# ICT-248891 STP FREEDOM

Femtocell-based network enhancement by interference management and coordination of information for seamless connectivity

## D2.3

***Market opportunity, business model and technology implementation-dissemination plan***

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| **Author(s):** | **Lamhot S.P. Simamora, Patricia E. Gasperz, Holly Miratna, Zdenek Becvar (CTU), Gian Paolo Imponente (DUN), Yoann Corre (SIR)** |
| **Participant(s):** | **TELK, CTU, DUN, SIR** |
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**Abstract:**

**Aspects related to business models are crucial in determining the success of a technological innovation. This deliverable describes the opportunity and business model of femtocell innovations resulting from Freedom activities in WP5. Sustained by the initial market study and business scenarios developed in D2.1 document, we focus here on financial calculations and projections for a representative European country.**

**Keyword list: business model, market, customer segment, mobile subscriber, tariff**

# Executive Summary

This document summarizes the business model research activities carried out by the Work Package 2 (WP2). The aim of this deliverable is to show and simulate the business model scenario related to femtocell technology innovation carried out by the technical Work Package, especially Work Package 5 (WP5), which runs the system level test and simulation.

Many researches have shown that femtocell technology offer significant value for the operator and customer. Operator can achieve significant cost reduction by deploying femtocell rather than setting up an indoor base station or another macro base station. While femtocell increases the coverage and capacity of the spectrum investment, customer will gain better in-building experience in using its mobile devices, and this value proposition will lock in the customers to the operator and may reduce the churn rate of customer.

This deliverable, as the continuation of the previous document (D2.1), will focus on the financial aspect of femtocell deployment in particular region based on the scenario resulted in technical work package. The business model simulation try to show the projection that may occur in femtocell business and calculate the feasibility of the femtocell deployment scenario. Some assumptions are taken for the simulation due to the data limitation.

This document uses the region size approach to calculate the dimension of femtocell within an urban and Sub-urban area. It also considers the possibility of various building (single floor and multi floor) within the region and possibility of customer segments involved in the market. The simulation also compares the value created by macro base station and femtocell in term of sales projection, capacity demand, and revenue (basic and value added service). The business model also expose between two deployment scenarios, which are operator push and customer pull scenarios.

The business model simulation indicates that the Freedom technology innovation is feasible to deploy within the particular area and market. Within 10 years of projection the femtocell business model simulation contributes positive net present value and it also shows that operator push model contributes bigger value than what the customer pull model.

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# 1. Introduction

## 1.1. The Femtocell Concept

Femtocell is a small cellular base station and designed to extend the cellular service coverage and capacity indoors, especially where access would otherwise limited or unavailable. At first the use of femtocell is for homes then it evolved to serve offices and metro areas. As small base station, it is so simple and easy to install in customer's site. Femtocell connects to the fixed network operator via broadband access (such as xDSL, cable or fiber) then forwarded to the mobile operator's core network. So femtocell uses and operates over licensed spectrum and enable users to communicate across any IP access network using a standard mobile handset. Femtocell is now supported in 3G and next-generation standards by 3GPP, 3GPP2, WiMAX Forum and Broadband Forum.

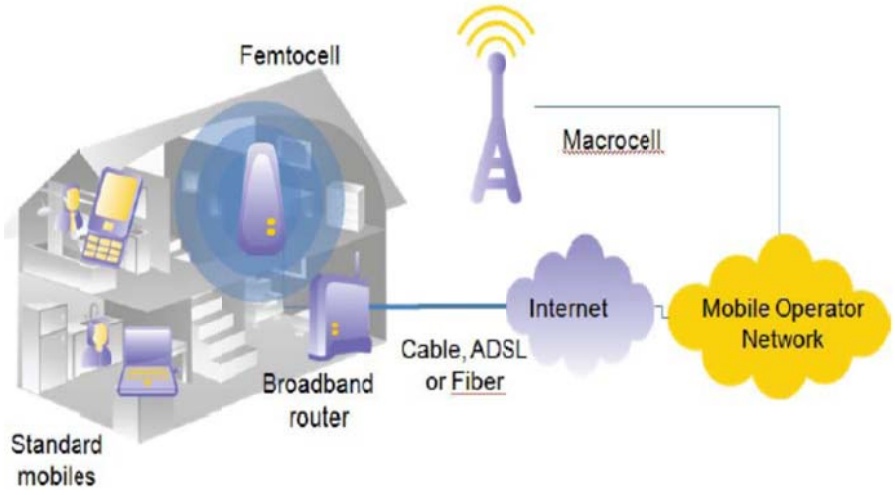



**Figure 1. Femtocell Concept [1]**

## 1.2. The Need for Femtocell and Challenges

Since the broadband (3G/4G) technology introduced to the market, the data traffic behaviour has increased dramatically. This growth has been promoted by the emergence of smartphone, tablet, netbook and other mobile internet device (MID) in the market. But then the market fell suffers from inadequate indoor-signal penetration, and it is leading to poor coverage in the environment (home, office, and public area). Poor coverage diminishes the quality of voice and video applications, and slows down high-speed data services.

It has been identified that 60% of the cellular voice traffic and 70% of the wireless data traffic originates in home/office environments [AnRes08] and that the 19% of the European users complain about the poor voice coverage at home (58% of which in every room) [FSAC08], therefore to keep customers satisfied, operators have increased capacity by building additional microcell sites (eq. DAS-Distributed Antenna

System). But this solution is becoming much less attractive due to the cost incurred for installation, insurance, and operation and maintenance of the system in the buildings. The net present value of a cell site in the U.K. is estimated to be $500,000.

Therefore femtocell plays an important role for operators in satisfying customers indoors (home and office) and mobile operators also may seize residential minutes from fixed operators by offering VoIP service. This better indoor service experience may create better customer satisfaction and loyalty for operator and it may lead to churn reduction and market share growth by acquiring other operators' customers. And finally it will improve the ARPU of femtocell's operator.

Using femtocell also solves problems with a device that employs power and backhaul via the user's existing resources. It also enables capacity equivalent to a full 3G/4G network sector at very low transmit powers, dramatically increasing battery life of existing phones, without needing to introduce WiFi enabled handsets.

Some key benefits that can be delivered by femtocell are:

- **Better coverage and capacity**: due to the short transmit-receive distance of access point, femtocell gives a strong radio signal to the mobile user's equipment. It also creates a lower transmit power, prolong handset life, higher SINR and higher spectral efficiency.
- **Improved macro reliability**: because some traffic diverted to femtocell, the macro has more space or capacity for outdoor users.
- **Cost**: femtocell is much cheaper than the macro. Femtocell Capex/Opex is €150/€1 while macro is €140K/€15K [6].
- **Reduced subscriber turnover**: the improvement of coverage and capacity indoor lead to customer satisfaction, therefore will reduce the subscriber turnover (churn).
- **Value added service**: not only voice and data as a basic service, but also the opportunity of other serices for enterprise, family and personal market. Some of value added services have already been identified and hope be able to reinforce the positive trends of femtocell

In deploying femtocell, there are still some technical challenges that still be pursued by all the players in the ecosystem of delivering the optimal femtocell inovation. This is also being done by Freedom. Some challenges are:

- **Interference management:** as femtocell use the same spectrum as the macrocell, the uncoordinated femtocell deployment may lead to the creation of coverage dead zones, created by near-far effect.
- **Handovers:** Handovers from femto to macro are not an issue however in the other direction, the classical cellular handover schemes do not scale properly. Solutions to macro to femto handovers are needed to maintain service continuity.
- **Backhaul quality:** Femtocells may use public IP networks, without guaranteed QoS, so that it becomes significantly important to have enough backhaul capacity. It has been shown by Telefonica's trial [6] that when the femtocell is connected to an ADSL router with WiFi capabilities, a massive download from a WiFi client can interrupt femtocell operation when the ADSL router does not include QoS traffic prioritization.

- **Synchronisation:** Base Stations and femtocells require synchronization to align received signals with minimal multi-access interference and to allow handovers to macrocells and viceversa. The reason is that femtocells have to support users with low mobility users and that the oscillator cost increases with its precision.

## 1.3. The Growth of Femtocell Ecosystem

The Femtocell ecosystem can be classified into 3 major players, they are equipment vendor, service provider, and customer (end-user). These players are contributing their own value to the success of the femtocell in the market.Vendor guarantees the supply of equipment devices (FAP, Chipset, Network Gateway, Components and Software) to service providers who offer the service to fullfill the customer needs. Most of the player in the femtocell ecosystem has joined the Femto Forum. Today there are about 68-vendors joined in this forum and make a significant contribution in the development of femtocell technology in the world. They provide end-to-end system providers (8-vendors), network elements (23-vendors), products (23-vendors), components and software (17-vendors), and enablers (11-vendors).

To accelerate the femtocell market growth, some vendors to collaborate and now they have made important progress in the evolution of femtocell chipsets and femtocell-specific 3GPP, 3GPP2 and WiMAX standards have been completed, and signalling that femtocell technology has been ratified by the highest profile standardisation bodies worldwide.


