Windsor Place Consulting

NBTC Thailand

Optimally allocating spectrum

The case for further auctions of IMT spectrum in Asia

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Outline of WPC's Presentation

1. Spectrum management principles
2. Spectrum allocation and assignment
3. Economics of spectrum management
4. Why auction spectrum?
5. Types of spectrum auctions
6. Setting a reserve price
7. Spectrum caps to promote competition

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Spectrum management principles

Typical legislative provisions for spectrum management

Legislation will typically give responsibility for spectrum management to an independent sector regulator. Specific radiocommunications legislation or regulations cover *inter alia* radio frequency planning, licensing (including spectrum, apparatus and class licensing), reallocation, technical standards, interference and dispute resolution.

Regulations will typically include a number of objectives which the regulator must balance. E.g. from Australia's *Radiocommunications Act*:

- *Maximise, by ensuring the **efficient allocation and use of the spectrum**, the overall public benefit derived from using the radiofrequency spectrum.*
- *Provide a **responsive and flexible** approach to meeting the needs of users of the spectrum.*
- *Provide an **efficient, equitable and transparent system of charging** for the use of spectrum, taking account of the value of both commercial and non-commercial use of spectrum.*

Achievement of these objectives requires the regulator to develop effective methods for the efficient assignment of spectrum rights, or for the discovery of efficient prices.

Spectrum management principles

ACMA's *Principles for Spectrum Management*

ACMA's *Principles for Spectrum Management* intended to guide ACMA's management of the radiofrequency spectrum within its existing legislative responsibilities and government's policy settings. Key point is maximising overall public benefit of spectrum requires balance between regulatory and market mechanisms.

1. ***Allocate spectrum to the highest value use or uses.***
2. ***Enable and encourage spectrum to move to its highest value use or uses.***
3. ***Use the least cost and least restrictive approach to achieving policy objectives.***
4. ***To the extent possible, promote both certainty and flexibility.***
5. ***Balance the cost of interference and the benefits of greater spectrum utilisation.***

Pricing of spectrum involves **principles 1 to 4**. Regulator must ensure price results in highest value use for spectrum, that pricing mechanism is not too restrictive, and that price provides market participants and users with certainty and flexibility.

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Spectrum allocation and assignment

Managing mobile spectrum

Spectrum must be managed to ensure it is being used in highest value areas. Government and regulator must consider commercial and public benefit value of different types of spectrum. Broadly there are three main approaches to allocation:

- **Command & control**: Historical approach. Regulator decides how much spectrum each operator should have and allocates and assigns spectrum accordingly. Beauty contest involves comparison of different potential users based on network, rollout, coverage, technology, etc.

- **Spectrum available for licence-exempt use**: Also known as "spectrum commons" or "unlicensed access". Regulator allows free access to the spectrum, usually with restrictions on power levels, making it most suitable for short-range devices.

- **Market mechanisms**: Auctions and other price-based mechanisms. Allows market to modify historical allocations towards those more likely to maximise economic efficiency. Spectrum pricing can also inject some market disciplines into the allocation and assignment process.

Spectrum allocation and assignment

Administrative assignment

Principle behind this method is that the right to use the spectrum is assigned by government or regulator using non-price process. Often this was to whichever candidate was first to apply.

Other methods include beauty contest, lottery, equal assignment, etc.

- Administrative assignment has historically been popular due to simplicity and low cost. Effective means of managing spectrum interference. Can be used effectively when there is excess supply of spectrum.

- However, it is inappropriate when there is a spectrum shortage and there is risk of over-valuing the spectrum.

- In addition, it does not lead to an efficient assignment of spectrum given the selection is not determined by the price the prospective user is willing to pay.

Spectrum allocation and assignment

Problem with "beauty contests" and other direct assignment methods

Beauty contest was effective when there was low demand for spectrum. However, as market has become more competitive and value for spectrum has increased, beauty contest has been seen as unfair/not transparent.

- In recent years spectrum demand has started to exceed supply, especially in key mobile spectrum bands. "Command and control" approach is no longer appropriate to allocate spectrum effectively.
- Risk of political process undermining efficient/effective allocation. Risk of legal challenge. Creates uncertainty for operators.
- Large body of economic literature points to benefits of spectrum auction. Beginning with Ronald Coase in 1959. Auctions allow spectrum to be assigned to highest best use. Transparent process with clear rules and outcomes.

Spectrum allocation and assignment

Thailand's spectrum management framework

Spectrum management in Thailand is governed by the *Act on Organization to Assign Radio Frequency and to Regulate the Broadcasting and Telecommunications Services*. The amended Act provides for the establishment of the NBTC as the body responsible for planning and managing the radiofrequency spectrum and for the licensing of telecommunications and broadcasting services.

The Act specifies that spectrum licences are to be acquired through an auction, with transition arrangements providing that all persons assigned frequency prior to the Act shall be deemed licensed under the Act (Section 83).

Spectrum licences are not transferable under the Act (Section 46). This means there is a lack of flexibility, both with regard to the use of technology, which is prescribed in the spectrum licence, and the transferability of spectrum rights, which is prohibited under the Act.

Spectrum allocation and assignment

Thailand's 2012 auction of 2.1 GHz spectrum

The NBTC designed the auction of 2x45 MHz spectrum to license nine spectrum blocks, each having the standard minimum amount of 2x5 MHz with the aim of allowing bidders to determine their desired amount of spectrum pursuant to market forces. The main conditions imposed were:

- Licenses issued under the auction had a duration of 15 years.
- Licences required holder to achieve 50% population coverage within two years of issue, and 80% within four years of issue. There were provisions for lesser requirements of 20% and 30% respectively if any bidders had secured only a single 2x5 MHz block, however this did not eventuate.
- A spectrum cap of 2x15 MHz per operator was also enforced for the auction.
- Successful bidders were also required to provide a minimum of 10% of their network capacity to MVNOs on request. This meant that even if the auction itself was not highly competitive, it would still have a positive effect on market competition at the retail level.

The NBTC elected not to impose asymmetric requirements (for example 5%) on bidders who received only a single 2x5 MHz block as the requirement to support MVNOs was generally not seen as a barrier to entry.

