WiMAX: The Business Case for Fixed Wireless Access in Emerging Markets

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Introduction

Wireless access networks based on WiMAX-compliant solutions provide an opportunity for operators to participate in the high growth opportunities that exist in emerging markets. Traditional wire-line infrastructure in these countries is either non-existent or only accessible to a small segment of the population. WiMAX-based access networks will enable local operators to cost-effectively reach millions of new potential customers and provide them with traditional voice and broadband data services that up to now have been denied. Although these markets have all the attributes required for a winning business case, they are not without challenges. This paper is intended to provide some insights as to what it takes for a profitable WiMAX deployment strategy and to provide some typical deployment examples.

Emerging Markets Characteristics

The definition of an emerging market is a nation having an economy with a very low current gross domestic product per capita (GDP) with an above-average economic growth potential. The annual GDP per capita for China and India for example is under $1,000, whereas the United States, Japan, and countries in Western Europe have GDPs per capita ranging from $24,000 to $36,000 per year. The above-average growth potential makes these countries attractive for investment but the low current GDP creates one of the major initial challenges. In terms of broadband services the low discretionary income per household has the following impact:

- Lower revenues (ARPU) for broadband services.
- Fewer customers can afford to purchase their own customer premise equipment.
- Higher churn and higher percentage of bad debts can result in higher operating expense
- Lower percentage of households own personal computers thus reducing the size of the addressable market for broadband services.

On a more positive note there are a number of favorable attributes in addition to the above-average economic growth that make these markets particularly attractive for communications network investment. These attributes are summarized in the following table.

Characteristics of Emerging Markets	Impact on WiMAX Operator
Support of government telecom regulators	• Spectrum available at low or no cost • Facilitated licensing process
Very high HH density in metro areas	• Lower infrastructure CAPEX per HH passed
Limited wire-line competition	• Gain higher penetration of addressable market
High pent-up demand	• Rapid market adoption rate (1 to 2 years instead of 3 to 5 years)
Lower labor rates	• Lower costs for labor-intensive deployment activities such as, civil works and equipment installation
High percentage of high density multi-tenant buildings (MTUs)	• Multiple customers sharing CPE/IAD CAPEX can improve the business case

Table 1: Characteristics of Emerging Markets

WiMAX in the End to End Network

In analyzing the business case for fixed wireless access it is informative to breakout the end to end network as described in figure 1 and look at the three major CAPEX components separately;

- Customer Premise Equipment (CPE)
- Base Station Infrastructure
- Edge, Core, and Central Office Equipment

For an incumbent wire-line operator trying to extend the reach of an existing network with wireless access; most, if not all, of the edge, core and central office equipment would already be in place. The exception would be the possible need to add capacity to support the additional anticipated customers that would be covered by the WiMAX portion of the access network. For a new operator the equipment for edge, core, and central office will be a sizable up-front investment. However, since the investment will be spread over tens of thousands of metro-area customers it will generally have a minor impact on the business case.

The wireless portion of the network begins at a fiber node with a WiMAX base station or a wireless point-to-point link to a remotely located WiMAX base station. This wireless

backhaul connection must have sufficient capacity to match the WiMAX base station capacity. This backhaul link can be a WiMAX-compliant point-to-point solution or another commercial off-the-shelf point-to-point radio. In addition to the WiMAX equipment the base station may also include additional hardware such as uninterruptible power supplies, electronics cabinets (in some cases climatized for outdoor locations), and possibly some additional equipment to interface with the backhaul link. Another major cost consideration for the base station is the civil works which includes antenna masts, conduits, cables, and the overall base station preparation required prior to the installation of the WiMAX point-to-multipoint equipment. This component of the base station CAPEX often has a considerable amount of labor content. In a typical metro area deployment the base station CAPEX will be shared over a customer base of a thousand or more subscribers thus having moderate impact on the business case.