**Figure 2. Femtocell Vendors [2]**

Informa Telecoms & Media forecasts the femtocell market to experience significant growth over the next few years, reaching just under 48 million femtocell access points (FAP) in the market by 2014

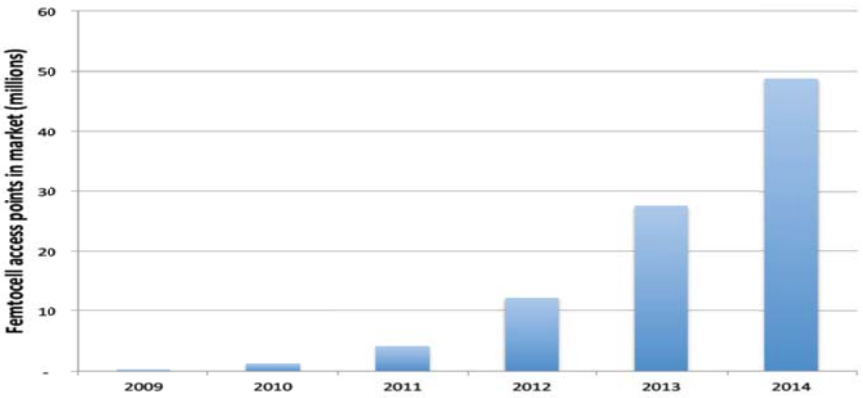



**Figure 3. FAP forecasts [2]**

The enthusiasm of femtocell market has given attention to the analyst to give a projection of this industry. Some thoughts that emerged is shown in the following exposure:

- Mobile Experts claimed that more than 1.8 million small cell wireless backhaul unit shipments during 2016 ( *October 2011*).
- IDate gives a bigger number than mobile expert, that by 2015 a cumulative total of 29.4 million FAPs will be deployed and representing a CAGR of 71% between 2011 and 2015 (*September 2015*) .
- ABI Research said Enterprise femtocells are to make up 26% of shipments by 2016 which relats to 50% of security revenues (*August 2011*).
- Infonetics said that total global revenue from femtocells used in consumer,enterprise rural and public spaces grew 45% during the past 4 quarters (*June 2011*).
- Juniper Research predicts that Wi-Fi and femtocell networks will play a significant role in easing data traffic by carrying 63% pf data traffic, or almost 9,000 petabytes by 2015 (*April 2011*)
- Cisco expects that 2015, over 800 million terabytes of mobile data traffic will be offloaded to the fixed network by means of dual-mode devices and femtocells. Without dual-mode and femtocell offload of smartphone and tablet traffic, total mobile data traffic would reach 7.1 exabytes per month in 2015 growing at a CAGR of 95% (*February 2011*)

Some operators also join in the Femto Forum and by December 2011 there are 37 operators, come from 23 countries, have commercialized femtocell to the markets and other 46 operators have expressed their commitment to deploy femtocell in the near future. All these operators represent 1.99 billion mobile subscribers worldwide, across multiple wireless technologies (WiMAX, UMTS, and CDMA) and account for 34% of total mobile subscribers worldwide. Most of top operators (by revenue group) now offer femtocell services, including AT&T, France Telecom/Orange, Telefonica, T-Mobile/Deutsche Telecom and Vodafone amongst others. And according to an Informa survey (Q2 2011), 60% of operators believe that small cells will be more important than macrocells for an effective LTE deployment strategy.


**Figure 4. Femto Forum Mobile Operators Member**

The femtocell market continues to grow and now some operators have reached into 100s of thousand units, including Vodafone, Sprint, AT&T, Softbank and SFR. Some other operators show new business model by offering free femtocell to their subscribers, like SFR France, Softbank Japan, KDDI Japan, and Megafon Russia.

## 1.4. Operators Go for Commercial Femtocell

Femtocell market continues to move forward today, we see each year several operators commercialize femtocell and many trial activities conduct in the laboratories, and also some operators do market trial. This growth is also influenced by the massive 3G/4G technology development among mobile operators in the world.

Femtocell has become one of significant strategy for operators. If at first the provision of femtocell is only to increase coverage and capacity, with the development of existing technology and industry support, operators begin to use femtocell to be part of the cost efficiency strategy, traffic off-loading and also the possibility of new revenue sources through offering value added services (VAS) or applications to residential and enterprise market.

Femtocell usually offer to residential/homes market, but today operators have considered and offered femtocell both to residential and enterprise market segments and even some operators provide femtocell only to specific public areas or facilities just to increase capacity and service coverage.

**Table 1. Target Market of Femtocell Deployment [2]**

| Target group | Number of deployments | Examples |
|---|---|---|
| **Consumer** | 20 | Vodafone UK, AT&T, Cosmote |
| **Enterprise** | 6 | T-Mobile UK, Network Norway, Orange France |
| **Consumer and Enterprise** | 6 | Vodafone NZ, Verizon Wireless, Sprint |
| **Public** | 3 | Vodafone Qatar, SK Telecom, TOT Thailand |
| **Rural** | 1 | Softbank (using satellite backhaul) |

Recently, some operators also offer femtocell free of charge to all its customer, like what being done by SFR in France, Softbank-Japan, Vodafone, and Cosmote in Greece. Table 1 shows market group being targetted by operator, consumer (residential) market segment is still as the primary target of operator to deploy femtocell.

**Table 2 Femtocell Technology Platform based on Regional View [2]**

| Regional view | UMTS femtocell launches | CDMA femtocell launches |
|---|---|---|
| **APAC** | 8 | 1 |
| **EMEA** | 24 | - |
| **Americas** | 1 | 2 |

Based on mobile technology platform, femtocell UMTS is the most widely developed technology by operators (33 operators), while CDMA only launches by 3 operators. EMEA region (24 operators) is the region that mostly deploy fentocell then followed by APAC region as shown in Table 2.

A variety of pricing model has been introduce to the femtocell market. Enterprise femtocell usually offer with a high upfront fee, while it is low upfront fee to consumer/residential market. This difference also due to the the different capacity of the femtocell and also some service level guarantee that give to the enterprise customer. Orange France charges an upfront fee of €1100 and €70 per month for an enterprise femtocell.

**Table 3 Femtocell Services Pricing Model [2]**

| Market | Pricing model | Deployment examples |
|---|---|---|
| Consumer | Addons for unlimited calling | MoldTelecom, Sprint, Optus |
| | Free femtocell | Softbank, Vodafone (GR), SFR |
| | Low upfront fee | Vodafone (UK) |
| | High upfront fee | Vodafone (IT, HU), Verizon |
| | Monthly fee | Sprint, Movistar, NTT DoCoMo |
| Enterprise | High upfront fee | All operators |

## 1.5. The Drivers of Femtocell Market in EU Countries

### 1.5.1. Broadband Market and Trend

The broadband market in EU is still contininuing to grow become the largest in the world. The penetration is diverse among countries and fixed broadband penetration rate was about 24.8% in January 2010, which represented 123.7 million subscribers. Most EU countries using xDSL technologies for the fixed broadband. About 83.4% of fixed broadband lines in the EU offer speeds above 2 Mbps, only a quarter of them are above 10 Mbps. The use of fiber-to-the-home (FTTH) solutions technology for broadband only represent between 2 and 5 % of all broadband lines.

**Table 4 EU Broadband Growth [4]**

| Period | January 04 | January 05 | January 06 | January 07 | January 08 | January 09 | January 10 |
|---|---|---|---|---|---|---|---|
| Broadband lines | 23 302 070 | 39 488 334 | 59 348 726 | 80 117 975 | 99 812 771 | 113 446 213 | 123 738 940 |
| Broadband penetration | 4.9 % | 8.2 % | 12.1 % | 16.3 % | 20.2 % | 22.8 % | 24.8 % |
| New lines per day | 28 752 | 44 225 | 54 412 | 56 902 | 53 958 | 37 250 | 28 199 |

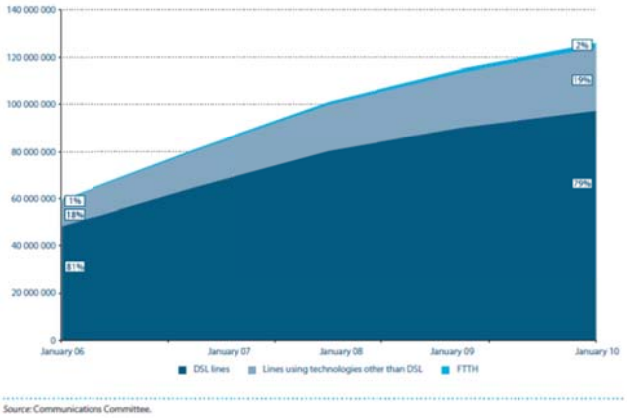



**Figure 5. EU Fixed Broadband lines by Technology [4]**

There is a clear trend in EU that the market needs toward higher bandwidth due to the emergence of many multimedia content and services in the market. In the begining of 2010, about 66% of fixed broadband lines in the EU offered speeds between 2 and 10 Mbps, 16% offered download rates between 144 Kbps and 2 Mbps, and about 23% offered 10 Mbps and above, which increased from 14% in 2009. But the penetration of broadband in household within EU countries is still about 56%, so there are about on average 40% of households are not yet connected to broadband.

Based on comScore Media Metrix report, On April 2011 there were about 365.2 million internet unique visitors from Europe, and each visitor had about 21.9 average hours and 1,963 average pages on internet. Another report from EIAA (November 2010) said that in average about 10% of European internet users are multi-screeners, and internet is the ‘must have’ media for them. In term of data consumption, Sandvine reported in May 2011, that Europe’s median monthly subscriber consumption on fixed broadband is about 14.7GB.

### 1.5.2. Consumer Attitudes on Femtocell

Based on survey result done by Parks Associates [3], Femtocells can bring multiple benefits to mobile operators in the form of reduced customer churn, improved customer loyalty, and service plan consolidation among families using multiple operators, and these benefits will be concentrated among the highest-ARPU customers.

Femtocell has raised interest for mobile users worldwide including in Europe region. Based on Parks Associates survey, about 33% to 49% of users are very interested in the value offered by femtocells and about 55% to 71% are interested in the femtocell. In fact there are about 26% of customers with lowARPU category also has an interest in femtocells.