Spectrum allocation and assignment

Thailand's 2012 auction of 2.1 GHz spectrum (2012)

Format for the auction was a simultaneous multi-round ascending process. Only the three existing operators (AIS, Dtac and True) were qualified bidders. Final price paid was only 3% above the reserve price of THB 40.5 billion. Total revenue raised was THB 41.63 billion (USD 1.36 billion).

In summary, the objectives and the outcome of the 2.1 GHz spectrum auction were consistent with international practice and achieved the goals of the NBTC in managing the radio spectrum resource. Namely:

- Spectrum licenses were efficiently and fairly assigned with minimal disruption and without legal challenges from the participants.
- The accompanying licenses incorporate helpful measures to improve competition through access to network capacity for MVNOs.
- The 2.1 GHz 3G licenses include provisions to benefit consumers by requiring price reductions of 15% in comparison to 2G services.
- Prices paid for spectrum by the winners compare reasonably with international benchmark prices for auctioned 2.1 GHz spectrum.

Spectrum allocation and assignment

Hong Kong's hybrid spectrum auction

Hong Kong used a combination of market and adminitrative measures for its reassignment of 2.1 GHz spectrum in 2014.The hybrid approach seeks to fulfil the dual goals of service continuity and efficient use of spectrum by using an administrative assignment for part of the spectrum (right of first refusal for the incumbent 3G licensees) with the remaining spectrum auctioned.

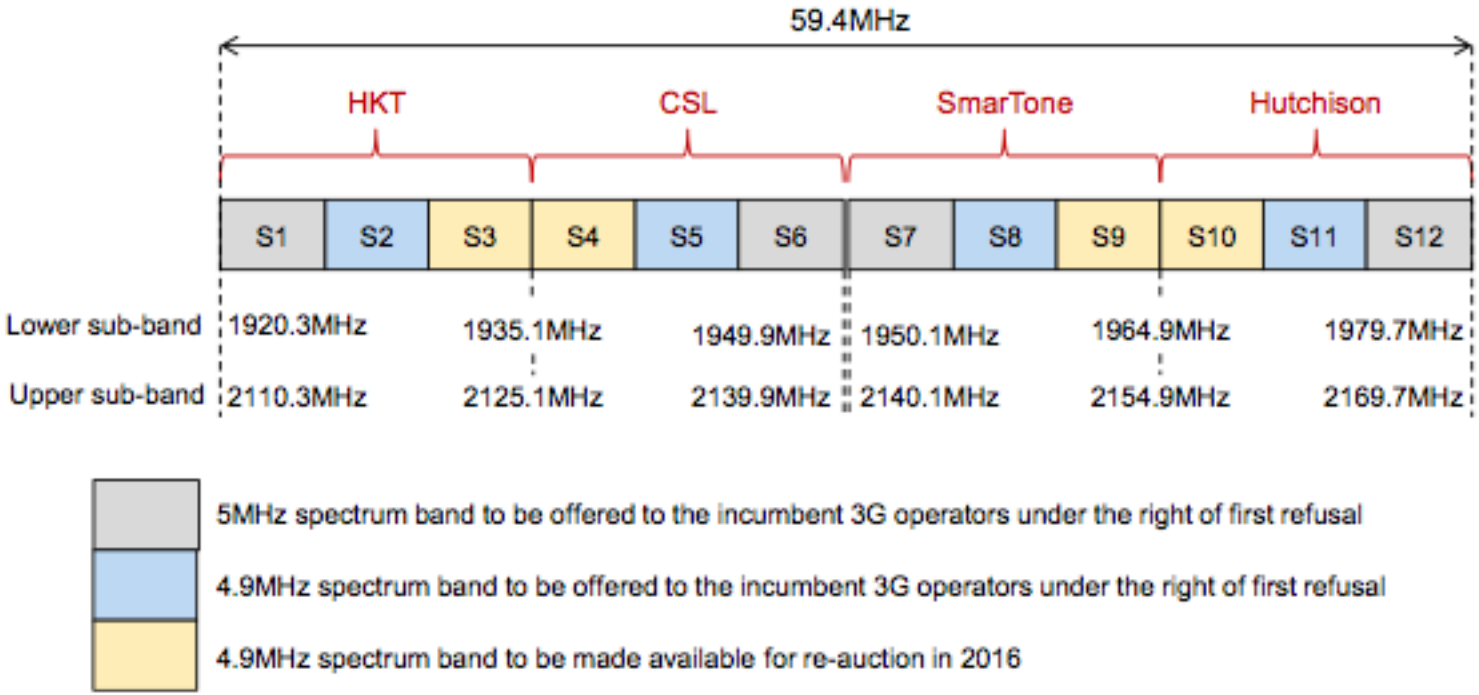
- Auction was for 2x49.2 MHz of spectrum in the 1.9-2.2 GHz band. Total funds raised were HKD 2.42 billion (USD 312 million) for a duration period of 15 years.
- 'Hybrid' approach was originally proposed by OFCA in November 2013 for reassignment of 2x59.2 MHz of 2.1 GHz spectrum due to expire in October 2016. Four incumbent 3G operators (CSL, HKT, HTCL and SmarTone) were to be offered a right of first refusal (RFR) for two thirds of their currently assigned spectrum.
- Separately, in April 2014, OFCA gave approval for HKT to acquire CSL, with a requirement that the merged entity divest 2x29.6 MHz of 2.1 GHz spectrum by not seeking reassignment. This provided a total of 2x49.2 MHz of spectrum available for auction. This was divided into five frequency bands, each with a bandwidth of 9.8 or 10.0 MHz.

Spectrum allocation and assignment

Hong Kong's hybrid spectrum auction

New entrants to the mobile market as well as the incumbent spectrum assignees (excluding HKT under the conditions imposed under its acquisition of CSL) were permitted to participate in the auction. A spectrum cap of 40 MHz is imposed on individual holdings of spectrum in the 1.9-2.2 GHz band.

