Extracted version

Fixed Wireless Access handbook Insights 2024

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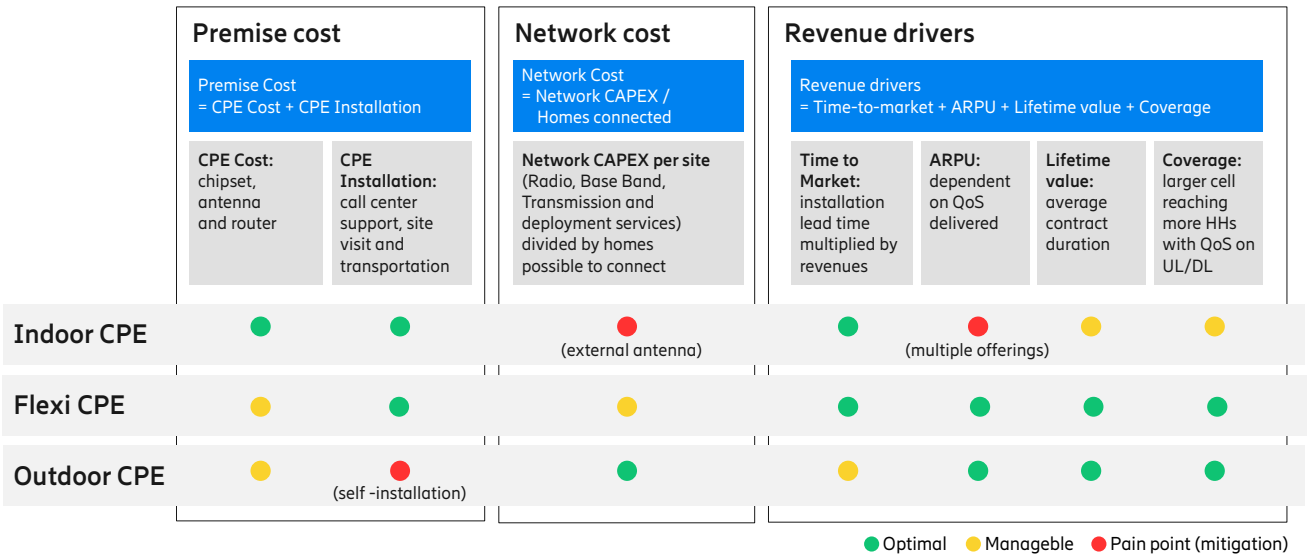
Emerging CPE choices drive fast adoption

Flexi CPEs maximizing major profitability drivers

Selecting the correct CPE form factor is a key parameter for designing FWA offerings. There is a lot of focus on the CPE premise cost, while two other drivers, network cost and revenue drivers, often need to be assessed in defining the complete profitability impact of the CPE choice.



Premise cost is related to the direct costs to connect a premise, home, or Small Medium Business location. It includes the cost of the CPE, where indoor CPEs tend to be cheaper than outdoor CPEs as these contain less expensive antenna components. Installation cost is another parameter, with indoor CPE having an advantage as they come with no (or minor) cost from call center support for self-installation. While outdoor CPEs often come with a self-installation app, many people prefer professional installation. Based only on these criteria, indoor CPEs score better than outdoor CPEs.

Network Cost is an often neglected key parameter that needs to be adequately quantified. Network cost includes all related FWA network costs for a RAN site (and proportion for Core and other elements such as packet core), which needs to be allocated for connected FWA users. Outdoor CPEs have a much higher spectral efficiency than indoor CPEs, enabling two to three times more FWA connections per site. As a result, outdoor CPEs score much better than indoor CPEs on this parameter as unitary network cost per CPE would be two to three times lower for outdoor CPEs compared to indoor CPEs. Some service providers address the drawbacks of indoor CPEs by adding external antennas as an option, including upgrading to external antennas for high-end users at a later stage.

A complete CPE profitability review considers four revenue drivers related to the CPE choice. Time-to-market is a key differentiation for FWA, with CPE choices also affecting that parameter. Indoor CPEs enable a faster time-to-market as there is no need for on-site installation. The lead-time difference of Order-to-Activation days between indoor and outdoor deployments multiplied by monthly ARPU would quantify the time-to-market difference. Another parameter is related to customer lifetime value, where outdoor CPEs could provide higher stickiness, resulting in longer customer contracts and lower churn compared to indoor CPEs. They can provide faster and more predictable broadband speeds than indoor CPEs and could be monetized with higher ARPU levels. Last, outdoor CPEs will provide larger cells reaching more households.