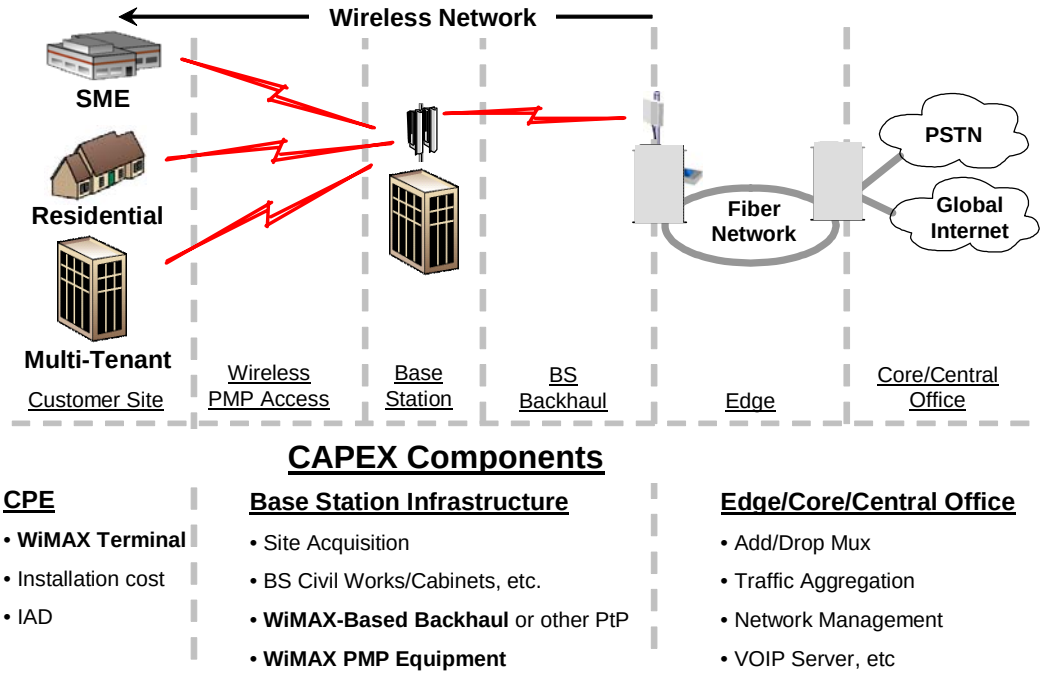


Figure 1: WiMAX in the End-to-End Network

WiMAX-compliant customer premise equipment (CPE) or terminals are expected to be available in a number of configurations for customer specific applications and for different types of customers. Residential terminals will generally be configured with Ethernet connections for data applications and a POTS connection for VOIP applications. Designs comprised of an operated-installed outdoor unit and a self-installable indoor terminal will enable links with greater range, whereas a lower cost, single package, self-

installable indoor unit will be available for customer sites located closer to the WiMAX base station. Households in multi-tenant buildings can be served by installing a high throughput WiMAX outdoor unit with a DSLAM as an in-building access device utilizing the in-building telephone wiring to reach individual apartments or by installing an individual WiMAX terminal in each household. High performance business terminals with greater throughput capability will typically be configured with T1 or E1 ports in addition to 10/100BaseT ports to meet the more stringent requirements of small and medium businesses.

The impact that the terminal CAPEX has on the business case greatly depends on how the operator chooses to treat this part of the investment. Some of the options are:

- Operator bears the full cost of terminals and installation. In return the operator may also require a 1 or 2 year service commitment.

- Operator offsets terminal costs by charging a one-time activation fee and/or an equipment rental fee.

- Operator requires or offers incentives to encourage customers to purchase their own terminals. Incentives may be in the form of an equipment rebate or reduced fees for services.

Depending on the option elected, the impact on the business case can be minor, moderate or major. Obviously the goal for equipment vendors and operators is for terminal prices to get low enough to enable the majority of customers to purchase and install their own terminal equipment. As we will see later however, the use of indoor terminals does have an impact on base station capacity which in turn impacts the base station CAPEX; another cost trade-off that must be taken into account.

Table 2 provides a summary of the CAPEX components and their relative impact on the business case.