Original hybrid auction plan (with four operators)



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Economics of spectrum management

Objectives of spectrum management

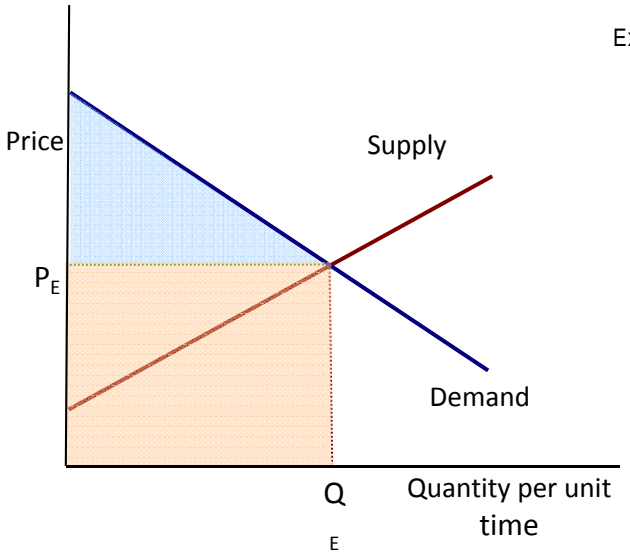
The overall aim of spectrum management is to maximise welfare by ensuring spectrum is used most efficiently and for the right purpose. This requires balancing a number of objectives:

- Maximise overall public benefit derived from using the radiofrequency spectrum.
- Make adequate provision of the spectrum for use by agencies involved in defence, emergency, community services, etc.
- Encourage the use of most efficient radiocommunications technologies to maximise range and quality of services.
- Provide an efficient, equitable and transparent system of charging for the use of spectrum taking account of the value of both commercial and non-commercial use of spectrum.

Economics of spectrum management

Economic concepts in spectrum management

- Scarcity and efficiency
- Consumer surplus, economic welfare, social welfare
- Public goods, private goods and commons goods
- Excludability and rivalry
- Market failure



Excludable? \ Rival?	Yes	No
Yes	**Private goods** RIVAL, EXCLUDABLE Exclusive spectrum licences where congestion occurs	**'Club' goods** NON-RIVAL, EXCLUDABLE Exclusive spectrum licences where no congestion occurs
No	**Common resources** 'The tragedy of the commons' RIVAL, NON-EXCLUDABLE Unlicensed or 'commons' spectrum where congestion occurs	**Pure public goods** NON-RIVAL, NON-EXCLUDABLE Unlicensed or 'commons' spectrum where no congestion occurs

Economics of spectrum management

Scarcity of spectrum and efficient use

- Spectrum is increasingly scarce relative to demand.
- Traditional "command and control" allocation methods often do not consider the need to maximise social welfare.
- As the economic importance of spectrum increases, the costs of not allocating spectrum increases - the returns to good spectrum management increase.
- Spectrum crunch has placed greater pressure on regulators to correctly balance demand for frequencies across an increasingly diverse set of competing uses.
- While governments have generally kept pace with spectrum demand by gradually increasing supply, more recently technological advances and market liberalisation have dramatically increased the rate of growth of spectrum demand.

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Why auction spectrum?

Key benefits of auctions

Auctions are now commonly recognised as the best way of assigning key mobile spectrum. Benefits of auctions are well known to regulators globally.

- Auctions allow spectrum to be allocated to its **highest value use** and to the highest value set at a price that reflects opportunity costs.
- Auctions are **open and transparent**, are not subject to allegations of corruption, and can be verified by third party accountants.
- Auctions are **fair**, with award criteria open and known and bid/prices are not based on subjective criteria.
- Auctions can be **relatively quick** (compared to other methods such as a beauty contest where selection can drag on for long periods).
- Auctions allow the government to **extract the maximum value** of the spectrum through auction revenue, which can then be used for the public benefit.

Why auction spectrum?

What are the downsides to using auctions?

There are downsides to using auctions. They may require additional preparation, expertise, resources, cost, etc. However, the advantages of using auctions far outweigh the disadvantages.

- Auctions will not achieve an efficient allocation in all circumstances. The auction design will influence the efficiency of the outcome achieved. **However**, the right auction design will ensure efficiency.

- Auctions are resource intensive for regulators and potential bidders. Auctions can require more preparation and are more complex. **However**, there is a lot of experience globally that can inform auction processes.

- Auctions are inappropriate for certain public spectrum, e.g. defense, emergency services, etc. It may also be inefficient for low value spectrum used for community access. **However**, it has proven to be the best method for high-value mobile spectrum.

Why auction spectrum?

Auctions are now the trend in Asia and Pacific

Auctions are now common throughout Asia Pacific, with the exception of Malaysia which still uses beauty contest. Hybrid methods also used for some allocations.

Country	Method of spectrum assignment
Australia	Auctions used for IMT spectrum, including most recent auction of digital dividend spectrum (including 700 and 2600 MHz) in 2013.
Hong Kong	Auctions used for IMT spectrum, including wireless broadband spectrum in 2009 and 2011. OFCA has decided to use a hybrid assignment for 3G spectrum in the 1.9-2.2 GHz band.
India	Auctions for IMT spectrum including 2100, 900, 1800MHz etc (although some spectrum has previously been allocated on a first-come, first-served basis).
Indonesia	Assignment of 2.1 GHz 3G spectrum in 2006 and 2.3 GHz WiMax spectrum in 2009 via a prequalification and auction hybrid proces. Previously, spectrum has been allocated on a first come, first served basis.
Malaysia	Beauty contest used for IMT spectrum, with other spectrum allocated on a first-come, first-served basis.
New Zealand	Auctions for IMT spectrum.
Singapore	Recent 3G spectrum auctions for 1800 and 2100 MHz, with the regulator moving away from administrative allocation.
Thailand	Regulator has moved to auctions, including for 2100 MHz, and auction for 900 and 1800 MHz spectrum to occur later in 2014.

Why auction spectrum?

But not all bands should be auctioned

Despite growing demand for spectrum and trend towards liberalisation, there remain areas where spectrum will continue to be managed directly by regulatory authorities.

Services	Usage and content
Satellite bands	International nature of satellite services and need to harmonise frequencies limits scope for allowing change of use in any one country. Some earth stations will use shared band, but could be advantages in permitting some flexibility.
Maritime and aviation bands	International nature of these bands and treaties associated with them will prevent reductions in restrictions on permitted use. Some commercial bands (e.g. maritime business radio) may offer flexibility.
Services below 30 MHz	Propagation of these frequencies is such that almost all usage will need international co-ordination.
Broadcasting band	Broadcasting is governed by both national broadcasting legislation and a number of international agreements. But digital dividend is seeing new uses in 700MHz band for PMR/Mobile/Wireless.
Radio astronomy	Radio astronomers need access to particular protected frequencies and work on an international basis.
Amateur radio	This is a use of the spectrum where there is an operational need for harmonisation on an international basis.
Community groups & NGOs	Frequencies reserved on a public policy basis.