Flexible installation CPEs: best of both worlds

A new type of CPE, known as 'flexible CPEs,' aims to combine the best of indoor and outdoor CPE worlds. These flexible CPEs capture the benefits of self-installation and fast time-to-market from indoor CPEs while having better spectral efficiency somewhat comparable to outdoor CPEs (i.e., higher antenna gains and lower attenuation loss). The most recommended approach is for service providers to have multiple CPEs depending on the market offering and location type (suburban and rural) being served.

Differences in CPE performance

The most significant difference between outdoor and indoor CPE versions is the ability to achieve promised service levels, especially during busy hours. An indoor CPE device is comparable to a smartphone device in terms of the required radio resources or slightly worse as it's always indoors. By contrast, an outdoor CPE device has the advantage of a 15–25 dB better signal quality, which equates to lower Mbps production cost, higher speeds, and better coverage – which is especially valuable further out in the cell in mid-band and mmWave deployments.

Many parameters impact the network gain when selecting CPE types, like antenna gain, CPE power class, attenuation, inter-site distance, and spectrum frequency.

An outdoor CPE performs best as it has an in-built directional antenna (e.g., 10–14 dBi at 3.5 GHz) and is installed with a predictable radio link quality to the selected Radio Base Station. The typical antenna configuration has two Rx antennas, but devices with four Rx antennas are also available. More Rx antennas can be useful in urban environments, as multiple signal paths are available to the device. However, the transmission mode for a single CPE is still only rank-2 as the modem is expected to be installed with good line-of-sight or near line-of-sight.

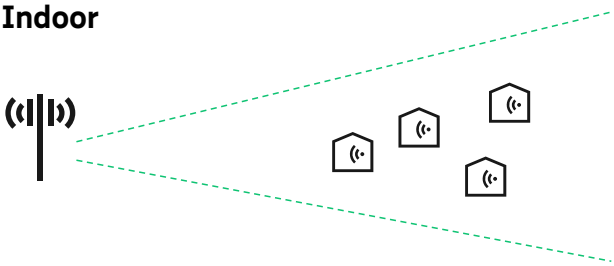
A correctly installed outdoor CPE is directed to the best serving cell, leading to a lower link budget path loss and improving the utilization of mid-band and mmWave TDD spectrum. The large gain in signal quality results from the 10–15 dB difference in antenna gain and the avoidance of another 10–15 dB in wall/window attenuation losses suffered by indoor devices. Another contributor to signal attenuation in indoor devices is the deep indoor loss, as the device is likely to be placed in the middle of the home (i.e., away from the window), perhaps to provide optimal Wi-Fi coverage, contributing another 5 dB in path loss.

Whereas indoor CPE is comparable to a smartphone in spectrum efficiency, outdoor CPE is typically two to three times more efficient. Put another way, around two to three times as many households can be served for the same data consumption, or two to three times as much spectrum would be needed to serve indoor-only FWA households. A final advantage of outdoor CPE is that the relative performance difference between the best, median, and worst users is significantly lower, which makes FWA commercial service agreements easier. The most important aspect is to ensure that the users on the cell edge or in poor radio conditions get an outdoor CPE to use radio network resources as efficiently as possible.

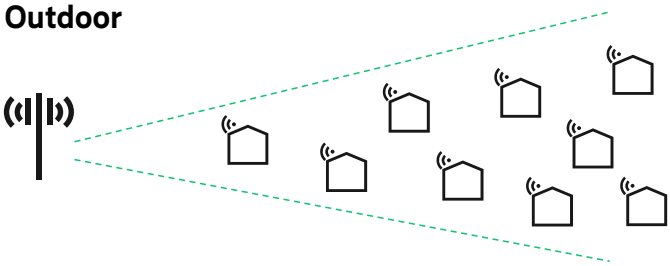
End-users may detect that they receive fairly good coverage and acceptable speed with an indoor device, but this can change very fast once a specific cell gets loaded with more users. In an unloaded cell, any user can get many radio resources (PRBs) allocated and achieve acceptable speeds, regardless of the radio link quality and the fact that only QPSK modulation may be possible. In a loaded busy hour scenario, significantly fewer resources are scheduled, and only the devices able to handle higher modulations (such as 64- and 256-QAM) can achieve acceptable speeds.

The modulation and channel coding scheme is determined by the devices' continuous Channel Quality Indicator (CQI) feedback in the uplink. A lower CQI indicator will make it very 'expensive' for the radio network to stream higher data rates, such as video and TV, with a lower modulation level.