CAPEX Items	Investment Type	Impact on the "Payback"
Edge/Core/Central Office	**One-Time:** An upfront investment to cover entire metro or multi-city areas	**Minor:** CAPEX is spread over 10s of thousands of customers. Typically <$10 per subscriber in heavily populated areas. Less for an incumbent

CAPEX Items	Investment Type	Impact on the "Payback"
Base Station Infrastructure (Includes WiMAX equipment, backhaul, civil works, etc.)	**Phased:** An on-going investment as network is built out. Operator can initially target areas with highest potential	**Moderate:** CAPEX is spread over 1,000 or more subscribers. Typically <$100 per subscriber at maximum BS capacity, can be considerably higher in low density rural areas.
CPE (or Terminal) (Includes IAD when applicable, installation when required – offset by activation fee)	**Phased:** Investment incurred when customer is actually signed up. Exception is MTU when deployed with in-building access device.	**Major:** When operator supplies all equipment with no rental charges **Moderate:** When CAPEX is offset by equipment rental fees. **Minor:** When majority of customers purchase their own equipment.

Table 2: Summary of CAPEX Items and Impact on the Business Case

Service and Revenue Assumptions for Business Case Analysis

Table 3 summarizes the service and revenue assumptions for the emerging markets business case analysis that follow in later sections. The assumed ARPUs reflect the prevailing economic conditions in these markets.

Service	Average Data Rate	Overbooking Factor	ARPU	Mix
Residential				
Internet Access	384 kbps	40 :1	$ 15.00	100%
VOIP	128 kbps	4 :1	$ 5.00	50%
Average Monthly Revenue (ARPU) for Residential Customers			$17.50	
One-Time Connection Fee for Residential Customers			$ 20.00	
Business				
Basic Service	512 kbps	4 :1	$ 75.00	90%
Premium Service	1 Mbps	4 :1	$100.00	10%
Average Monthly Revenue (ARPU) for Business Customers			$ 77.50	

Service	Average Data Rate	Overbooking Factor	ARPU	Mix
One-Time Connection Fee for Business Customers			$ 50.00	

Table 3: Service and Revenue Assumptions

To assess the relative impact of the two categories of capital investment that typically have the greatest impact on the business case, i.e. Base Station Infrastructure, and Customer Premise Equipment, it is instructive to look at the impact that each has on the payback period based on projected costs.

Customer Premise Equipment

A major focus for equipment vendors will be driving down the cost of the terminal equipment, particularly residential terminals. There appears to be consensus that $100 is a benchmark that must be reached and manufacturers are making headway towards meeting that goal. Current projections indicate that $100 can be achieved for self-installable indoor terminals by the end of 2007 and for outdoor terminals by the end of 2010. The following chart shows the expected average selling prices for various types of WiMAX terminals. The year to year price reductions are based on projected volume growth and the subsequent manufacturing efficiencies that follow. Another key enabler for subscriber terminal cost reduction will be the availability of low cost components and ASICs based on the IEEE 802.16 standard. Business terminals are also expected to drop in price but, due to lower anticipated volumes, not as aggressively as residential terminals. Price reductions for business terminals are expected to be approximately 10% per year.

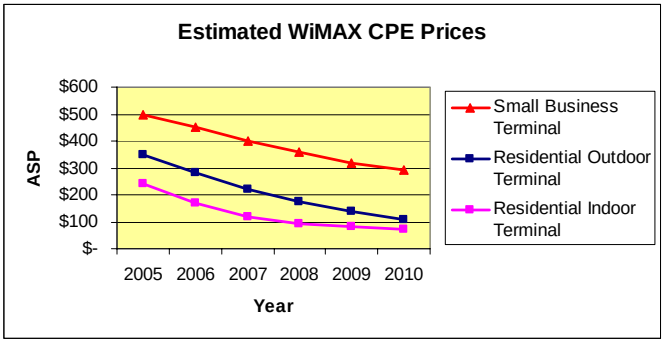


Figure 2: WiMAX CPE Price Projections

To gain a perspective on the impact of residential CPE costs on the business case it is of value to look at some of the potential deployment scenarios. The following table includes a few residential scenarios that are of interest. The equipment prices listed in the CPE column are estimated 2005 prices. The assumed price erosion for the 24-port DSLAM, being a more mature technology is assumed to be 5% per year while residential CPE prices follow the curve shown in figure 2. The net average CPE CAPEX per residential subscriber includes the applicable installation costs and is reduced by the nominal one-time hook-up fee that would be charged to the customer.