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Types of spectrum auction

An ideal auction format

- Provides price discovery (bidders can respond to increases in price)
- …while not subjecting bidders to exposure risk
- Is not too complex
- Is transparent
- Limits opportunities for strategic bidding

Therefore, maximising chance of an efficient allocation of spectrum to maximise the benefits to the Indonesian economy and society.

Auction formats used globally

- SMRA (simultaneous multiple round ascending)
- Clock auctions - ascending or combinatorial
- Sealed big auctions

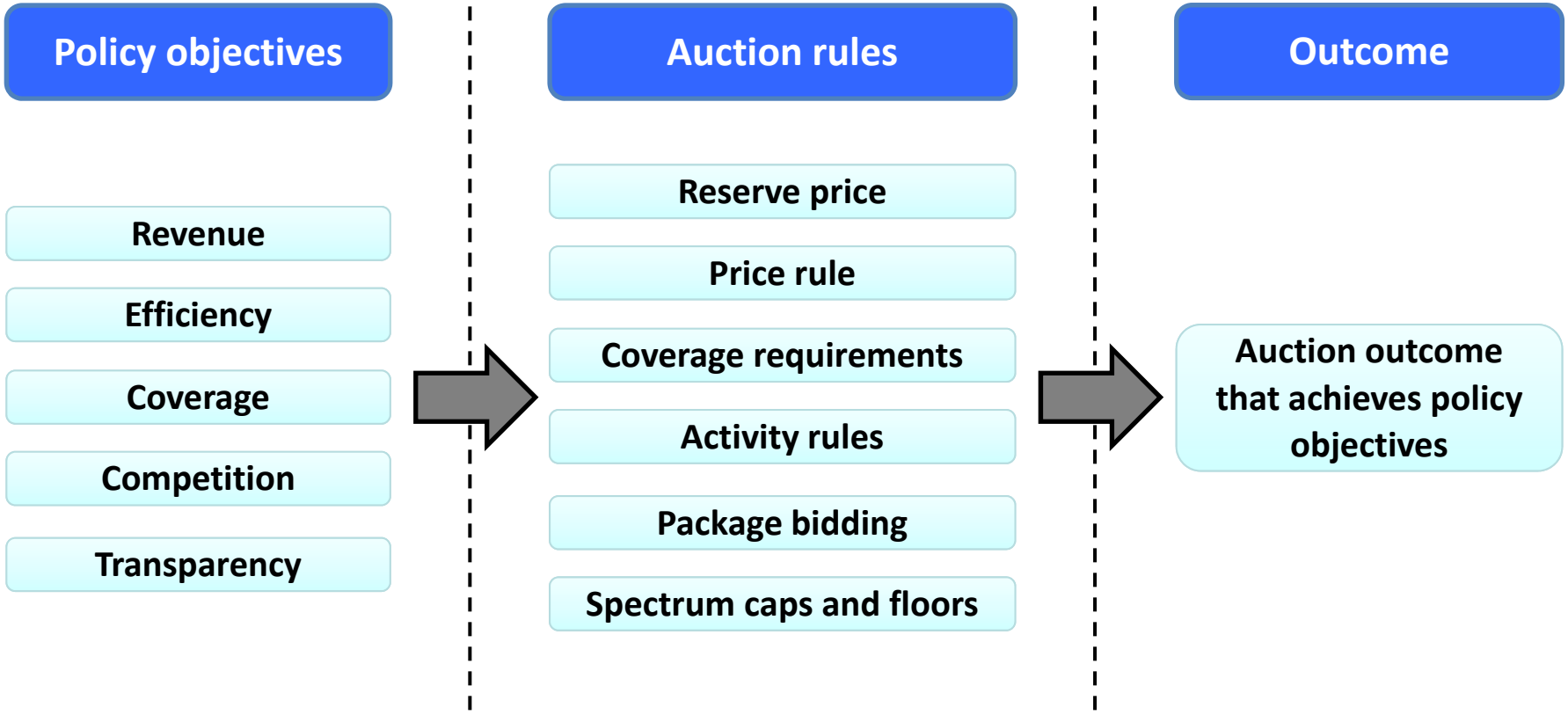
Types of spectrum auction

Comparison of main auction types

SMRA Simultaneous multiple round ascending auction	• Bid on specific blocks of interest (between minimum and maximum set by auctioneer for each block) • 'Standing high bids' for each lot in each round • Auction ends when there is no excess demand • 'First price': pay what you bid
CCA Combinatorial clock auction	• Bid on packages of generic lots rather than on individual lots • Pay 'second price': minimum needed to win and to avoid 'unhappy losers' • Separate assignment round for positioning in the band • Also pay 'second price' for assignment
Clock + 'First price' CCA	• Bid on packages of generic lots rather than on individual lots • Exit bids allowed (between last and current clock prices) • First price: pay what you bid • Auction ends when there is no excess demand • Separate assignment process (auction or administered)
Sealed bid auction	• Bidders simultaneously submit sealed bids - no bidder knows the value of other bids • Bidders submit one bid and cannot adjust based on competing bids • 'First price': pay what you bid (can use second price or shaded bid) • No subsequent rounds of bidding

Types of spectrum auction

Why should we worry about auction design?



Auction design should be about translating policy objectives into suitable auction rules.

Adapted from Copenhagen Economics, 2014

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Setting a reserve price

What determines the value of spectrum?

The value of spectrum derives its value from the expected net cash flow resulting from the use and ownership of the spectrum. This sounds simple but in practice is difficult to estimate. Drivers of value are:

- **Project-based value**: The value gained by offering additional or enhanced services through the use of the acquired spectrum. This will depend on the availability and use of technology, existing economies of scale and scope achieved by the operator, etc.

- **Defensive value**: The value gained by denying spectrum to a competitor in a way that limits the competitor's ability to compete. In an efficient market there is no value to defend. Regulations (including spectrum caps, etc.) aim at limiting defensive value and preserving competition.