Indoor



Outdoor



Key parameters

Power and antenna gain

Attenuation loss

Frequency and cell size

Rule of thumb

Outdoor CPE will improve spectrum efficiency and allow two to three times as many served households with comparable service levels.

Alternatively, two to three times as much spectrum is needed for indoor CPE.

The right mix of indoor and outdoor CPEs

As mentioned, outdoor CPEs provide significantly better spectral efficiency than indoor CPEs. While it may be necessary to have outdoor CPEs for homes in some locations, there are other locations, such as those close to a base station, where indoor CPEs are sufficient. Outdoor solutions are generally more expensive and complex to install, so there is a trade-off between providing high performance and the cost of equipment and installation.

In cost-sensitive cases (such as where there is a lower ARPU) or where time-to-market is crucial, it makes sense to choose indoor units, which are typically cheaper and faster to deploy. For example, if the available spectrum is large, a first approach could be to provide indoor CPEs to most homes, with an option to replace them later with outdoor units, as required.

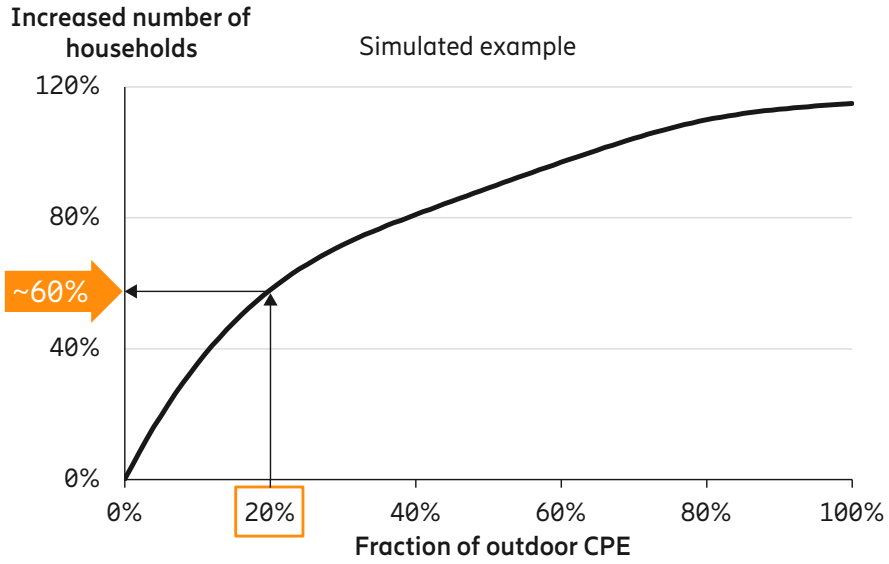
On the other hand, if the number of potential customers in an area is large relative to the available spectrum, it might be worth identifying customers who would benefit the most from outdoor CPEs during the sales process. The proportion of outdoor units might be larger in more difficult propagation conditions, such as significant foliage, terrain variation, and obstacles blocking line-of-sight. Moreover, the improved spectral efficiency of outdoor CPEs typically boosts range, increasing the potential customer base and increasing the proportion of outdoor CPEs.

Benefits of indoor
- Lower CPE cost
- No installation cost
- Fast deployment

Benefits of outdoor:
- Increase capacity
- Address more customers
- Larger coverage
- Higher speed and consumption level

The graph to below illustrates how performance can differ with CPE type. In this simulated example, the indoor CPEs have gradually been replaced with outdoor units, starting with the homes in the worst propagation conditions. The capacity increase has been normalized against a reference number of subscribers that can be served per sector on average, with only indoor CPEs. It is clear from the shape of the curve that most of the capacity gains come from providing the worst-located homes with outdoor CPEs. If 20 percent of worst-located households are assigned outdoor CPEs, the average number of homes per cell increases by around 60 percent, while the capacity is slightly more than doubled when only outdoor CPEs are used. In this case, the uplink was the limiting factor when only indoor units were used. However, when 20 percent of worst-located homes were assigned outdoor equipment, the uplink capacity increased so much that the case became downlink-limited instead.

Capacity gains by replacing indoor with outdoor CPE



Most capacity gains achieved by providing outdoor CPE to worst located households

Clear form factors for sub-6 GHz FWA CPEs

As sub-6 GHz 5G FWA deployments reach mass market, the industry is converging to three distinct CPE form factors.