Scenario	Customer Premise Equipment (2005 Prices)	Install	Hook-Up Fee	Net Avg. CPE Cost/Sub
High density MTU with one DSLAM in-building access device per bldg	WiMax outdoor unit @ $500 24-Port DSLAM @ $2,200 + Customer purchased DSL modem @ $0/subscriber	$200 per Bldg	$20	Assuming 12 customers per MTU 2005: $205 2010: $150
One Outdoor CPE per HH	100% Outdoor CPE at $350	$50	$20	2005: $380 2010: $132
One Indoor CPE per HH	100% Indoor self-installable CPE at $240	$0	$20	2005: $220 2010: $60
One CPE per HH Mixed Outdoor & Indoor	35% Indoor self-installable CPE at $240, 65% Outdoor CPE at $350	$33 Avg.	$20	2005: $324 2010: $102
	64% Indoor self-installable CPE at $240 36% Outdoor CPE at $350	$18 Avg.	$20	2005: $278 2010: $81

Table 4: Residential CPE Deployment Scenarios

The graphs in figure 3 provide a view of the payback for the CPE portion of the investment for varied CPE costs, assuming the revenues listed in table 3 and an assumed operation expense (OPEX) of 50%. It is also evident from figure 3 that an operator strategy that targets both the business and the residential market segments will improve the business case insofar as the customer terminals are concerned. This will be the case as long as the average net cost of residential CPEs is above approximately $75; which will likely be the case for the next few years.

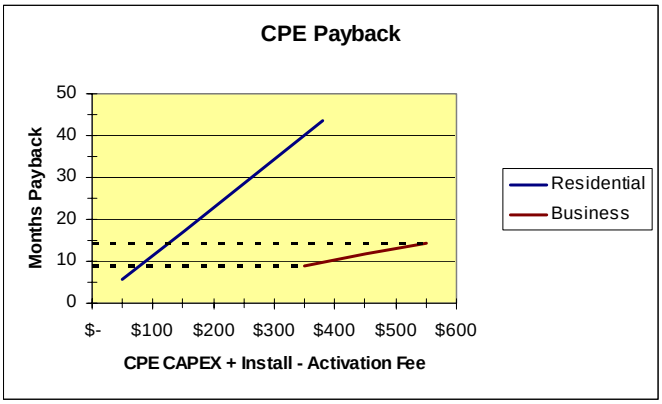


Figure 3: Payback for Net CPE Investment

Base Station Infrastructure

A summary of the base station infrastructure CAPEX items that will be used in the following business case examples are provided in table 5. The assumed "fixed" base station costs, which tend to be labor intensive, are lower than what would be typical in a developed economy due to the lower prevailing labor rates in emerging markets. The civil works for urban area deployments can also be expected to be somewhat more costly than suburban and rural area deployments due to the added complexities associated with base station installations on high rise buildings.

The WiMAX base station point-to-multi-point equipment will be available in varied configurations and prices from multiple vendors. The price per channel assumed in the table represents an average derived from discussions with different vendors. Although these prices are also expected to decline over time, they are assumed to be constant for the purposes of the business case examples that follow. The differences in the wireless backhaul costs reflect the price difference for a lower capacity link suited to a 3-channel base station configuration versus the higher capacity link required to match the capacity of a four or six channel base station.