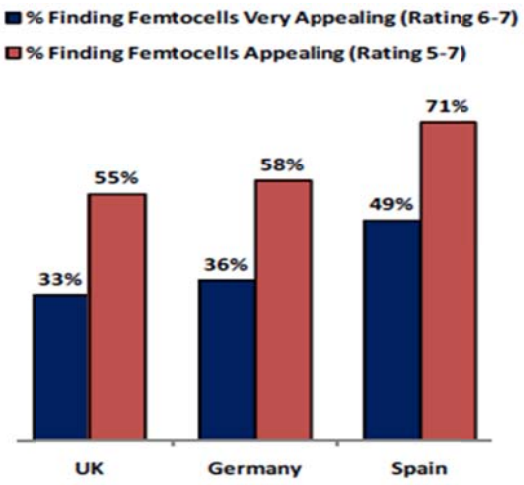



**Figure 6. Appeal of Femtocells**

The survey also showed that top drivers of femtocells for Europe users are Better In-Home Coverage/Signal Strength, high speed mobile internet, and Cheaper In-home Voice Calling/Mobile data Costs. Enhanced Audio/Video Downloading or Streaming Speed also be the driver for femtocell especially for Spain users.

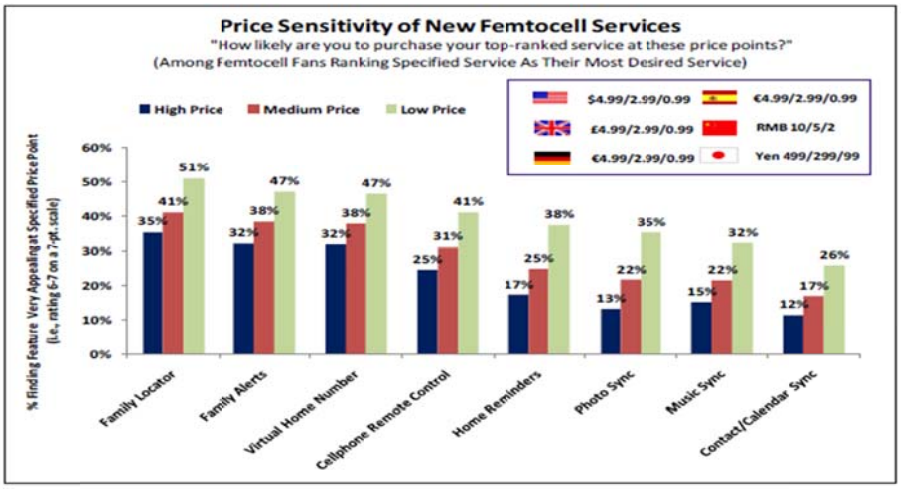



**Figure 7. Price Sensitivity of New Femtocell Services**

For home users, the most demanded femtocell services are Family Locator, Family Alerts dan Virtual Home Number and in average about 32% of users are willing to purchase the service for about €4.99 per month.

# 2. Freedom Use Case

## 2.1. WP5-SIRADEL Deployment Case

Refer to what had done in WP5 (System level benefits of the femto-based network) by SIRADEL, which is network planning for the interference management, there are six scenarios deployed for femtocell which may reflect the Urban and Sub-Urban areas environment contain of offices (single floor, multi-floors, and homes).

The outcomes for femtocell deployment in multi-floor building and single floor building are very similar. Remark the simulation outputs are highly sensitive to the realized FAP deployments (generated from a random process); therefore only statistics given in one same table may be directly compared in order to assess gains or degradations in spectral efficiency.

Figure 8 gives spectral efficiency statistics for a FAP subscriber located into the same small 10m×10m area as the FAP, considering different FAP densities (20% or 50%), FAP transmit powers (20dBm or 10dBm), FAP activation ratios (50% or 100%), macro inter-site distance (ISD=500m or ISD=1732m), FAP ranges to the macro BS (>ISD/3 or <ISD/3) and FAP deployment types (within the ground-floor or within the whole building). These statistics are compared to the spectral efficiency provided by the macro-only network.

Outage probabilities of spectral efficiency
- for a FAP subscriber located in the same 10m*10m area as the FAP
- considering a FAP ground-floor deployment in a 20m*80m wide building

| | 0.1 bps/Hz | 1 bps/Hz | 3bps/Hz | 5bps/Hz |
|---|---|---|---|---|
| **(a) Macro ISD = 500m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 44% | 96% | 100% |
| Reference FAP dplt [1] | 0% | 0% | 3% | 11% |
| FAP density 50% | 0% | 2% | 9% | 25% |
| FAP transmit power 10dBm | 0% | 0% | 5% | 21% |
| FAP activation ratio 100% | 0% | 1% | 6% | 21% |
| **(b) Macro ISD = 1732m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 36% | 94% | 100% |
| Reference FAP dplt [1] | 0% | 0% | 2% | 5% |
| **(c) Macro ISD = 500m, FAP located at range < ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 18% | 88% | 100% |
| Reference FAP dplt [1] | 0% | 0% | 10% | 27% |

Outage probabilities of spectral efficiency
- for a FAP subscriber located in the same 10m*10m area as the FAP
- considering a FAP deployment into a whole building (of random size)

| | 0.1 bps/Hz | 1 bps/Hz | 3bps/Hz | 5bps/Hz |
|---|---|---|---|---|
| **(a) Macro ISD = 500m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 58% | 96% | 100% |
| Reference FAP dplt [1] | 0% | 0% | 2% | 8% |
| FAP density 50% | 0% | 0% | 4% | 16% |
| FAP transmit power 10dBm | 0% | 0% | 3% | 15% |
| FAP activation ratio 100% | 0% | 0% | 3% | 13% |
| **(b) Macro ISD = 1732m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 59% | 98% | 100% |
| Reference FAP dplt [1] | 0% | 0% | 2% | 7% |

[1] FAP density 20%, transmit power 20dBm, activation ratio 50%

**Figure 8: Spectral efficiency offered to a corporate FAP subscriber into a small corporate area (10m×10m); Single Floor and One Building Scenario**

These figures will help a LTE network operator to assess the gain in quality of coverage it can offer to its corporate customers, in case a closed-access FAP is installed for subscribers located in a restricted area.

Figure 9 give similar results for a corporate FAP subscriber but considering here that this subscriber has access to all FAPs deployed within the corporate unit area. Two different corporate unit sizes are considered: one single building floor (the ground-floor actually) or the whole two neighbor buildings.

These figures help a LTE network operator to assess the gain in quality of coverage it will offer to its corporate customers, in case several closed-access FAPs are deployed within the customer premises. Remark these same results apply to any user when FAPs are in open-access mode.

Outage probabilities of spectral efficiency
- for a corporate FAP customer[2] located anywhere within the ground-floor
- considering a closed-access FAP deployment in the ground-floor of a 20m*80m wide building

| | 0.1 bps/Hz | 1 bps/Hz | 3bps/Hz | 5bps/Hz |
|---|---|---|---|---|
| **(a) Macro ISD = 500m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 40% | 98% | 100% |
| Reference FAP dplt [1] | 0% | 18% | 62% | 75% |
| FAP density 50% | 0% | 11% | 49% | 67% |
| FAP transmit power 10dBm | 0% | 24% | 74% | 85% |
| FAP activation ratio 100% | 0% | 19% | 65% | 80% |
| **(b) Macro ISD = 1732m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 56% | 95% | 100% |
| Reference FAP dplt [1] | 0% | 17% | 44% | 60% |
| **(c) Macro ISD = 500m, FAP located at range < ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 9% | 84% | 100% |
| Reference FAP dplt [1] | 0% | 5% | 64% | 85% |

Outage probabilities of spectral efficiency
- for a corporate FAP customer[2] located anywhere in the building
- considering a closed-access FAP deployment into a whole building (of random size)

| | 0.1 bps/Hz | 1 bps/Hz | 3bps/Hz | 5bps/Hz |
|---|---|---|---|---|
| **(a) Macro ISD = 500m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 56% | 96% | 100% |
| Reference FAP dplt [1] | 0% | 5% | 34% | 61% |
| FAP density 50% | 0% | 0% | 16% | 43% |
| FAP transmit power 10dBm | 0% | 16% | 56% | 76% |
| FAP activation ratio 100% | 0% | 15% | 82% | 95% |
| **(b) Macro ISD = 1732m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 58% | 98% | 100% |
| Reference FAP dplt [1] | 0% | 0% | 14% | 42% |

[1] FAP density 20%, transmit power 20dBm, activation ratio 50%

[2] Apply also to any user if FAP access-mode is open

**Figure 9: Spectral efficiency offered to a corporate FAP subscriber (or any user if FAPs are in open-access mode) within the whole FAP deployment area; Single Floor and One Building Scenario**

Outage probabilities of spectral efficiency
- for an indoor non-subscriber located in ground-floor
- considering a closed-access FAP deployment in the ground-floor of a 20m*80m wide building

| | 0.1 bps/Hz | 1 bps/Hz | 3bps/Hz | 5bps/Hz |
|---|---|---|---|---|
| **(a) Macro ISD = 500m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 40% | 98% | 100% |
| Reference FAP dplt [1] | 20% | 60% | 99% | 100% |
| FAP density 50% | 42% | 76% | 100% | 100% |
| FAP transmit power 10dBm | 12% | 52% | 99% | 100% |
| FAP activation ratio 100% | 34% | 71% | 99% | 100% |
| **(b) Macro ISD = 1732m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 56% | 95% | 100% |
| Reference FAP dplt [1] | 30% | 71% | 96% | 100% |
| **(c) Macro ISD = 500m, FAP located at range < ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 9% | 84% | 100% |
| Reference FAP dplt [1] | 10% | 24% | 86% | 100% |

Outage probabilities of spectral efficiency
- for an indoor non-subscriber located anywhere in the building
- considering a closed-acess FAP deployment into a whole building (of random size)

| | 0.1 bps/Hz | 1 bps/Hz | 3bps/Hz | 5bps/Hz |
|---|---|---|---|---|
| **(a) Macro ISD = 500m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 56% | 96% | 100% |
| Reference FAP dplt [1] | 46% | 87% | 99% | 100% |
| FAP density 50% | 76% | 97% | 100% | 100% |
| FAP transmit power 10dBm | 24% | 77% | 98% | 100% |
| FAP activation ratio 100% | 72% | 96% | 100% | 100% |
| **(b) Macro ISD = 1732m, FAP located at range > ISD/3 from Macro BS** | | | | |
| Macro only | 0% | 58% | 98% | 100% |
| Reference FAP dplt [1] | 78% | 96% | 100% | 100% |

[1] FAP density 20%, transmit power 20dBm, activation ratio 50%

**Figure 10: Spectral efficiency offered to a non-subscriber (macro user) located within a corporate closed-access FAP deployment; Single Floor and One Building Scenario**

Figure 100 give similar results but for a non-subscriber (i.e. a macro user) who is located within a FAP deployment in closed-access mode. These figures will help a LTE network operator to anticipate and control the degradation in quality of coverage that will be experienced by the non-subscribers.