- **Option value**: Spectrum creates the opportunity but not the obligation to invest in network and services. Gives operator flexibility to invest in response to changing market. Flexibly defined spectrum rights will enhance option value. Greater supply and availability of spectrum will reduce option value.

Setting a reserve price

What determines the value of spectrum?

The value or price of spectrum is determined by a range of factors, including the spectrum's highest value use, changes in technology and its availability across spectrum users, government's spectrum allocation plans, etc.

In short, value of spectrum may be summed up as:

V = f{*physical characteristics, geographic coverage, licence regulations and conditions, technological change, underlying demand, policy certainty, etc.*}

There are two general methods used for calculating spectrum price:

- **Direct calculation method** (using some form of NPV or cost reduction approach) and
- **Market-based method** (which incorporates current/recent market information).

Setting a reserve price

Calculating spectrum value using NPV

A rational firm will value spectrum based on its expected net present value (NPV) of future returns. Can be represented by the generic NPV equation:

$$NPV = \sum_{t=1}^{n} \frac{C_1}{(1+r)^t} - I_0$$

The NPV should in theory incorporate both the project-value and defensive value of the spectrum. This is sometimes known as **full enterprise value**.

Licence conditions will affect spectrum value

Spectrum licences may have different characteristics/conditions that affect option value. These include licence term/duration, licence coverage, technology, licence fees, and other conditions such as rollout requirements, coverage requirements, QoS, MVNOs capacity, etc.

Setting a reserve price

Major revenue drivers

There a range of possible revenue drivers for spectrum value. ARPU and subscriber growth tend to be difficult to forecast, meaning developing models of spectrum value based on these components will be highly variable.

Forecasting future demand for mobile services over economic life of transmission network is subject to a lot of uncertainty.

Revenue component	Drivers
ARPU	• Income growth within target market segments • Competition from other operators and services (e.g. fixed and WiFi) • Range of services offered • Coverage (roaming capability, national coverage • Service quality (capacity, dropped calls, latency) • Investment in brand development
Subscribers	• Population growth • Logistic growth in penetration for market as a whole • Market share for particular operator

Setting a reserve price

Major cost drivers

Cost drivers tend to be more objectively measurable than revenue drivers. However, there is still uncertainty regarding future network and service costs, and these costs can vary with the type of spectrum being valued.

Cost component	Drivers
Core network and rollout costs	• Infrastructure investment requirement, rollout profile • Network deployment, installation, maintenance • Testing and optimisation of sites
Back haul costs	• Number of base stations, price of backhaul • Coverage and penetration
Marketing and administrative costs	• Advertising • Distribution of handsets • Customer billing
Base station equipment costs	• Harmonisation of frequency band

Setting a reserve price

Cost reduction value

Value arising from use of an incremental block of spectrum to reduce infrastructure costs. Cost reduction value is calculated by modelling infrastructure costs with and without additional spectrum.

In congested areas additional spectrum allows more capacity to be deployed per site (and therefore fewer sites are required). Must account for coverage and in-building penetration advantages of lower frequency bands, etc.

Cost-reduction value is calculated as the difference between costs from:

- A spectrum scenario with a marginal block of spectrum deprived in the relevant band
- A base-line spectrum scenario

Cost reduction value sets a lower bound for spectrum value and hence the reserve price, because competition between operators will prevent price from falling below this value.

Setting a reserve price

Benchmarking using international comparisons

Benchmarking involves using data from spectrum awards in other jurisdictions to determine likely price of spectrum. Derives estimates of spectrum value from revealed willingness to pay (WTP) for spectrum in other awards. Based on prices that have been paid by specific buyers in a particular country.

Must ensure comparison countries are properly selected. Awards must be as comparable as possible in all respects:

- Country should have similar income, level of economic development, political development.
- Spectrum should have similar physical characteristics.
- Licences should have similar duration.
- Market should have similar structure, level of competition, existing spectrum holdings, access to technology.

Adjustments will need to be made to ensure comparability, i.e. adjusting for differences in licence durations, inflation, PPP, population, etc.

Setting a reserve price

Benchmarking using international comparisons

Generally three different approaches for interpreting and using benchmark data:

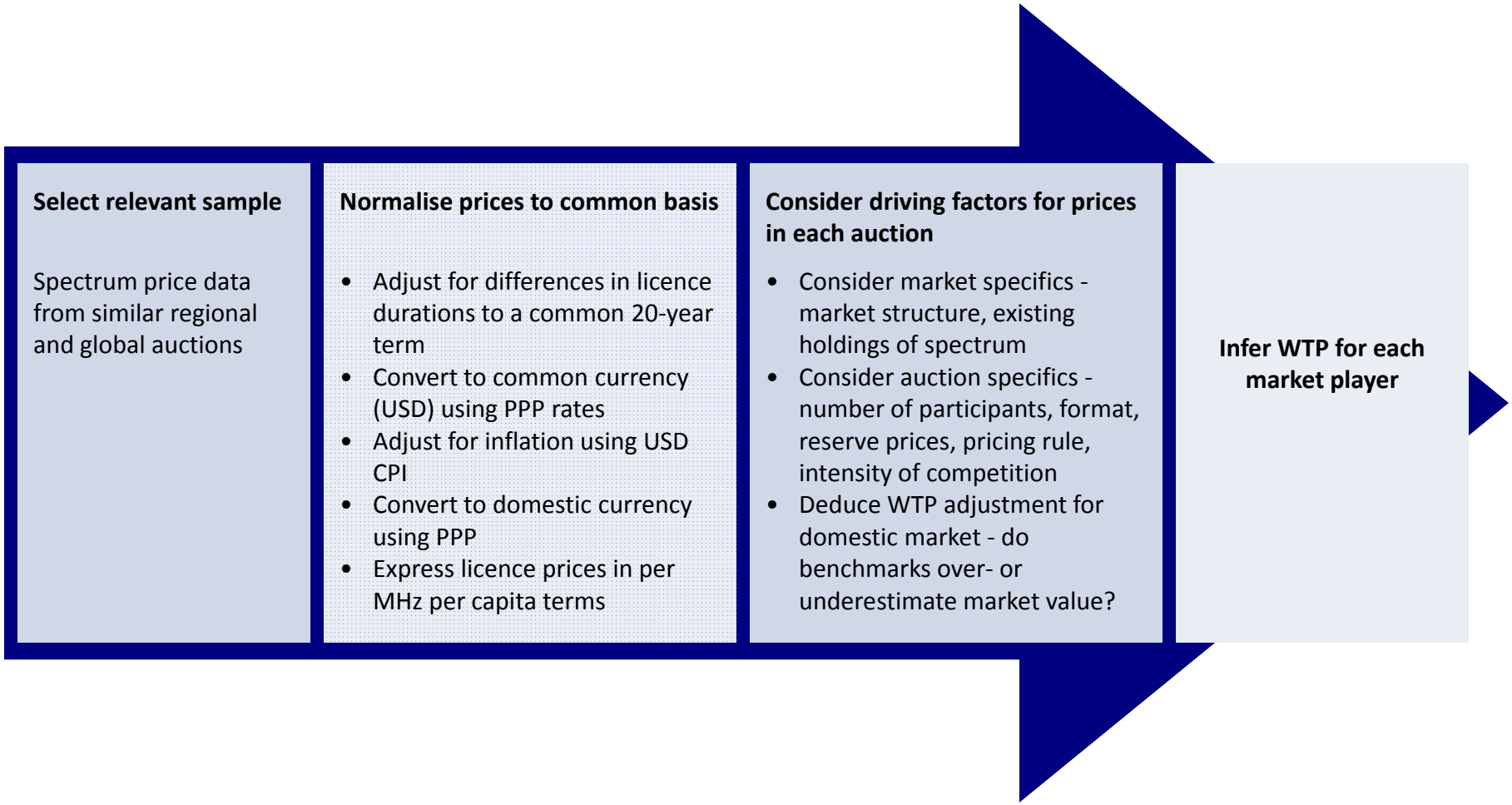
- **Absolute value approach**: Most common method based on simple average for a selected set of data points.
- **Relative value approach**: Using ratios of benchmark prices for different mobile bands to derive values.
- **Econometrics**: Using econometric models to explain and estimate spectrum values.

None of these approaches is perfect:

- Absolute and relative value approaches do not take direct account of country differences.
- Econometrics takes account of these differences but it is difficult to get robust results. Note regional comparison may be more appropriate than global comparison.

Setting a reserve price

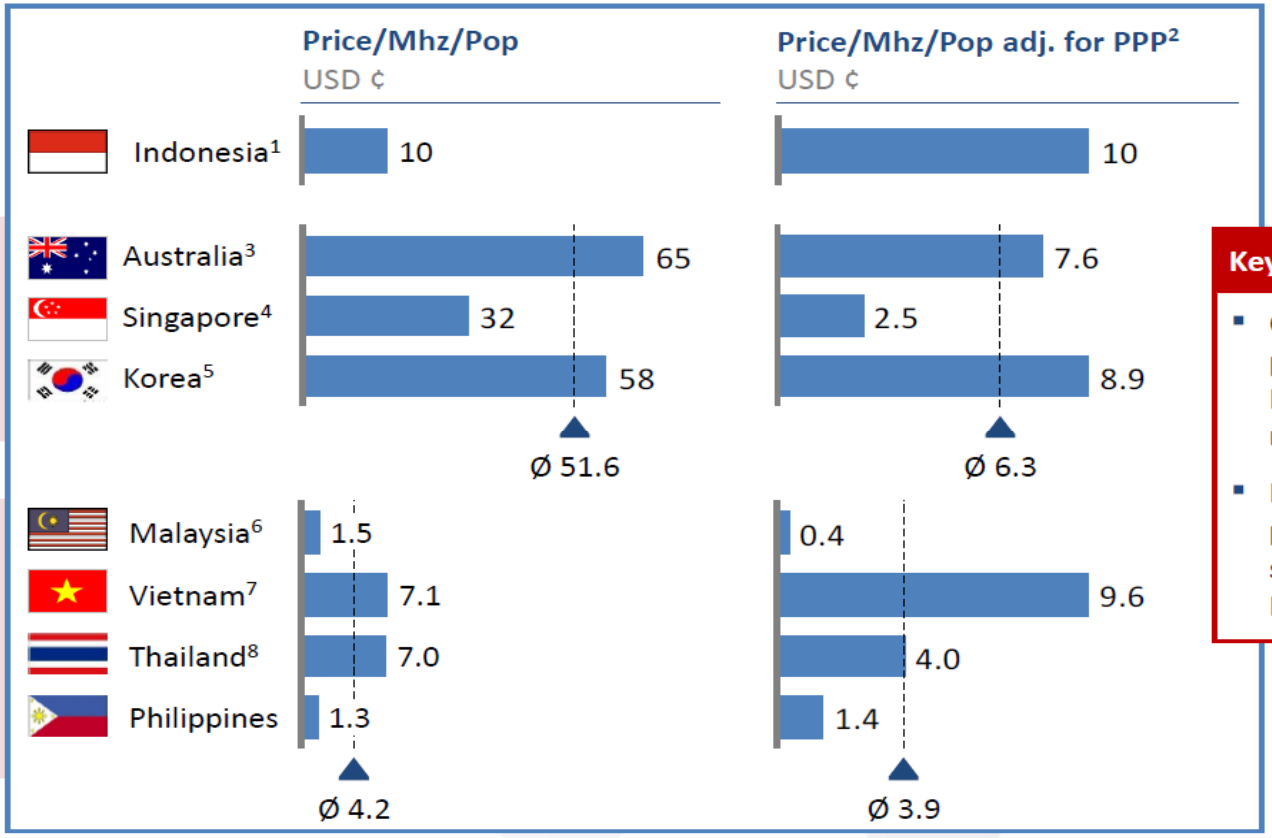
Benchmarking using international comparisons



Setting a reserve price

Benchmarking using international comparisons

Adjusting for local purchasing power, spectrum cost is not cheap



Key takeaways

- On a nominal basis, price set for Indonesia seems reasonable
- But adjusting to PPP, pricing on the high side of the average Price/MHz-Pop paid