Base Station Infrastructure Components	Assumed CAPEX
Site Acquisition, Civil Works, and Other Base Station Equipment	Assume: $50K/Base Station, Urban $35K/Base Station, Suburban
Wireless Point-to-Point Backhaul	Assume: $25K/Base Station, 4-6 Channels $15K/Base Station, 3 Channels
WiMAX Point-to-Multipoint Equipment	Variable Cost: $7K per Channel

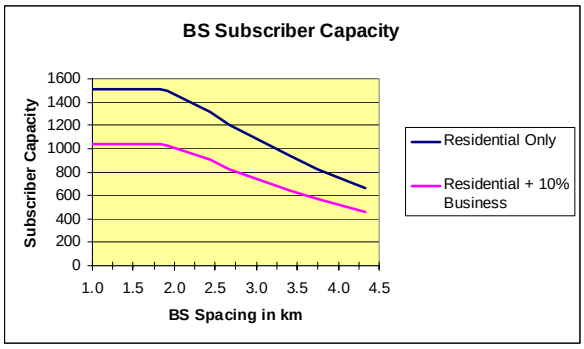
Total Base Station CAPEX Range
• 3-Channel BS = $50K to $65K + $21K = $71K to $86K (Rural or Suburban) • 4-Channel BS = $60K to $75K + $28K = $88K to $103K (Suburban or Urban) • 6-Channel BS = $75K + $42K = $117K (Urban)

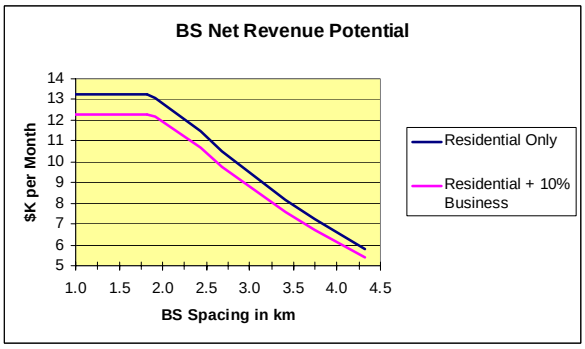
Table 5: Base Station Infrastructure Cost Assumptions

Since WiMAX-based systems use adaptive modulation the channel capacity in a multi-cellular network is dependent on the base station coverage area[1]. With greater coverage area a larger number of active subscribers will be operating at a more robust but less efficient modulation thus reducing the channel capacity and therefore, the channel's revenue potential. Assuming a uniform distribution of non-LOS subscribers, the downlink base station subscriber capacity for a 4-channel configuration, is shown in the graph in figure 4. The base station revenue potential is also shown in figure 4 for a residential-only and a residential plus business market segment. As stated earlier, the net revenue assumes an OPEX of 50%. The graphs suggest that a residential-only market segment would result in a somewhat better business case from the base station infrastructure point of view but these graphs do not convey the complete picture. It is also necessary to consider the demographics and estimate the market penetration required to support closely spaced WiMAX base stations and maximize base station revenue. This is depicted in figure 5 for a high density urban area typical of what would be encountered in an emerging market. Choosing to address both the residential and business market segments is the more conservative strategy in that it takes only 3.6% market penetration to maximize the base station revenue potential as opposed to 5.3% if one were to address only the residential market. Other benefits in addressing both market segments is the improved payback for terminals (see figure 3) and the potentially lower churn and bad debts with the business market as compared to the residential market.

Figure 5 also shows the base station infrastructure CAPEX per subscriber for the two market segments and varied market penetrations. This number along with the expected net monthly revenue provides a view of the payback for the base station infrastructure portion of the overall investment.

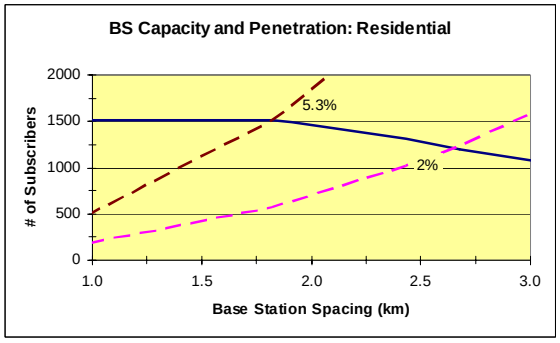
[1] For a more complete discussion of the trade-offs between range and channel capacity see WiMAX White Paper, "WiMAX Deployment Considerations for Fixed Wireless Access in the 2.5 GHz and 3.5 GHz Licensed Bands", May, 2005.

