# Business Case for Small Cell Backhaul Architecture

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Due to the unquenchable user thirst for higher speed mobile devices, analysts are predicting a greater than 20x increase in mobile traffic over the next 4 years. At the same time, access spectrum remains a very scarce resource, with very little new spectrum being released to address surging mobile traffic. The desire for higher user bandwidths, along with the need for better in-building and urban mobile coverage, is driving mobile operators to search for ways to significantly increase their spectral efficiency.

New technologies, such as LTE and LTE-advanced provide some improvements in spectral efficiency but, even in the best case, will only provide a 2-3X capacity improvement over existing networks. As a result, operators are looking for new architectures that allow them to deliver higher user bandwidth with limited spectrum resources, while improving their metro and in-building coverage. The architecture that is being heralded as the solution to these problems is small cell deployments. However, small cell architectures present many challenges, the most significant being backhaul.

Even in traditional mobile networks, where basestations are typically deployed on telecom towers or buildings, backhaul is a major challenge for operators. This challenge is magnified in microcellular architectures, where basestations will be located on traffic lights, lamp poles, and sides of building, as these sites generally have no access to fiber, and no standard telecom facilities such as backup power, heating and cooling. With most small cell networks adopting 3G and 4G access technologies, backhaul capacities of 50 Mbps to 100 Mbps and above will be required on a per site basis. These high capacities will rule out copper solutions in most cases. With fiber and copper not suitable for backhaul at the majority of the small cell sites, wireless will be the primary backhaul technology.

In order for small cell architectures to be adopted, the cost per site of all elements must drop significantly compared to a traditional macrocellular deployment. This is driven by the fact that the ARPU from high data services is not expected to increase significantly, but the number of sites to deploy a small cell architecture will need to increase by 5-10X in an urban environment. This study focuses on the backhaul costs of small cell versus macrocell architecture, and examines the key areas of sensitivity in the small cell backhaul business case.

Wireless backhaul for small cell architectures has its own challenges, and any business case analysis must address the unique requirements of such deployments, including:

- Small form factor, urban aesthetics, lightweight;
- Line of sight blockage that occur at street level;
- Capacities >100 Mbps;
- End-end delay of a few milliseconds;
- Rapid installation by city maintenance staff;
- Carrier-grade, easy to troubleshoot;
- Deployable in common spectrum.

To meet these requirements, our business case assumes a wireless point-to-point solution in the 24-60 GHz bands, optimized for street-level light pole and traffic light deployments. This solution will deliver 500 Mbps-1 Gbps of capacity per link, which will be required to aggregate multiple basestations on a link in a daisy-chain or ring deployment. For locations that do not have line of sight, a sub-6 GHz NLOS solution would be used as a last-mile spur.

There are 5 key elements to the wireless backhaul business case in both small cell and macrocell deployment. These are:

- Engineering and installation;
- Equipment CAPEX;
- Monthly tower/pole lease costs;
- Spectrum costs;
- Annual maintenance.

Starting with engineering and installation, the installation of small cell backhaul will be on shorter links, will not require a tower climb, will use much smaller antennas, and will be much easier to align. This is expected to reduce the installation costs by 50% per link, from €10,000 to €5,000 for an average installation. The equipment CAPEX for a traditional tower site versus a small cell installation will be reduced due to a number of factors. Antennas sizes can be reduced, along with cable lengths, and perhaps the output power. In addition, less protection will be used, and switching and battery backup capabilities will be reduced, resulting in a total equipment CAPEX reduction of about 50%. Monthly Lease costs will be reduced significantly relative to traditional tower installations, where antennas are typically 60cm or larger and monthly tower lease costs are about €300 per end. In a small cell deployment, the cost is expected to range from nil to €20 per month per end, as these are non-telecom sites with small equipment that will use existing AC power. Small cell deployments have very short ranges, allowing them to use higher frequency, lower cost spectrum, such as 38 and 60 GHz. In Europe, this expected to reduce spectrum cost per link by a factor of 10, moving from €2000 annually to €200 annually. The backhaul for a small cell site will be easier to align and easier to obtain access to. In addition, a longer MTTR may be acceptable, as network redundancy would be provided through the existing macrocellular network. These combined effects are expected to reduce the annual maintenance by about 50%.

With all of these cost factors combined, we can complete a five year and ten year net present value comparison of the two architectures and measure the relative contribution of each element, as shown in the graph below. The cost per site for small cell backhaul is 4.6X lower than that of a macrocell deployment over a five year period and 5.6X lower over ten years. The five year total cost of ownership for backhaul is reduced to about €12,000. It can also be seen in the graphs below that the major contributing TCO factors change dramatically when moving from macrocellular backhaul to small-cell backhaul. The largest change is in site leasing costs which move from greater than 50% contribution in a macrocellular network to less than 10% in a small cell network.

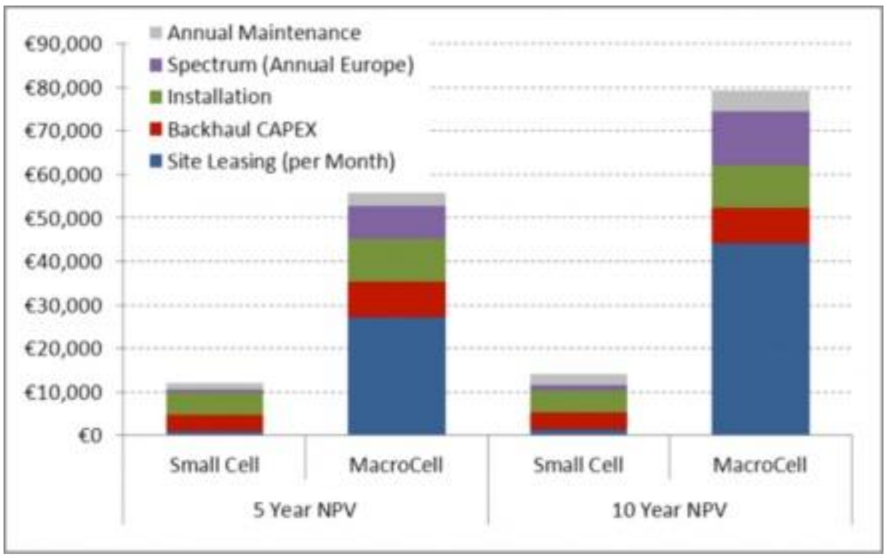


*Figure 1: TCO factors change dramatically when moving from macrocellular backhaul to small-cell backhaul. Click image to enlarge.*

Due to site leasing costs being such a large contributor to the macrocellular total cost of ownership, the improvement in the small cell business case is very dependent on the reduction in site leasing costs. This sensitivity analysis is shown in the chart below. In the case where the small cell site leasing is obtained at no cost, there is 5-6X improvement in the TCO compared to macrocellular, whereas if the small cell lease costs are 25% of the macrocell case, there is only a 3-3.3X improvement.


*Figure 2: Small cell site lease costs versus tower site lease costs. Click image to enlarge.*

Based on this study, it is evident the wireless backhaul for microcellular deployments is economically feasible, and does have a strong business case. It is, however, very important that site lease costs are minimized in order to optimize the business case. This will be achieved through coordination with urban authorities, and by optimizing the backhaul system footprint. Additional areas that will see future improvement to further enhance the business case are total site equipment cost through further integration, and engineering and installation costs through next generation systems with improved automation and integration.

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