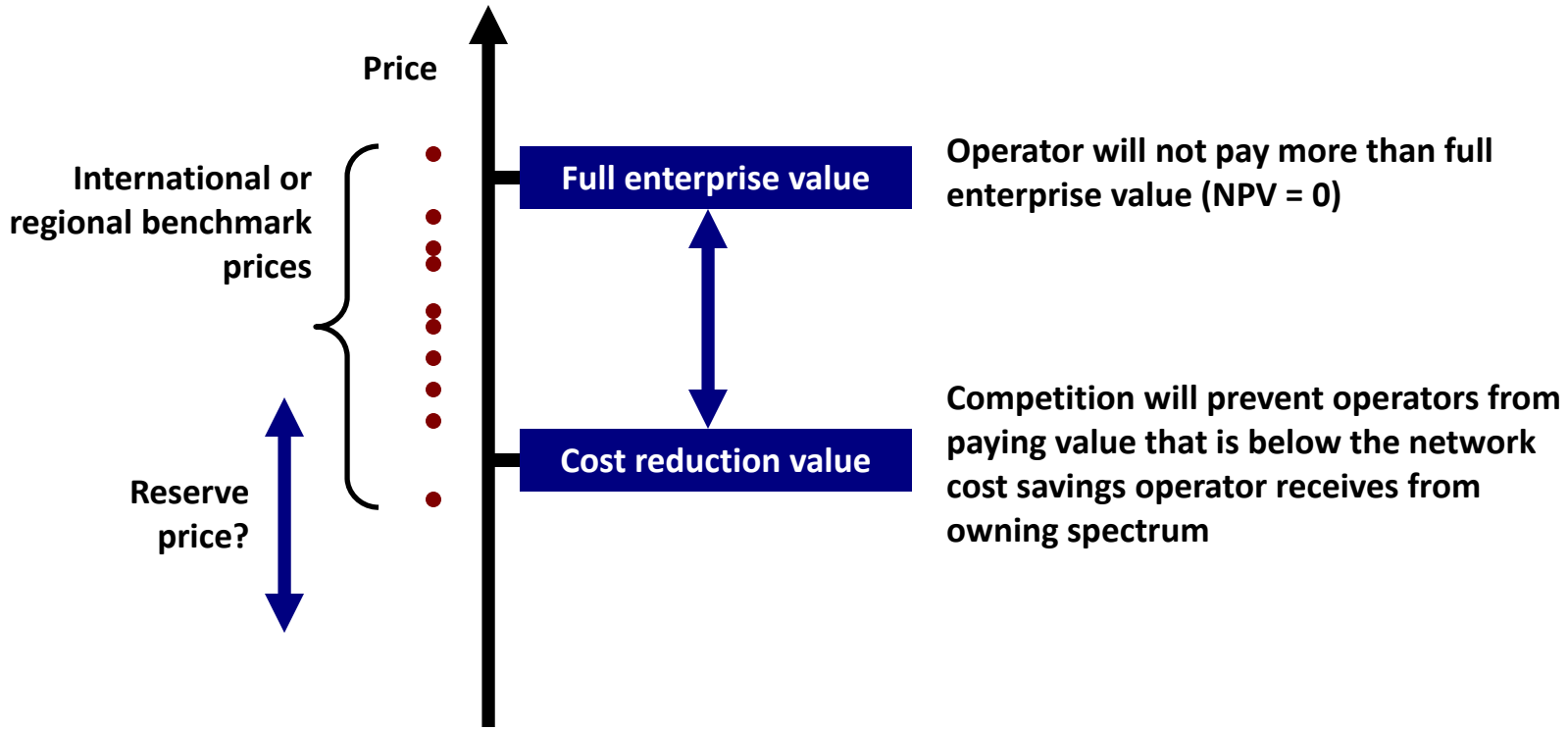
1 Taking NPV value for Indonesia as to compare with other countries which has no annual fees; 2 Adjusted based on GDP PPP from Worldbank, all PPP adjustment done by keeping Indonesia as the base; 3 2100 MHz 2012 license renewal estimates; 4 From 2010 beauty contest allocation; 5 From 2001 allocation, NPV of fees at time of allocation using 4% inflation rate; 6 From 2006 Beauty contest allocation; 7 From 2009 Allocation; 8 From 2012 allocations, NPV of base fees using 3.3% inflation rate, excluding annual payments and tax

SOURCE: Tsel, Regulators websites, Telegeography, press research, Worldbank, Team analysis

Setting a reserve price

Must incorporate each method to find appropriate reserve price

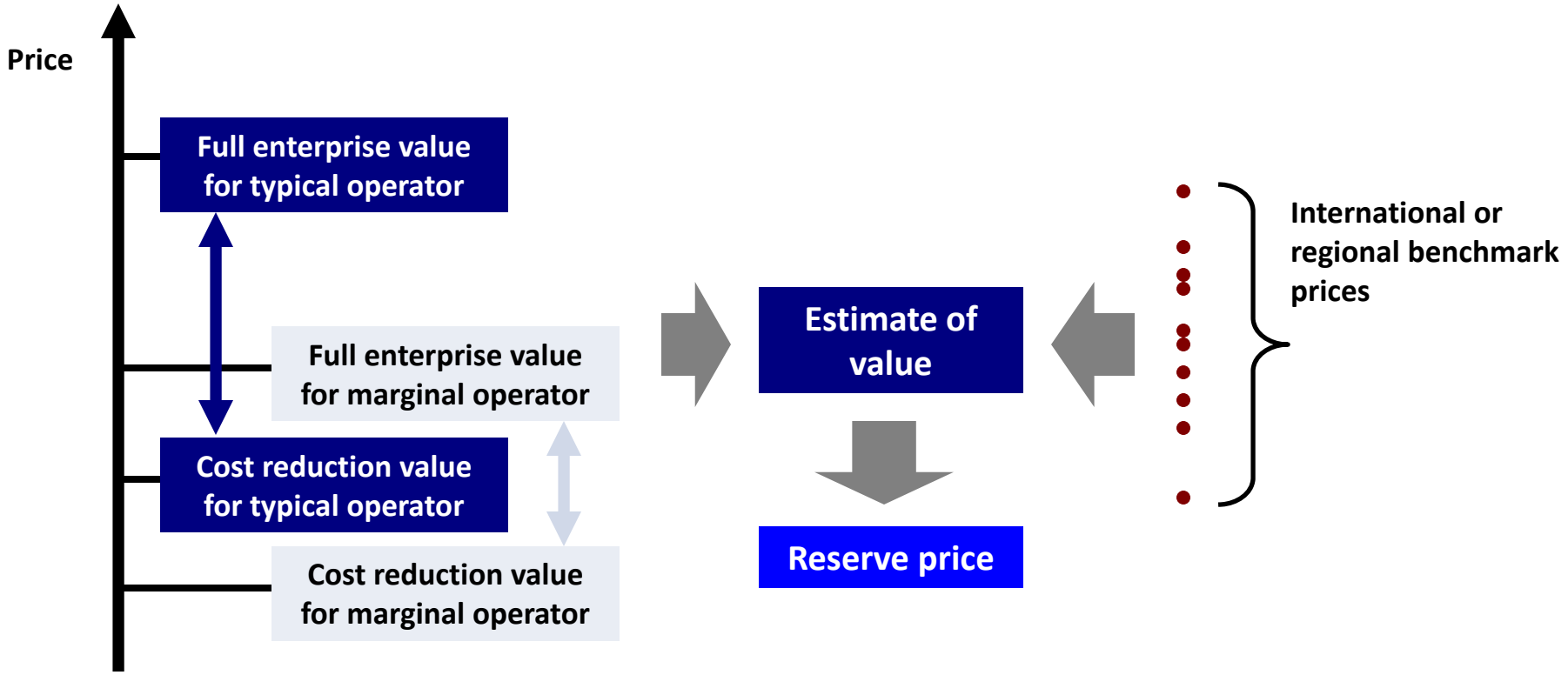
Use full enterprise value, cost reduction value and benchmarking to determine appropriate reserve price. Reserve price **cannot** be above full enterprise value or some operators will be priced out. Should reflect international auction values.