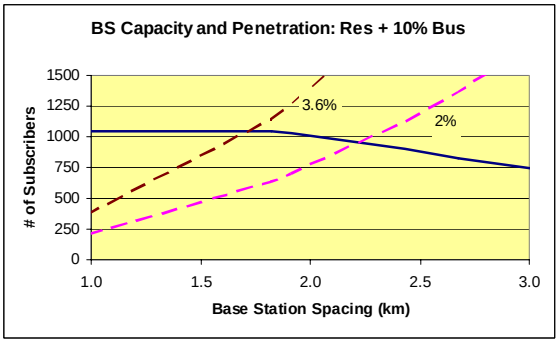




- 4–Channel Base Station
- 3.5 GHz FDD
- 3.5 MHz Channel BW
- 100% Non Line-of-Sight
- 100% Outdoor CPEs
- Uniform Customer Distribution
- Residential ARPU = $17.50/mo
- Business ARPU = $77.50/mo

Figure 4: Urban Area Base Station Capacity





Residential Only Market Segment

- 10,000 HH/sq-km
- 5.3% Market penetration required to maximize BS capacity
- BS CAPEX = $68/Subsciber
- BS CAPEX = $82/Subscriber at 2% penetration
- Net Revenue = $8.75/Subscriber

Residential + Business Segment

- 1,000 Businesses/sq-km
- 3.6% Market penetration required to maximize BS capacity
- BS CAPEX = $99/Subscriber
- BS CAPEX = $101/Subscriber at 2% penetration
- Net Revenue = $11.75/Subscriber

Figure 5: Urban Demographics

For the residential market segment, there will always be a strong motivation to maximize the use of lower cost self-installable indoor CPEs. This not only reduces the cost to the

operator but also provides a more affordable terminal for customers desiring to choose and purchase their own equipment. Indoor CPEs however, have a lower system gain thus impacting the base station range and/or channel capacity. This is illustrated in the graphs in figure 6. The left hand graph compares the base station downlink channel capacity for an all outdoor CPE deployment compared to a deployment with mixed indoor and outdoor CPEs. The range would have to be limited to less than 0.4 km to maximize channel capacity as well as support 100% indoor CPEs. This however, would require unrealistically high numbers for household density and market penetration. At path length "a" (~0.85 km) the channel supports 100% indoor CPEs but with a significantly reduced channel capacity. Between path length "b", which supports 64% indoor CPEs and path length "c", which supports 39% indoor CPEs, the base station capacity can be regained by increasing the number of channels from four to six. This comparison is shown in the right-hand graph in figure 6. Deploying within this range of path lengths (between "b" and "c") will generally turn out to be a cost-effective compromise between maximizing base station revenue and maximizing the number of indoor CPEs[2].