Segment/Performance	Indoor gateway		Flexible installation receiver		Outdoor receiver	
Attenuation loss	High		Mid – Low		None	
CPE antenna gain	~3–6 dBi	~7–11 dBi	~3–6 dBi	~7–11 dBi	~10–14 dBi	~15–18 dBi
CPE size	In-built		Smartphone	Tablet	Laptop	
CPE mounting options	Desktop		Flexible (desktop, window, wall)		Wall/rooftop	
Typical installation	Self-install				Technician	
Typical areas	Urban – Suburban				Suburban – Rural	

Indoor or outdoor?

Traditionally, FWA CPEs come in two main form factors: indoor gateways and outdoor receivers. Indoor gateways offer an integrated form factor with a built-in WiFi router. The indoor form factor is the most common in the market, enabling self-installation, short time-to-market, and lower solution costs. Some of the indoor gateways have high antenna gains with 7–11 dBi. On the other hand, outdoor receivers require a complementing indoor router with WiFi to distribute the signal. Outdoor CPEs offer high spectral efficiency (enabling high capacity and speeds), long lifecycle, and higher longevity with customers.

Best of both worlds

A new type of CPE, known as 'flexible installation receivers' (or Flexible CPEs), aims to bring the best of indoor and outdoor CPE worlds. These flexible devices lower the bar for self-installation and offer higher spectral efficiency than indoor CPEs. Like regular outdoor CPEs, flexible CPEs are receivers powered over Ethernet and IP65 rated. They can be installed inside, close to a window, or outside on the wall or roof, all with the help of a smartphone installation app that guides the end user to the best possible placement. Although some of these flexible CPEs offer similar antenna gains as indoor CPEs, the performance is improved as attenuation losses are eliminated.

A key benefit of such flexible CPEs is enabling service providers to use the same unit type for homes near and further away from the radio site. The device must offer the required antenna gain, power class, household mounting options, and attenuation loss to deliver the desired ease of installation and performance.

CPE ecosystem cooperation

There are a large number of vendors who offer both indoor and outdoor CPEs for FWA. However, quite a few are small players compared with MBB device vendors, with typically a handful of customers. The largest market is indoor LTE CPEs, including Wi-Fi and router functionality, sold in mobile service providers' retail stores. The Global Mobile Supplier Association (GSA) now regularly publishes a '4G/5G FWA Device Ecosystem Company Directory' (4G-5G FWA Company Directory) and periodically reports on service provider FWA activities and devices (5G – FWA Global Status Update). In June 2023, the GSA identified over 100 FWA CPE vendors for LTE and 80 FWA CPE vendors for 5G, with over 1,000 LTE CPEs and over 250 5G FWA CPEs.

In principle, any CPE device on the market will work – after relevant and normal IODT has been conducted at the chipset level – just as with smartphones. Ericsson is currently working with six OEM suppliers of LTE and NR CPE, all capable of design and adaptation and able to supply the necessary volumes to meet market demand. Some vendors focus on 'off-the-shelf' product portfolios, while others are ODM design houses.

Several of these OEM suppliers are based in Taiwan and include:

- Zyxel Communications offers CPEs with high-capacity connectivity, enhanced network security, and deployment flexibility. Zyxel 5G NR FWA solutions incorporate the most advanced technologies, providing customers with a superior, self-adaptive, zero-dead-zone Wi-Fi experience.
- WNC is one of the world's leading companies for RF design, especially in Cellular and Wi-Fi products. WNC has also designed and tested advanced high-power mmWave CPEs, which use mmWave extended range feature.
- Askey, another innovative OEM, focused on being early to market with 5G NR mid-band and mmWave outdoor and indoor use products.

GreenPacket, a Malaysia-based company, offers innovative 5G/4G FWA CPE solutions with different characteristics for multiple usage scenarios. GreenPacket can redesign products to fit every customer's unique deployment scenario with a wide range of high-performance indoor, outdoor, and flexible installation FWA CPEs to meet customers' diverse needs.

Casa Systems, with over a decade of experience in 3GPP Fixed Wireless devices and many industry firsts, has products spanning from indoor to outdoor, Wi-Fi 6 gateways to modems, and self or technician install, and sub-6 GHz and high-power mmWave. Its device portfolio is supplemented by several generations of toolset development, including physical support tools for installers and smartphone-based applications for installers and consumers.

Oppo is one of the leading smartphone manufacturers actively promoting the development of 5G worldwide. Oppo has started to engage in the growing FWA market with indoor units, bringing its ability to industrialize products for high-volume manufacture to bring 5G to more people and homes worldwide.

Overall, there is a fast pace of innovation and evolution in the FWA CPE market, and we will see new products continuously being introduced. The 3GPP device ecosystem is vast, and service providers with an Ericsson FWA network will benefit from this by using and interworking with the most suitable CPE at the best price, functionality, and performance.

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