## 2.2. WP5-DUNE Deployment Case

The massive deployment of femtocells network impacts several aspects that influence the business parameters considered by a MNO when addressing economic and technical issues. The results driven by the dynamic system simulator for various scenarios provide room for considerations that can be adopted by a MNO for its commercial plans:

- **Scenarios**. The results reported in previous sections show how network benefits arise in all scenarios considered: residential urban, suburban, and corporate. In all cases network performances improve, thus supporting benefits for both users and MNO.
- **QoS**. Users benefit from deployment of a femto network in a direct as well as in an indirect way: directly, users attached to a FAP get higher indoor communication quality, unprecedentedly ensured by the MBS; on the other side, users linked to the MBS benefit from the higher availability of resources which are now shared among less competing units. Overall customers' satisfaction will improve.
- **Interference**. The deployment of (indoor) femtocells injects a moderate amount of interference in the network which affects mostly indoor users. The benefits in terms of cell performances surpass possible drawbacks.
- **Transmitted power**. Interference caused by a dense deployment of indoor FAPs impacts mainly MUEs indoor, whose link to the MBS is already poor. In absence of specific techniques, a reduction of transmission power for FAPs and FUEs, while guaranteeing a comparable QoS to FUEs (loss of few percents both in outage and in capacity), reduces outage of indoor MUEs. On the other side, indoor FUEs attached to a FAP with high levels of traffic can have a demand of batteries due to the applications running on their devices, this way battery consumption would be significantly reduced.
- **Band partition**. Although analyzed in more details in Freedom 5D2, the overlap in band usage between the femto and the macro network impacts the overall QoS offered to both MUEs and FUEs. Since a licensed band is a resource that must be exploited at its best by a MNO, a rigid partition of the band is unlikely to be implemented, giving space to optimization methods focused on interference mitigation or reduction with a significant impact on the QoS offered to its customers.

A complementary aspect arises from changing point of view about coverage issues: although an improvement in transmission performances can be seen as a benefit for both MUEs and FUEs, its necessity can be considered as an issue about MNO offer. Indeed, since the business evaluation accounts for the deployment of femtocells as a mean for MNO to overcome a poor coverage and therefore a reduced service level, the task is to reach a level that could already be part of the agreement with the customers. Thus, improvements for users are also a benefit for the MNO, allowing expenses reduction, such as renovation of the macro network or increase of MBSs numbers in poorly covered areas.

In this view, MNOs could evaluate to compose targeted offers to poorly served customers with different pricing options, such as for example free or reduced femtos for households in poorly served areas (e.g., at cell border, or in very dense urban areas).

A final point that could be taken in consideration is the decrease of backhaul link quality for higher floors, paired with an increase on radio link towards the MBS. Since the MNO gets an overall advantage from the deployment of femtocells, it could adopt a strategy to encourage the adoption of femtocells also for users which already have a reliable QoS wireless link with the MBS.

The simulations performed at system level in 5A2 confirm how the indoor interference is one of the major drawbacks for a MUE in a closed environment. This situation is even worsened when inside buildings there is a FAP deployment interfering with it. In this view, simulations show how a modest management of transmission power can be implemented at system level, allowing to save power consumption and significantly improve overall network performances, both in terms of average throughput per user per PRB, and in terms of outage. Indeed, the methodologies exposed in this activity, show how management of band and/or transmission power allow to gain a clear better system performances. Indeed, clustering strategies open the way to fast and management of resources by different optimization methods.

Transmission power can be assigned with a set of criteria, minimum power, adapted power, optimized power) and similarly band can be partitioned in different ways (by assigning maximum band usage to FAPs in a rigid or adaptively) such that overall experience of users is improved, both for femto-users and, moreover, for MUEs, which are the ones most suffering from indoor interference.

Different types of band partition have been analyzed and offer to a MNO several means to manage and reduce interference, improving QoS and traffic flow.

## 2.3. WP5-CTU Deployment Case:Connection Cost Based Handover for Extension of Time in FAP

The purpose of the proposed algorithm is to prolong the time spend by UE connected to the FAPs and thus offload MBS. Extension of the time in FAP is achieved primarily by decreasing the CINR threshold for disconnection from a FAP and by using absolute threshold for performing handover to the FAP. Further, handover considers requirements of individual users on the quality of connection with respect to the cost of the connection. This way, the operator can give a benefit to user’s that are willing to offload its network as the cost of higher outage.

The results show that the proposed handover decision algorithm enables prolongation of the time spent in FAP for users that tolerates higher handover outage probability. The handover outage of the proposal still does not exceed the outage of the conventional handover. On the other hand, the proposed algorithm significantly reduces handover outage probability for users targeting high quality connection. In this case, the time in FAP is also slightly prolonged comparing to competitive handovers.

## 2.4. Femtocell Services

The growth of femtocell market has inspired many parties to create innovative services or solutions to strengthen the value propositions of femtocell. So femtocell does not only offer great coverage and capacity but enable a wide range of services, some of which are existing services delivered in a more efficient manner, and others that are entirely new.

### 2.4.1. Basic Service

The basic service of femtocell is to improve the coverage and capacity of mobile services within in-building areas like home, office building, and public facility. By offering femtocell to the users, operator may differentiate its in-building mobile service competitive advantage from other operators and may increase its customer loyalty. By having this better in-building quality experience, the femtocell operator has a bigger opportunity to acquire new customers.

Through the femtocell, customers can enjoy the basic operator services such as voice calls, SMS, and internet access. Operator would also benefit from the femtocell basic service. Some traffic will be offloaded to femtocell and fixed network, so that the macro users will enjoy a better capacity than before.

Most operators now set specific tariff rate for its femtocell. This rate may include ownership or lease of the femtocell access point along with the use of operator's basic service (ex: voice, sms, internet) which is generally cheaper than regular mobile rates. And some tariff models are offered in the context of group rates and family. And surprisingly,since last year we may also found that some operators (KDDI, SoftBank, Megaphone) have offered free femtocell access to their customers and off course in order to improve their customers loyalty or reducing the customer churn by giving better in-building coverage service quality.

### 2.4.2. Femtocell Value Added Service for Residential Customer

The value of femtocell be more competitive as it can be bundled with value added service. The value added service running over femtocell can be as new source of revenue for operator. As femtocell can contribute cost efficiency to operator, it may offer free of charge to the market but operator can achieve a better return by offering attractive value added service to its subscriber.

Some specific value added service may offer to residential segment are: family locator, family alerts, vistual home number, cellphone remote control, home reminders, photo snync, music sync and contact.calender sync [3].

Femtocell also captures the value for residential segment especially when there are family members belong to another different operator. By experiencing the better coverage, capacity, femtocell service and value added service through femtocell, they may think of joining to the operator who provides the femtocell service.

### 2.4.3. Femtocell Value Added Service for Enterprise Customer

The existence of mobile devices has become an important part for office workers or executives. These mobile devices (example: smartphones, laptops, tablets, mobile internet device) are always connected and be important parts in generating productivity and better collaboration within the enterprise.

The presence of femtocells in the office will be able to further empower the mobile devices so that the activities of data sharing, video and audio conferencing, telephony, instant messaging, which is integrated in a unified communication solutions and colaboration will be done easily by employees without having to move from one device to another.

Therefore the offering of femtocell value added service to enterprise customer should be able to empower employee's mobile devices and be part of their business process.

## 2.5. Femtocell Driver in Spain

### 2.5.1. Demographic

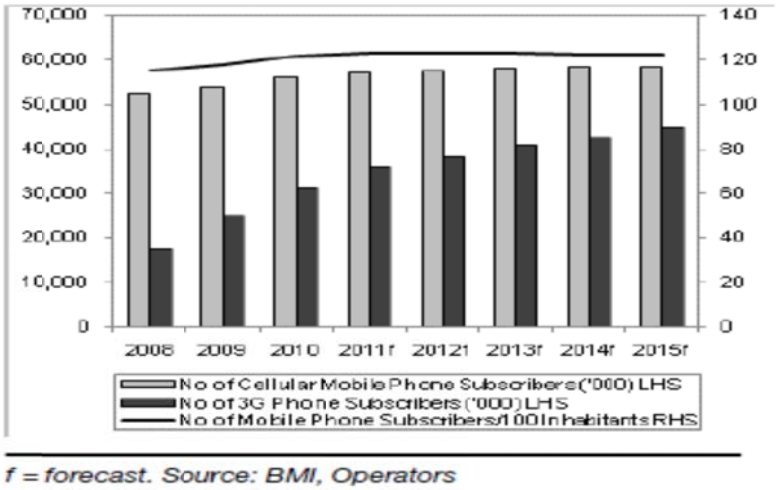
Spain population reached 46 million people in 2008, with density at 91/km² (235/sq mi), and this is lower than that of most Western European countries. Madrid is the most populated areas lie around the coast. Spain is a country in Southwestern Europe with an area 505,782 $km^2$ (194,897 sq mi) and now its population is about 46,777,373 people. The Table 5 below shows six largest cities of Spain with each population in specific urban area.