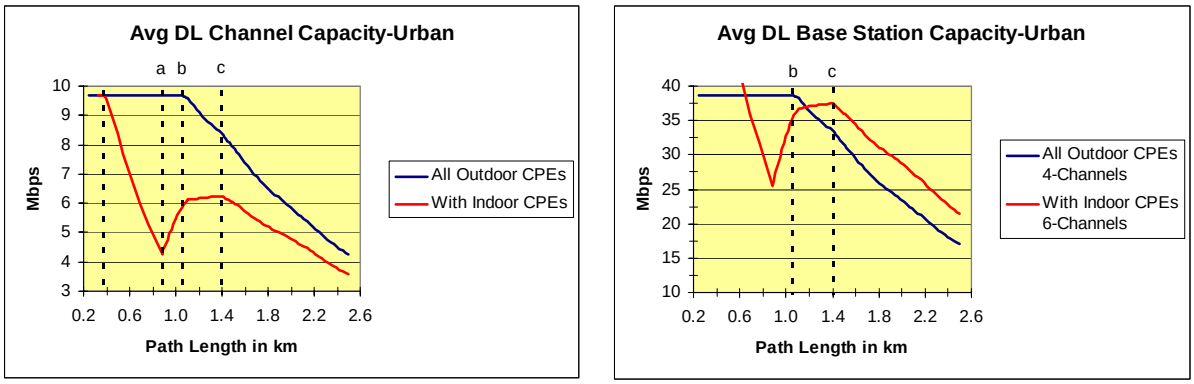
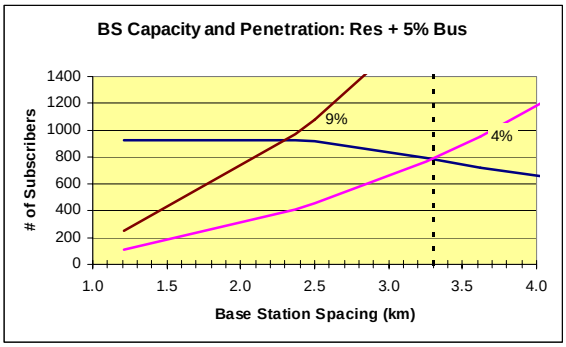


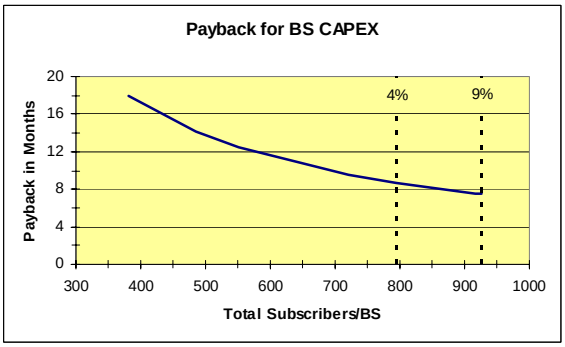
Figure 6: Deploying with Indoor CPEs

The base station range will generally be greater in suburban and rural areas due to the more favorable terrain and propagation characteristics. This along with the lower household and business densities encountered in these areas requires a higher market penetration to achieve the maximum base station capacity. The left-hand graph in figure 7 depicts this for a suburban environment with a household density of 2,000 households per sq-km and a business density of 100 businesses per sq-km. The second graph in figure 7 provides some insight as to the sensitivity of the payback for the base station infrastructure portion of the CAPEX. Assuming a more conservative market penetration

[2] For a more complete discussion of this topic see WiMAX White Paper "Deployment Considerations and Cost Trade-offs with Indoor Self-Installable CPEs", June, 2005

of 4% adds approximately 1.5 months to the payback for the base station infrastructure portion of the CAPEX.





Residential + Business Market Segment

- 3-Channel Base Station
- 2,000 HH/sq-km
- 100 Businesses/sq-km
- 4% is a conservative market penetration

Payback for BS CAPEX

- BS CAPEX = $90/Subscriber at 4% penetration
- BS CAPEX = $76/Subscriber at maximum capacity
- Net Revenue = $10.25/Subscriber

Figure 7: Suburban Area BS Capacity and Demographics

Urban Business Case

For the urban area business with residential households predominantly located in high-rise buildings, two scenarios are considered. Urban Scenario 1 makes use of a broadband WiMAX outdoor unit with a 24-port DSLAM as an in-building access device to reach individual households via existing in-building telephone lines. For this scenario it is assumed that the subscribers purchase their own DSL modems to provide an Ethernet connection for data access and an RJ-11, or equivalent, connection for POTS. Although the DSLAM has a 24 port capacity it is assumed for the business case that there is an average of only 12 customers per building. The deployment for Urban Scenario 2 is comprised of both indoor self-installable residential CPEs and residential outdoor CPEs. The base station for this scenario is configured with 6 channels rather than 4 channels to achieve a comparable base station capacity at the same base station spacing (see figure 6). Both scenarios therefore, require 48 base stations to cover a geographical area of 136 sq-km and in scenario 2, 64% of the residential CPEs can be deployed with self-installable indoor units. Table 6 provides a more complete summary of the assumptions for the urban business case.

