. If the existing frequency usage fee calculation formula is not adjusted, there is still room for minor growth of total income budget for the next few years due to the Progressive Sunrise Promotion Period of “Business Adjustment Factor”.

Along with the preparation schedule and license release planning of 5G spectrum,

³ NCC passed the supervisory policy of Co-RAN (Coordinated Radio Access Network) in the 604th committee meeting on August 13, 2014. After its validation date, mobile communication network operators can apply for establishing the integration of radio frequency unit (RU/RRU) and base band unit (BBU) within the station.

the newly released mid-to-high bands of 5G can all provide rather large continuous accessible bandwidth in order to meet the huge demand for transmission speed.

Considering the current status of annually collected fee being far greater than the spectrum management cost (as compared to NCC fund budget), there should be a transition measure for collection of frequency usage fee during the process of conversion to covering the frequency management administrative cost in order to avoid the negative impact on the financial stability of our government.

F. Direction of suggested improvement

Based on the spectrum charging principle of ITU, in this study multiple countries have been further analyzed and compared, and we find that the frequently seen natures of collection of international frequency usage fees include direct or indirect management costs, the charging nature based on policy purpose, and the reflection of partial spectrum value. In some countries in which the spectrum resources are released via price bidding, the competent authorities may not impose frequency usage fee. Yet some countries might collect administrative management fee or a part of frequency value.

After comparison of natures of charging, charging standards, and charging purposes of mobile broadband frequency usage fees in our countries and other countries, in this study it is suggested that the management cost factors to be included in the mobile broadband frequency usage fee of our country in the future should include the direct and indirect cost of spectrum assignment and management by competent authority, and the resources consumed by our government for achieving the policy

objectives formulated based on public interest, including popularized service, broadband network performance measurement, and cultivation of communication equipment talents.

As for the charging standard of existing mobile broadband frequency usage fee per MHz in our country, in this study the results of international spectrum bidding from 2015 to 2018 have been used as the reference to derive the suggested frequency usage fee per MHz according to the past calculation logic of frequency usage fee by competent authority. It is suggested that the existing charging standard of NTD 10.675 million per MHz should be adjusted to NTD 9.08 million per MHz.

In this study there are also two suggested plans proposed with respect to band adjustment factor. The suggested plans proposed in this study reflect that the low, medium, and high frequency bands in the future 5G era should better meet the future mobile broadband market demand.

VI. Suggestions for improvement of existing frequency usage fee system in our country

A. Radio broadcast

Generally speaking, when the spectrum demand surpasses spectrum supply, the spectra will mostly be allocated via bidding approach, and this is the best method for ensuring that specific spectrum is used for the most valuable service. In the case with public policy consideration, the review system will be adopted, which means the

controller should determine who can acquire the license by being in compliance with relevant conditions. In other words, the adoption of license release via bidding is still for reflecting the market value of spectrum. However, by referring to the countries with well developed broadcast industry such as US, Britain, and Australia, even though some licenses of commercial radio stations are released via price bidding, we can easily find that they still collect annual administrative management fees.

According to the commissioned research project of “The 11th Echelon Phase 1 Planning and Research of Radio Station License Release Bidding” of NCC in 2014, the research team of Professor Chun-Fa Zhuang proposed that the bidding price refers to the acquisition of franchise while excluding the frequency usage fee during the 9-year license period. This is not different from the existing measure of mobile business license release.

The past surveys revealed that the profits situations of large and small broadcast operators in our country were showing obvious bipolar phenomenon. With the aforementioned policies encouraging the development of regional (medium power) or community (small power) broadcast industry, we suggest that, in addition to the existing consideration of population factor, the calculation of frequency usage fee can include radio station power factor, or the general calculation formula adopted in countries like Finland. This is for preventing operators from causing negative impact on the market competition due to different burdens of frequency usage fees.