**Table 5. Urban Area and Population**

| No | City | Urban Area Population | City Area Population |
|---|---|---|---|
| 1 | Madrid | 5,078,100 | 2,905,100 |
| 2 | Barcelona | 3,871,400 | 1,497,700 |
| 3 | Valencia | 1,406,600 | 741,900 |
| 4 | Sevilla | 1,135,600 | 704,500 |
| 5 | Zaragosa | 607,000 | 607,000 |
| 6 | Malaga | 748,200 | 539,300 |

### 2.5.2. Mobile User/Broadband

Spain has four big mobile operators: Telefonica (with Movistar), Vodafone, Orange and Yoigo. As forecasted by BMI, mobile subscribers grew slowly under 4,1% in 2010 and even slower in 2011 (1,7%). This reduction reflects that the mobile market is saturated due to the high penetration.




*f = forecast. Source: BMI, Operators*

**Figure 11. Industry Trends – Mobile Sector 2008-2015**

By the end of 2010, the penetration rate has reached of 121.5%, therefore the growth rate for 2012 forecasted be less than 1%. Within next five years to 2015, the market will grow at an annual average rate of 0.8% or about 4.1% over the five years. By the end of 2015, BMI forecasts Spain will have about 58.3 million mobile subscribers which is of 122% penetration rate as showed in Tabel 6 below.

**Table 6. Mobile Phone Subscriber**

| Table: Telecoms Sector - Mobile - Historical Data And Forecasts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011f | 2012f | 2013f | 2014f | 2015f |
| No. of Mobile Phone Subscribers ('000) | 52,487 | 53,834 | 56,017 | 56,970 | 57,441 | 57,841 | 58,137 | 58,334 |
| No. of Mobile Phone Subscribers/100 Inhabitants | 115.2 | 117.3 | 121.3 | 122.4 | 122.5 | 122.5 | 122.3 | 122.0 |
| No. of Mobile Phone Subscribers/100 Fixed Line Subscribers | 260.3 | 268.4 | 284.4 | 283.7 | 292.5 | 304.6 | 308.3 | 311.1 |
| No. of 3G Phone Subscribers ('000) | 17,314 | 24,766 | 31,120 | 35,576 | 38,220 | 40,689 | 42,492 | 44,806 |
| 3G Market As % Of Entire Mobile Market | 33.0 | 46.0 | 56.6 | 62.4 | 66.5 | 70.3 | 73.1 | 76.8 |

*f = BMI forecast. Source: BMI*

**Table 7. Mobile Phone Subscriber per Operator**

| Table: Spain Mobile Market, Q211 | | |
|---|---|---|
| Operator | No. Of Subscribers ('000) | Market Share (%) |
| Telefónica Móviles (Movistar) | 24,370 | 43.0 |
| Vodafone | 17,350 | 30.6 |
| Orange | 12,221 | 21.6 |
| Yoigo | 2,672 | 4.7 |
| **Total** | **56,613** | **100.0** |

*Source: BMI*

As June 2011, mobile subscriber in Spain was about 56.613 million, represnting a 5.2% year of year increase. Telefonica Moviles (Movistar) has the biggest market share (43%) followed by Vodafone with 30.6 market share.

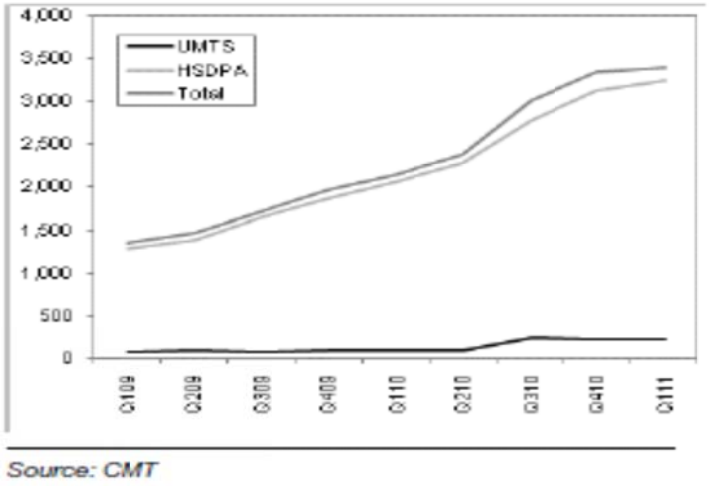



**Figure 12. Mobile Broadband Datacard (‘000) 2008-2010**

Mobile broadband subscriber has grown almost double within last two years (Q1-09 to Q1-11) as shown in Figure 12. Mobile broadband subscribers use their laptop/netbooks, smartphone, and other mobile internet device to connect to the internet through their operators broadband network (3G/HSPA). In March 2011, there are about 3.4 million mobile broadband users in Spain.

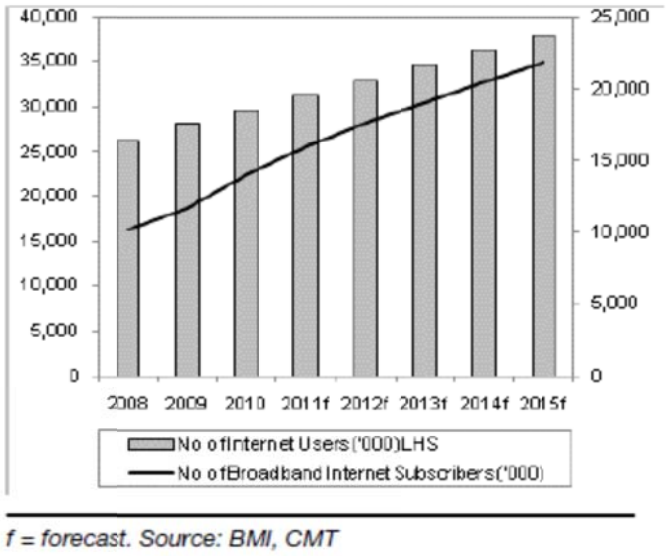



**Figure 13. Industry Trends-Broadband Sector 2008-2015**

### 2.5.3. Internet and Fixed Broadband

In the end of 2010, there were about 29.6 million internet users in Spain and this number is forecasted to grow to 37.9 million in the year of 2015. The growth of varius content and application in internet has encouraged the need of broadband internet connection in Spain, which was about 14 million in 2010 to be projected to about 21.8 million in 2015.

**Table 8. Internet-Historical Data and Forecast**

| Table: Telecoms Sector - Internet - Historical Data And Forecasts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011e | 2012f | 2013f | 2014f | 2015f |
| No. of Internet Users ('000) | 26,172 | 28,118 | 29,681 | 31,299 | 32,933 | 34,596 | 36,269 | 37,954 |
| No. of Internet Users/100 Inhabitants | 57.4 | 61.3 | 64.3 | 67.2 | 70.2 | 73.3 | 76.3 | 79.3 |
| No. of Broadband Internet Subscribers ('000) | 10,170 | 11,635 | 14,019 | 15,919 | 17,634 | 19,045 | 20,453 | 21,843 |
| No. of Broadband Internet Subscribers/100 Inhabitants | 22.3 | 25.4 | 30.4 | 34.2 | 37.6 | 40.3 | 43.0 | 45.7 |

*f = BMI forecast. Source: BMI*

By the end of June 2011, the fixed broadband connections grew to 10.895 million connections, which was up about 7.8% compare to June 2010 with only had 10.457 million connections. Most of fixed broadband connection in spain use the ADSL technology, only about 0.5% use fiber optic connections for business and residential customer. BMI expects ADSL to remain the dominant fixed broadband technology within the next five year period.

**Table 9. Spain Broadband Market Q210-Q211**

| Table: Spanish Broadband Market Q210-Q211 | | | | | | |
|---|---|---|---|---|---|---|
| **Number of fixed-line accesses ('000)** | **Q210** | **Q310** | **Q410** | **Q111** | **Q210** | **% Change (Q210-Q211)** |
| Telefonica Retail Broadband* | 5,620 | 5,672.1 | 5,722 | 5,749.2 | 5,669.1 | 0.9 |
| Telefonica Wholesale ADSL | 464 | 508 | 561.3 | 614.9 | 652.3 | 40.5 |
| Jazztel (ADSL) | 757 | 804 | 865.745 | 931.06 | 985.5 | 30.2 |
| Orange (ADSL) | 1,083 | 1,090 | 1,115 | 1,150 | 1,187 | 9.6 |
| Orange local loop unbundling (LLU) | 870 | 872 | 886 | 906 | 932 | 7.1 |
| Grupo Ono (Cable) | 1,356 | 1,361 | 1,379.552 | 1,406.155 | 1,414 | 4.3 |
| Other | 1,287 | 1,307 | 1,374 | 1,607 | 5.530 | 329.7 |
| **Total** | **10,103** | **10,234** | **10,457** | **10,844** | **10.895** | 8.4 |

**Includes ADSL, satellite, optical fibre and broadband circuits. Source: Operators; BMI*

### 2.5.4. Mobile Operators in Spain

Almost all of 4 big operators in Spain are global players and have a reputation for being technologically advanced operator. In gaining market share gains, Spain's fourth-ranked operator remains very small in comparison with its rivals. At the end of June 2011, the largest Spanish mobile operator remained by far Movistar, although it is slowly seeing its leading share decline. In March 2011, the operator had 43.4 % market share. Vodafone's performance was slowly chipped away throughout the rest of the year with 30,7% in Q111. And Orange has seen its position improve in recent months, compared with 2010. Orange managed to gain 320,000 and 119,000 subscribers respectively.