Setting a reserve price

Estimating spectrum value

Full enterprise value will be different for different operators. Estimate of spectrum value must consider both typical and marginal operators. Estimate is calculated using both full enterprise/cost reduction and benchmarks. Reserve price is usually a discount (e.g. 20-30%) of estimated spectrum value. It not done well then left with unsold spectrum (e.g. Australia 700 MHz 2013)



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Spectrum caps to promote competition

Using spectrum caps to promote competition

Regulators in many global markets implement spectrum caps and rules to avoid perceived spectrum hoarding by one or two major mobile operators. Key question for design of a spectrum auction is the appropriate cap (if any) to apply.

A large number of country markets are imposing, or considering imposing, caps for wireless broadband (including digital dividend spectrum), even where such caps were abolished or not favoured over the past few years.

Spectrum caps may have different characteristics relating to the penalties and conditions that may apply if the cap is breached, the spectrum cap threshold (which may be tight or loose depending on the regulator's concern regarding the potential for anti-competitive conduct) and other characteristics relating to applicability to particular bands and the durability of the cap.

Spectrum caps to promote competition

Different types of spectrum cap

Penalties of conditions	Spectrum cap threshold	Other characteristics
'Hard' cap Sets an absolute limit on the amount of spectrum an operator may hold.	**'Tight' cap** A spectrum cap with a low limit that could potentially be used to address the high risk of non-competitive market structures.	**Band-specific** A spectrum cap applying only to a particular spectrum band or bands.
'Soft' cap Sets a threshold amount of spectrum an operator may hold. If the operator exceeds the threshold, it may be subject to contingent licence conditions.	**'Loose' cap** A spectrum cap with a high limit used as a safeguard to prevent large concentrations of spectrum by a single operator.	**Event-related** A spectrum cap applicable only at the time of a spectrum award, allocation, acquisition, etc.
		Durable A spectrum cap that applies both at the time of allocation and for all subsequent reallocations, acquisitions, etc.

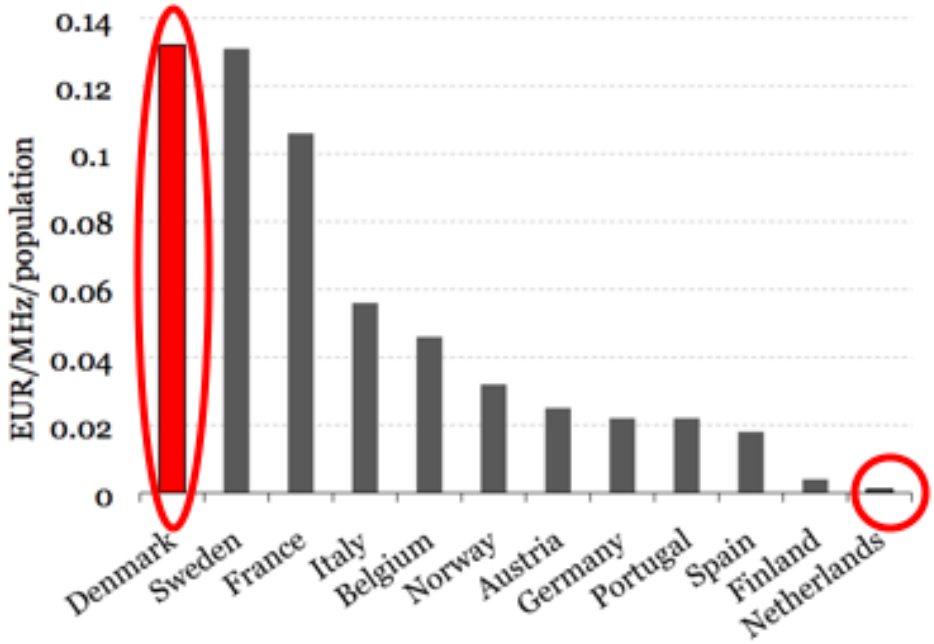
Spectrum caps to promote competition

Example: Dutch and Danish 2.6 GHz Auctions

Same auction format used (CCA), same band for sale, comparable countries. Different choice of spectrum caps:

- Dutch auction: Very restrictive caps destroyed competition in the auction and meant that all spectrum was sold at reserve prices.
- Danish auction: Tight, but not too tight, caps in a competitive market meant that prices were high but that the smallest operator still won 2x10 MHz.

Prices paid for 2.6 GHz



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Thank you

I am happy to answer any questions