B. Wireless TV

The station adjustment factor in existing formula is mainly for the discount of

public TV station. Since CTS is the only member of Taiwan Broadcasting System which did not receive any government budget subsidy, it still has to compete with other commercial channels for the TV commercials; for the implementation of publicization, the placement marketing, transaction of sell-off timeframe, and the production of religious or political call-in program of common commercial TV station cannot be found in CTS. According to the amendment of “Radio Frequency Usage Fee Charging Standard” passed by NCC in the 758th committee meeting on July 26, 2017, among the 5 CTS channels, the two with TV commercials (CTS channel (main channel) and News Information Channel) are granted the fee calculation factor of 1 as the commercial TV station. The other three channels for public missions without any TV commercials (Educational and Cultural Channel, Legislative Yuan Channel 1, Legislative Yuan Channel 2) are granted the factor of 0.2 as the PTS. According to the aforementioned considerations, another weighting adjustment factor of 0.52 is granted to CTS overall frequency usage fee, and there shall be no concern in the validity of this move. It is suggested that the revision or existence of this factor can be reviewed in the future after the government has dedicated more subsidies to the Taiwan Broadcasting System.

C. Fixed communication

Even though frequency multiplexing can be done by H/V different polarizing approaches within the same frequency band of microwave link, the operator must implement equipment upgrade investment, and this measure is in compliance with the principle of promoting the frequency use efficiency. Therefore, it is suggested that with existing or adjusted rate, the operators should be allowed to simultaneously acquire the use of different polarizations.

In addition, due to the impact of the trend of 5G network densification, the utilization of wireless backhaul to reduce the construction cost and maintenance difficulty can contribute to the large-scale construction of small base station; therefore, for the band applicability and rate adjustment in the future, the understanding of domestic fixed communication with respect to future spectrum demand can be deepened via public consultation in addition to continuous attention to international development trend.

D. Exclusive telecommunication

Conventionally, exclusive communication equipment must be capable of overcoming the impact of severe environment with longer service life. However, benefitted from the open competition of telecommunication liberalization, there has been significant progress in either service quality or price of public mobile communication technology, and it has been gradually applied to this field. One good example is the use of commercial LTE network for infrastructure required by Public Protection and Disaster Relief (PPDR).

The existing charging standard of exclusive telecommunication frequency usage fee in our country mainly depends on assigned bandwidth, emission power of emitter, and degree of sharing (represented by the number of mobile stations). A discount parameter d (adjustment factors such as special purpose, business nature, remote area, non-frequency crowded area, and price index) is also provided to special purposes such as policy, disaster relief, and rescue.

It is suggested that the simplified fee calculation mode should be adopted, and the

rate should be determined for radio stations above a certain power level with emission capability according to the exclusive or shared frequency and service coverage.

E. Satellite communication

The charging standard of existing satellite communication frequency usage fee in our country is mainly calculated according to the assigned bandwidth. The assigned frequency less than 1MHz will be calculated as 1MHz, and the assigned frequency more than 72MHz will be calculated as 72MHz. A discount parameter d (adjustment factors such as special purpose, business nature, remote area, non-frequency crowded area, and price index) is also provided to special purposes such as policy, disaster relief, and rescue.

In general, if the satellite of C band is used, the bandwidth of single transponder is 36MHz. So when more than two transponders are used simultaneously by the emitting station, the billing cap of NTD 360,000 ($= 72 \text{ MHz} / 1\text{MHz} \times 5,000$) has been reached, and it is not any higher than other countries. Considering the fact that satellite communication often uses the same band as the fixed communication or microwave link, in the future it can be evaluated to set the frequency usage fees for these three purposes at the same level.

VII. Supporting measures for frequency usage fee under the architecture of Telecommunication Administration Act

Along with the advancement of communication and information technologies, the development of broadband and digitalization allow telecommunication, communication, Internet infrastructure, and network services to fully integrate and quickly deliver various message contents such as voice, image, and data; in addition, the introduction and popularization of mobile smart terminal device have allowed consumers to access various services provided on the Internet via various networking services, thus driving the vigorous development of various information application services.