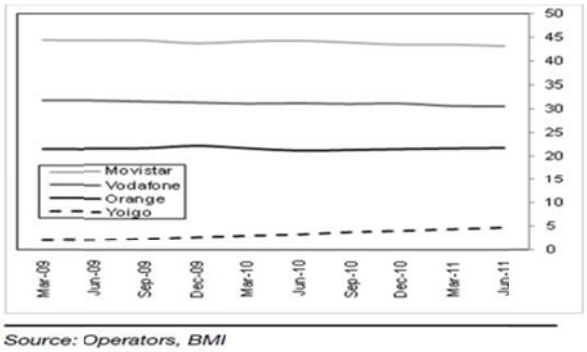



**Figure 14. Mobile Operator Market Share (%) 2009-2011**

#### 2.5.4.1 Telefonica

Telefónica is one of the world leaders integrated operator in the telecommunication sector, providing communication, information and entertainment solutions, with presence in Europe, Africa and Latin America. As one of the world's leading telecoms operators and dominant player in domestic fixed-line, mobile and data markets, Telefónica provides its mobile services under the brand name of Movistar.

**Table 10. Telefonica's Mobile Subscriber**

**Table: Movistar**

| | Mar-09 | Jun-09 | Sep-09 | Dec-09 | Mar-10 | Jun-10 | Sep-10 | Dec-10 | Mar-11 | Jun-11 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Subscriber Numbers (000)** | | | | | | | | | | |
| Total Number | 23,615 | 23,716 | 23,993 | 23,539 | 23,728 | 23,879 | 24,124 | 24,309 | 24,366 | 24,370 |
| Market Share (%) | 44.5 | 44.4 | 44.4 | 43.7 | 44.2 | 44.4 | 43.9 | 43.4 | 43.4 | 43.0 |
| No of Net Additions | 10 | 101 | 277 | -455 | 189 | 151 | 245 | 185 | 57 | 4 |
| Market Share of Net Additions (%) | 1.8 | 32.4 | 43.5 | 272.9 | -138.7 | 131.3 | 21.3 | 17.5 | 52.0 | 0.7 |

Numbers of customer grew by more than 6% in the year to June 2011. Now, the operator provides access service to 290.0mn customers in more than 20 countries including 227.3mn mobile, 40.7mn fixed and

18.9mn data and internet subscribers. As a dominant player, Telefonica provide domestic fixed-line, mobile and data markets. Tabel 6 below indicates Telefonica's mobile subscribers growth.

### 2.5.4.2 Vodafone

Vodafone España is the second largest mobile operator in Spain and backed by a large international investor. Vodafone as the largest 3G operator in the country has a reputation for being technologically advanced operator.

**Table 11. Vodafone's Mobile Subscriber**

| Vodafone - Continued | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mar-09 | Jun-09 | Sep-09 | Dec-09 | Mar-10 | Jun-10 | Sep-10 | Dec-10 | Mar-11 | Jun-11 |
| Subscriber Numbers (000) | | | | | | | | | | |
| Total Number | 16,910 | 16,991 | 17,069 | 16,910 | 16,745 | 16,827 | 17,107 | 17,484 | 17227 | 17350 |
| Market Share (%) | 31.9 | 31.8 | 31.6 | 31.4 | 31.2 | 31.3 | 31.1 | 31.2 | 30.7 | 30.6 |
| No of Net Additions | 372 | 81 | 78 | -159 | -165 | 82 | 280 | 377 | -257 | 123 |
| Market Share of Net Additions (%) | 66.0 | 26.0 | 12.2 | 95.4 | 120.8 | 71.2 | 24.4 | 35.7 | -232.8 | 25.3 |

### 2.5.4.3 Orange

Orange Spain has grown to become one of the largest alternative multiplay operators in Spain. Backed by international investor France Télécom with presence invested in fixed-line operator. In October 1999, France Télécom established its broadband internet service provider brand Wanadoo as a standalone operation.Backed by international investor France Télécom with presence across several

**Table 12. Orange's Mobile Subscriber**

| Table: Orange | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mar-09 | Jun-09 | Sep-09 | Dec-09 | Mar-10 | Jun-10 | Sep-10 | Dec-10 | Mar-11 | Jun-11 |
| Subscriber Numbers (000) | | | | | | | | | | |
| Total Number (2) | 11,426 | 11,469 | 11,620 | 11,879 | 11,552 | 11,294 | 11,620 | 11,940 | 12,059 | 12,221 |
| Mobile Broadband (Dongle) | 223 | 246 | 292 | 352 | 413 | 475 | 554 | 637 | 702 | 747 |
| Market Share (%) | 21.5 | 21.5 | 21.5 | 22.1 | 21.5 | 21.0 | 21.1 | 21.3 | 21.5 | 21.6 |
| No of Net Additions | 52 | 43 | 151 | 259 | -327 | -258 | 326 | 320 | 119 | 162 |
| Market Share of Net Additions (%) | 9.2 | 13.8 | 23.7 | -155.5 | 239.4 | -224.2 | 28.4 | 30.3 | 107.8 | 33.3 |

# 3. Business Model

## 3.1. Freedom Methodology

The business case is generated based on the results of Freedom technical innovation, to determine the benefit of the Femtocell to the operator and the market. In addition, the business case will also identify Femtocell implementation if it is associated with the operator push approach and consumer pull approach. Simulations will consider the existing 3G network, and the addition of LTE network capacity to meet user demand, both for Macro Base Station (MBS) and Femtocell.

Implementation scenarios and some technical parameters used in the simulation business case refer to the WP-5 simulation, while the market parameters refer to Spain Telecommunications Report Q-4 2011.

## 3.2. Network Dimensioning and Assumptions

In the business case simulation, the calculation will be focused to meet the needs of the service capacity in Spain. The land area of Spain is 504,030 km2 and divided into 40% urban areas with a population of 32%, 30% sub-urban with a population of 40% and 30% of rural with a population of 28% (source: Wikipedia). Further determination of the indoor area is done using the comparison assumption of indoor and outdoor areas, both for urban and sub-urban areas in accordance with the figure below. Rural area and an outdoor area not covered in this simulation.

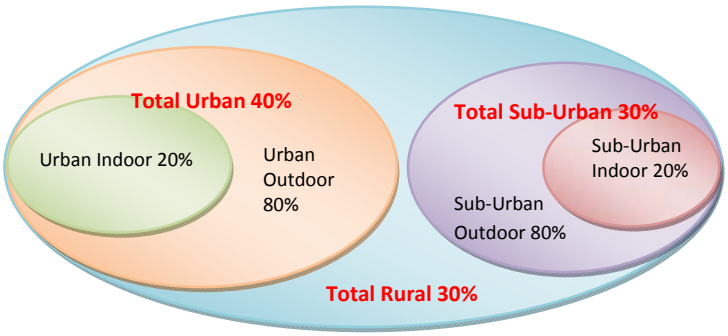



**Figure 15. Area Dimensioning**

Based on Spain Telecommunications Report Q-4/2011, number of mobile subscribers reached 56 million. To serve these customers required approximately 35,000 MBS, which consisted of MBS outdoor and MBS indoor (IBS). This assumption is used through a comparison in which Vodafone Germany has 20.000 MBS to serve 32 million customers. MBS serves customers in the outdoor and indoor areas, while IBS is only serving customers in indoor areas. In Siradel measurement report, MBS signal penetration into the indoor area is only about 20-30% of the MBS throughput. It means that the indoor areas are served by IBS with an additional 30% throughput of MBS. The total capacities are shared to serve all customers in indoor areas.

MBS density is different for urban areas and sub-urban areas. Inter-site distance (ISD) ranges from 500 m in urban, and 1.734 m in suburban. Some parameters used in calculating the capacity of BS:

a. MBS by location:

1. 17,500 MBS in urban area (50% of total MBS)
2. 8,942 MBS in sub-urban area (35 of total MBS)
3. 5,250 in rural area (15% of total MBS)

b. The number of MBS consist of outdoor MBS dan IBS. IBS is used to serve the HRB, which each IBS cover 2 HRB. The number of HRB in Spain by assumption are:
   1. Urban: 8,064 HRB
   2. Sub-Urban: 6,615 HRB

c. The maximum capacity of 3G MBS is 21 Mbps, while signal penetration in the indoor area reached only 30% of the capacity that is 6.3 Mbps.

In calculating capacity requirements, mobile users can be divided into corporate users and non-corporate users. Corporate users require greater capacity than non-corporate users. However, not all corporate users are high data rate customers with 2 Mbps speed. Based on experience, there is only 10% of all corporate users are high data rate customers. The same thing happened to non-corporate users, that only 10% is a high data rate customer with 1 Mbps speed.

The spread of customers is assumed to occur evenly in an indoor area:

a. 30% of users are in the area of corporate
b. 50% of users are in the home / apartment
c. 20% of users are in public areas

Parameters of Femtocell capacity calculation are based on the measurement report of WP-5, which is divided for urban areas and sub-urban areas. The capacity measurement (Mbps) is done in two deployment scenarios consist of macro only (MBS) and two tier (MBS and FAP). The report is summarized in table below.

**Table 13. Capacity prediction for Femtocell Deployment Scenario**

| Femtocell Deployment Scenario (SIRADEL) | | | | | | |
|---|---|---|---|---|---|---|
| Total Throughput (MBps) | | | | 2 Tier (Mbps) | MBS (Mbps) | Remark |
| Segment-1 | Urban ISD=500m | Closed FAP | Short Range (<ISD/3) | 42.6 | 10.78 | FAP Density=20%, Act Ratio:50% |
| | | | Long Range (>ISD/3) | 47.2 | 6.84 | |
| | | Open FAP | Short Range (<ISD/3) | 19.75 | 12.39 | |
| | | | Long Range (>ISD/3) | 20.98 | 6.8 | |
| Segment-2 | Sub-Urban ISD=1734 | Closed FAP | Long Range (>ISD/3) | 48.6 | 7.96 | |
| | | Open FAP | Long Range (>ISD/3) | 27.67 | 5.96 | |
| Non-Subscriber of Closed FAP | | | | | | |
| Segment-1 | Urban ISD=500m | Closed FAP | Short Range (<ISD/3) | 10.54 | 12.39 | FAP Density=20%, Act Ratio:50% |
| | | | Long Range (>ISD/3) | 4.6 | 6.8 | |
| Segment-2 | Sub-Urban ISD=1734 m | Closed FAP | Long Range (>ISD/3) | 4.11 | 5.96 | |

## 3.3. Cost Parameter

These two scenarios will be simulated to know the comparison between the macro only scenario and two tier scenario. Some parameters used in macros only scenario:

a. Existing capacity based on 3G specification.
b. Capacity by demand is driven by the needs of the customers comprising of corporate customers and non-corporate customers.
c. Network capacity planning is based on the needs of users in an indoor area.
d. Fulfillment capacity is obtained from the addition of MBS and IBS with LTE specification.
e. Cost parameters refer to BeFemto are [6]:
    1. CAPEX 3G BTS: 140k€. By experienced, the actual cost of equipment is less than 50% and the rest is used for site acquisition. Thus, CAPEX of LTE base stations are assumed to 70k €.
    2. OPEX: 15k€/year.

In two tier scenario, basically FAP implementation can be done based on capacity requirement. However, since the FAP coverage is much smaller compared to the coverage area of the MBS, the planning can not be done based on capacity requirement. To get more accurately planning, number of FAP is determined through the number of blocks that will be served. Specification of block which refers to WP-5 report is a room 20x80 m or 1600 m2. Some parameters of two tier scenario:

a. Existing capacity based on 3G specification.
b. Network planning is based on the number of blocks to be served in the corporate area, home/ apartment and public areas.
c. Each home/apartment use 1 FAP.
d. FAP density in block (1600 m2): 20% density = 0.002 FAP / m² within the floor assumption are used for corporate and public area.
e. Cost parameters refer to BeFemto are:
    1. CAPEX FAP: 150€.
    2. OPEX: 1€/year.

## 3.4. Revenue Projection

In macro only and two tier scenario business simulation, the same value used for some parameters such as customer growth, data growth, and churn rate. Basically, these two scenarios give a positive result for 10 years projection. The figure 16 below shows a comparison between the simulation results for macro only scenario and two tier scenario.

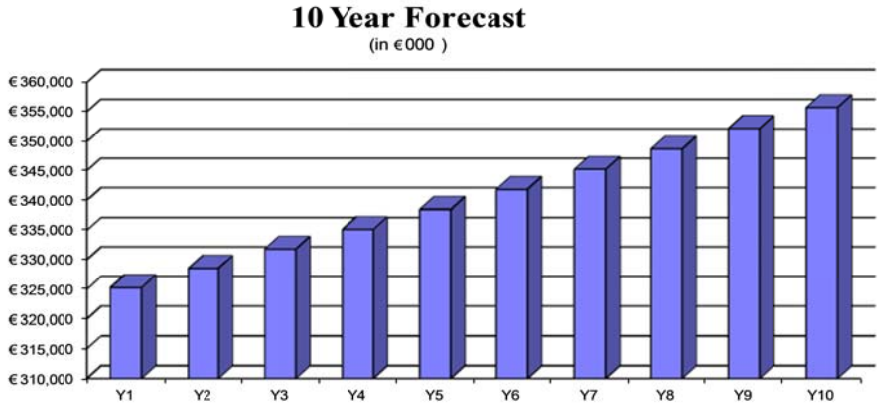



**Figure 16. Macro Only Scenario: Sales Projection**

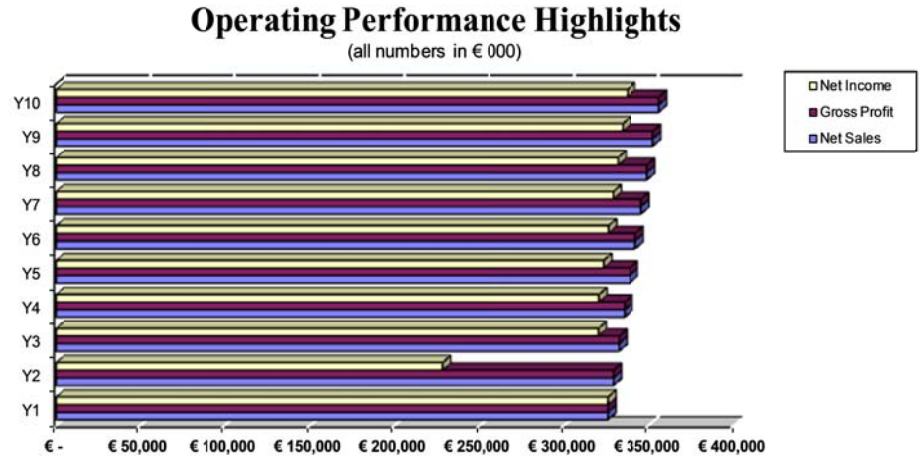



**Figure 17. Macro Only Scenario: Operating Performance Projection**

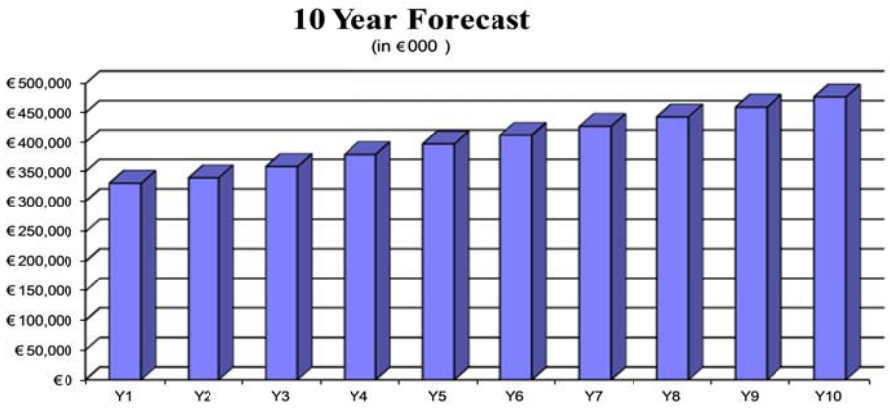



**Figure 18. Two Tier Scneario: Sales Projection**

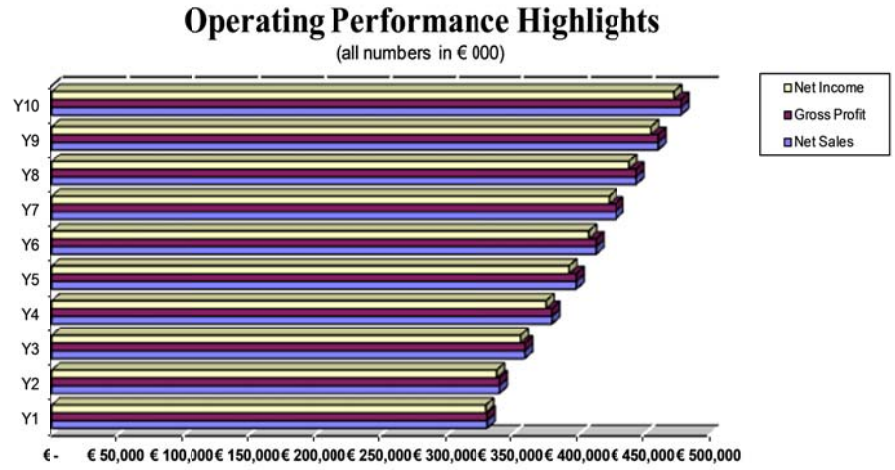



**Figure 19. Two Tier Scneario: Operating Performance Projection**

However, the business simulation results show a better projection for the two tier scenario. The simulation result is summarized in Table 14 below.

**Table 14. Business Simulation Comparison**

| Parameter | Macro Only Scenario | Two Tier Scenario |
|---|---|---|
| Net Income Growth (10 years) | 1,73% | 4,08% |
| NPV | € 416,454,000 | € 693,748,000 |
| IRR | 25,5% | 30,72% |

Besides a better projection, Femtocell which is installed in two tier scenario gives additional benefit that can generate additional revenue in the future. Femtocell implementation planning is carried out on location/coverage basis in the form of block (1600 m2). It will give much greater capacity than user capacity requirements. Therefore user will gain better in-building experience by using the capacity more freely. In addition, Femtocell allows sales of VAS through FAP. Operators can provide a variety of VAS for a various customer behavior to get significant incremental revenue from VAS sales. It means the implementation of two tier scenario will provide some benefits:

a. Higher customer growth
b. Greater bandwidth consumption
c. New revenue generator (up sell) through VAS services over Femtocell
d. Higher revenue can be collected related to the higher customer growth, greater bandwidth consumption and VAS sales.

## 3.5. Customer Pull and Operator Push Business Model

Today, most of operator offer femtocell service to the customers based on "Customer Pull" model. Customer Pull means services provider asks customers to invest in the femtocell device and pay a monthly fee. This model would be hardly to be implemented because the customers are not willing to spend more money to get additional services, especially basic services that they think it is become a service provider responsibility. A research was conducted by Cisco IBSG [8] shows that is hard for some service providers to charge monthly mobile device fees. To survive in acompetitiveness situation, service providers have to offer more minutes and data without the price increasing.