Under such development trend, there are significant changes in the draft of Telecommunication Administration Act as compared to the architecture of existing Telecommunication Act. In addition to the adoption of convergence architecture, the international legislation cases are introduced to greatly reduce the degree of market control. First of all, to encourage market participation to drive innovative service, the participation system is changed from the franchise system and permit system of existing Telecommunication Act to the registration system, and the types of behaviors to be registered have been specified (Article 5 of the Draft). As for the release of radio frequency, the existing control architecture of the frequency assignment being affiliated to the business franchise license is changed, and the permit is independently granted to the frequency use while including the legal basis for the use of multiple new types of frequency usage.

Frequency usage is changed from the existing management architecture of frequency being affiliated to business license to the management architecture based on

separation between telecommunication and frequency license. Telecommunication Administration Act is no longer based on the concept of individual telecommunication business. Instead, it is regarded as “Telecommunication Service”. In the future, the telecommunication service providers only need to register to the competent authority to decide the forms of telecommunication service they want to provide, and the competent authority will no longer distinguish the individual business.

In response to the convergence method architecture adopted by the draft of Telecommunication Administration Act, there will be significant changes of regulations of existing Telecommunication Act. The future spectrum management needs to be reconstructed. Authorizing legal basis needs to be converted for some regulations of existing Telecommunication Act, and there could be the need for formulate new sub-laws to supplement relevant regulation. Under the architecture of draft of Telecommunication Administration Act, the need for corresponding supporting sub-laws is mainly for the frequency use related subjects, including frequency reclamation compensation, secondary frequency transaction, spectrum sharing, incentive bidding, and frequency usage fee.

Among them, the frequency usage fee is stipulated in Article 64 of the draft of Telecommunication Administration Act, that competent authority should collect usage fees from radio frequency users for effective use of wave resources. However, the usage based on national security or statutory public obligation with approval by the Executive Yuan can be exempt for the usage fee (Paragraph 1). The collection of frequency usage fee should take into consideration the factors such as assignment approach, purpose, use effectiveness, and other public interests, and the competent authority should be authorized to determine the charging standard (Paragraph 2). According to the

legislative reason, the collection of frequency usage fee is for “Promoting the fair allocation of radio frequencies, improving the effective utilization of frequency resources, and implementing the user-pays principle”. However, consideration that some usages of radio frequency are for national security or statutory public obligation, so they can be exempt from this fee after being approved by the Executive Yuan.

The existing regulation of collection of frequency usage fee is the “Radio Frequency Usage Fee Charging Standard” announced in Article 48 Paragraph 2 of Telecommunication Act. After the promulgation of Telecommunication Administration Act in the future, competent authority can refer to this charging standard while formulating a new charging standard. For example, the purposes exempt for frequency usage fee in existing regulations can be reviewed to determine whether or not it should be maintained. However, the calculation standard of existing regulation is based on the type of telecommunication business, so it should be adjusted in the future according to the architecture of Telecommunication Administration Act.

As for the situation of telecommunication industry applying for radio frequency, it should be based on the principle of public bidding or auction release according to Article 94 of Budget Act and Article 54 Paragraph 1 of the draft, unless it is in compliance with Article 56 of the draft, that it should be assigned by additional review.

According to the draft, regardless of the frequency assignment approach for the user, in principle there is the obligation of paying frequency usage fee, and the assignment approach will affect the consideration of charging standard. In terms of the purpose, the use of commercial or other radio services should be taken into consideration; in terms of use efficiency, to prevent operators from stocking frequency resources and affecting the market competition, we can also consider higher frequency

usage fee in order to enhance the frequency use effectiveness.

In other words, under the architecture of Telecommunication Administration Act, with the independent authorization of frequency usage, competent authority can more flexibly utilize the formulation of frequency usage fee to serve as the incentives of communication policy in order to encourage or urge operators to help promote government policies and to enhance public interests of all citizens.

A. Proposing the corresponding measures of frequency usage fee of shared spectrum

The competent authority of Singapore believes that, based on the policy objectives of spectrum sharing and promotion of spectrum usage rate, the different rate stipulation approaches can contribute to the realization of spectrum usage mode with better effectiveness. This spirit is suggested to be adopted in this study, that in the future different rate structures can be distinguished with respect to exclusive spectrum and shared spectrum; the differentiation of rate structure can be based on the exclusive and non-exclusive rates set according to purpose and band of fixed communication in Hong Kong.

B. Proposing the frequency usage fee of commercial experiment R&D

The collection and analysis of frequency usage fee charging mechanisms in

various countries have revealed that, in Japan the spectrum technology R&D cost is included in the calculation of frequency usage fee when the frequency usage fee is calculated. In addition, in Singapore the charging mechanism of experimental network spectrum is stipulated. However, for promoting the development of 5G business, the competent authority of Singapore decided that the experiments related to 5G frequencies are exempt from frequency usage fee. For the frequency usage situations of technology testing and onsite verification in Hong Kong, if the band is used for the purpose of public interest, the competent authority can adjust the frequency usage fee to be zero.

The existing mechanisms of frequency usage fees of international commercial experiment R&D are rather rare, so in this study we refer to the experiment license rate mechanism in Singapore market to suggest competent authority to adopt the frequency usage fee of commercial experiment R&D.

In the Singapore rate mechanism, the frequencies used by coexistence approach can be divided into fixed communication business, non-aviation radio positioning business, satellite communication business, exclusive mobile communication, aviation radio positioning business, and other businesses. In response to the nature of commercial experiment R&D, in this study other businesses are selected as the comparison benchmark. Meanwhile, in the existing amendment draft of “Rules Governing the Installation and Use of Telecommunication Network for Academic Education or Network R&D Experimental Purpose”, the validation period of usage planned for commercial experiment R&D is six months. Therefore, in study we refer to the Singapore market experiment rate annual fee and convert it to the six-month rate as the frequency usage fee of commercial experiment R&D proposed in this study.

The commercial experiment R&D fee proposed in this study can be divided into two plans. Plan No.1 is based on the price after currency exchange rate conversion, and Plan No.2 is based on the price after the conversion of purchase power parity. They are as shown in the following table.

Table 1: Commercial experiment R&D frequency usage fee proposed in this study

Assigned bandwidth (BW)	Billing plan (per setting of use license)		
	Singapore rate (six months) Unit: Singapore Dollar	Plan No.1 (currency exchange rate) Unit: NTD	Plan No.2 (PPP) Unit: NTD
$BW \leq 25\text{kHz}$	150	3,300	2,667
$25\text{kHz} < BW \leq 500\text{kHz}$	250	5,500	4,445
$500\text{kHz} < BW \leq 10\text{MHz}$	2,000	44,000	35,560
$10\text{MHz} < BW \leq 20\text{MHz}$	3,850	84,700	68,453
$20\text{MHz} < BW$	3,650	124,300	100,457

It is believed in this study that setting up the frequency usage fee applicable to commercial experiment R&D should be able to effectively enhance the opportunity of frequency adopted by innovative experiments in order to encourage the development of innovative application.

VIII. Specific legislation suggestions

In study the specific amendment draft and total description are as shown below:

The existing charging standard of frequency usage fee is formulated by referring

to the commissioned research report in 2000. The frequency usage fee per MHz of mobile communication business is based on the spectrum value derived from UC PCS bidding result in 1997. In light of the change of environment since then, the relevant calculation formula and benchmark must be further reviewed such that the frequency charging standard will not be out of touch with the actual environment.

The required feature of future 5G spectrum usage is large bandwidth (it could reach hundreds of MHz for high frequency band), such that the frequency adjustment factor of existing mobile communication frequency charging standard must be reviewed and adjusted accordingly.

In coordination with the addition of proof of business (simply known as PoB) telecommunication network mechanism in the “Rules Governing the Installation and Use of Telecommunication Network for Academic Education or Network R&D Experimental Purpose”, the new charging standard of PoB is added.

The terminologies of microwave link and provision of program relay in outlying island in the category of broadcast and TV business among adjustment factors in charging standard appendix II have been clarified.