Given the scenario, the customers with poor mobile coverage will be prefer to switch a service provider rather than purchase an additional service from the existing provider. From the customer point of view, service providers have to provide a good coverage in customer areas.

The other business model for femtocell is an "Operator Push" model. Operator Push means service providers provide femtocell service as an integrated service with an existing mobile service without an additional fee. The service is not include femtocell VAS (Value Added Services). In this model, femtocell represent an attractive alternative to offload traffic directly onto customers broadband connections, thereby relieving the load of service provider networks. Moreover, femtocell can drive the key financial indicators that will increase femtocell attractiveness.

There are six major areas that can be improved the benefit and business metrics by femtocell:

**a. Services Revenue**
Services revenue is divided into two forms. First, monthly fee for femtocell basic usage. And second, mobile operator can charge for femtocell value added services (VAS)

**b. Churn Reduction**
There are three categories of customers by considering the quality of mobile coverage: 1) Service is acceptable, 2) service could be better, 3) service is unacceptable. For the two last categories,

femtocell solution will be prepared to improve customers perception about service they receive. For example, Orange in France has seen a 10% churn reduction as a result of its femtocell service.

c. **Upsell Opportunities**
   Due to unconvenience of poor quality services, customers with that condition have limited their mobile phone usage and instead relied on PC and fixed-line phones. With femtocell, these customers will increase usage of their mobile phones, and giving mobile operator opportunity to sell additional services.
d. **Broadband Impact**
   Broadband will be the sole transport mechanism for backhauling in home wireless traffic to mobile operator. As a result, a small percentage of homes will need to upgrade their existing broadband plans to receive higher levels of service.
e. **Market Share Gains**
   Because femtocell provide an improved mobile experience, household members that use a different carrier are likely to switch to mobile operator which provide better services. Additionally, new households may be more attracted to mobile operator that offer femtocell than those that don't.
f. **Network Cost Reductions**
   Because in home wireless solution represent a fixed cost per user with nearly unlimited usage, there is clear breakeven point after which it is more cost effective to use a femtocell solution rather than build out a 3G network.

Operator need to choose one model rather “operator push” or “customer pull” on implementing Femtocell. Therefore the business simulation is carried out on these two models. The aim is to show the different value which be offered by each model.

### 3.5.1. Subscriber Projection

In femtocell network, user can gain some advantage on signal quality and network capacity. It gives value for user to remain use the service. But the service will be more attractive on operator push model since the service can be acquired without additional fee. It can be ensured that new customer will prefer the better service offering. As a result, operator push model can attract more customers and perform an outstanding customer acquisition than the other model.

Moreover, some improvement on signal quality and network capacity will produce a better user experience, increase customer loyalty and reduce churn at once. Churn rate on operator push model will surely less than customer pull model, since the same service can be get without additional fee. It means that the number of subscriber of operator push model will be potentially higher than customer pull model.

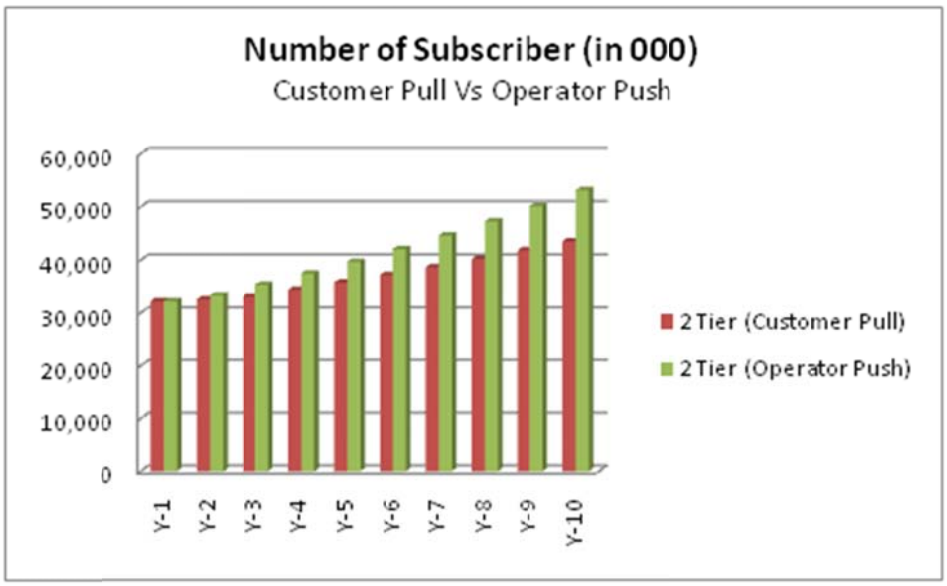



**Figure 20. Number of Subscriber Comparison**

### 3.5.2. Data Usage & Capacity Projection

Femtocell network provides much more capacity on limited coverage. It means user can freely using data communication in femtocell area. This experience will foster user to consume more bandwidth and capacity on its mobile. Such kind of behavior will generate more revenue for operator. Other opportunity comes from VAS, where user can be

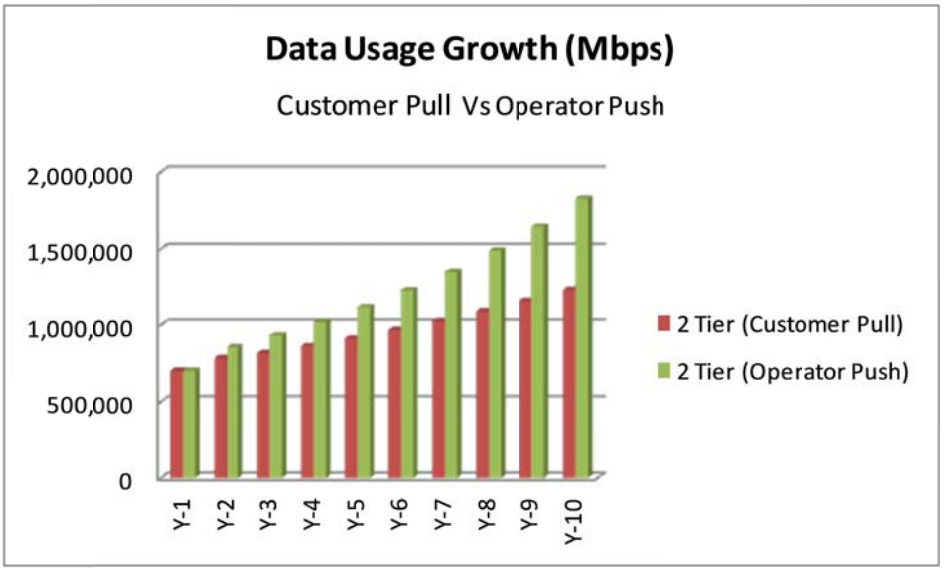



**Figure 21. Data Usage Growth Comparison**

### 3.5.3. Revenue Projection

Revenue projection for femtocell service wil be bigger cause of demand value projection is also bigger than macro. Femtocell operator will get revenue from FAP monthly fee and value added service (VAS).

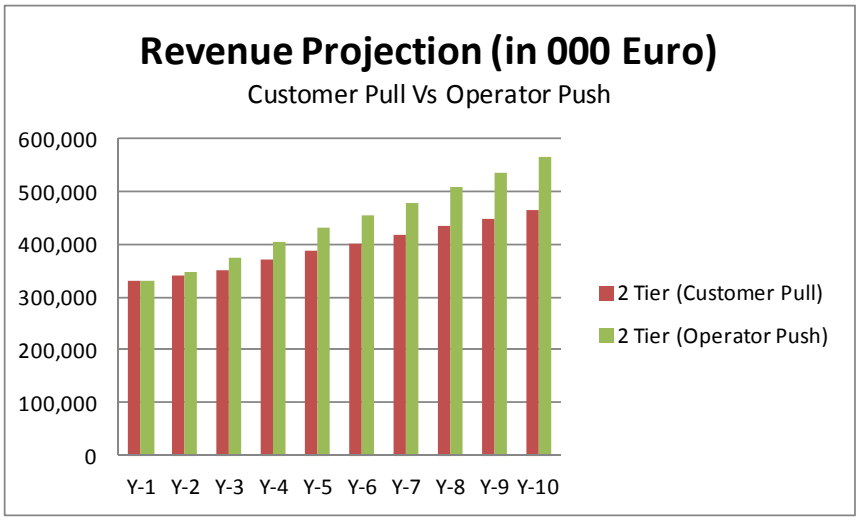



**Figure 22. Revenue Projection Comparison**

Revenue projection of Push Operator Model will be better than Pull Customer Model. It caused by potential of customer growth and amount of bandwith consumption that higher than other. Revenue is increasing significantly. Femtocell service implementation will not charge customer additional fee, and will has multiplier effects as follows:

a. Customer satisfaction, because decrease churn rate and make existing customer loyaler.
b. Opportunities for a new customer appearance from other operator.
c. Potential customers that more bandwith consumption.
d. Potential customers do upsale for example VAS service.

### 3.5.4. Financial Feasibility

Based on financial business case simulation on two tier scenario for Pull Customer Model, the final result for financial feasibility :

**Table 15. Financial Feasibility Comparison**

| Parameter | Push Operator Model | Pull Customer Model |
|---|---|---|
| NPV | € 822,560,000 | € 664,647,000 |
| IRR | 32.678% | 30.214% |

This value is better than macro only scenario. Based on financial feasibility model, the two tier service will give better performance than macro only. Value for Push Operator Model Final will much higher if we also consider sales improvement, cost reduction and other parameter which also give benefit like upsell opportunities, market share gain and network cost reduction.

# 4. Technology Implementation-Dissemination Plan

This section is submitted to the EC in a separate document due to confidentiality issues of the partners involved.