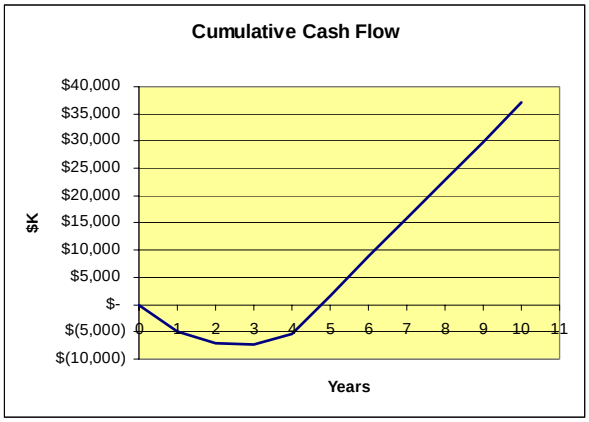
Assumptions for Urban Business Cases	
Market Segment	Residential + Business
Household Density	10,000 HH per sq-km with households located in high-rise, multi-tenant buildings
Business Density	1,000 Businesses per sq-km
Expected Market Penetration	~3.5%
Coverage Area	136 sq-km
Base Stations	48 WiMAX base Stations with an average spacing of 1.8 km
Network Build-Out	4 Years (12 base stations per year)
Edge, Core & Central Office	$1,000K
Business CPEs	2005 Price at $500, 10% per year price erosion
Urban Scenario 1: Shared CPE/IAD at MTU Site	
Base Station	4-Channel base station at $103K (WiMAX equipment = $28K, Backhaul = $25K, Civil works, etc. = $50K)
CPE Outdoor Unit	2005 Price at $500, 10% per year price erosion
In-Building Access Device	24-Port DSLAM at 2005 Price of $2,000, 5% per year erosion
CPE Installation	$200 per building
Customers per building	12
Customer supplies own DSL modem	
Urban Scenario 2: One CPE per Household, Mixed Indoor and Outdoor CPEs	
Base Station	6-Channel base station at $117K (WiMAX equipment = $42K, Backhaul = $25K, Civil works, etc. = $50K)
Operator-installed Outdoor CPE	2005 price at $350, ~20% per year price erosion, ~36% of households
Self-installable Indoor CPE	2005 price at $240, ~30% per year price erosion thru 2008 ~64% of households

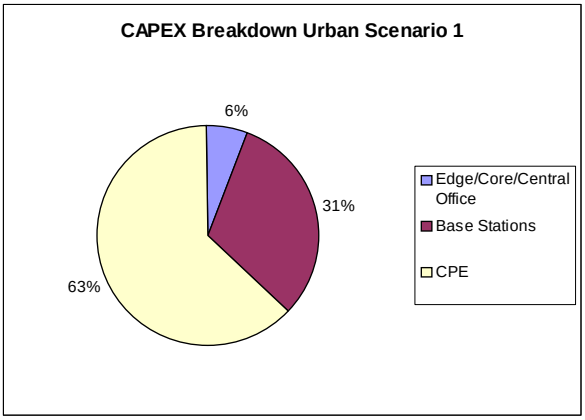
Table 6: Assumptions for Urban Business Case

Figures 8 and 9 provide a summary of the two urban scenarios. In scenario 2, the higher base station cost due to the two added channels is more than off-set by the lower CPE costs driven by the use of self-installable indoor CPEs. This results in approximately one year shorter payback for scenario 2 as compared to urban scenario 1. If the number of customers per building were increased from 12 to 24 for the DSLAM solution, the payback would be comparable for both scenarios.

The CAPEX contribution of the $1,000K investment assumed for the edge, core and central office is approximately $20 per subscriber as measured at the end of the fourth year. Even though this represents a large up-front investment its overall impact on the business case is relatively minor.

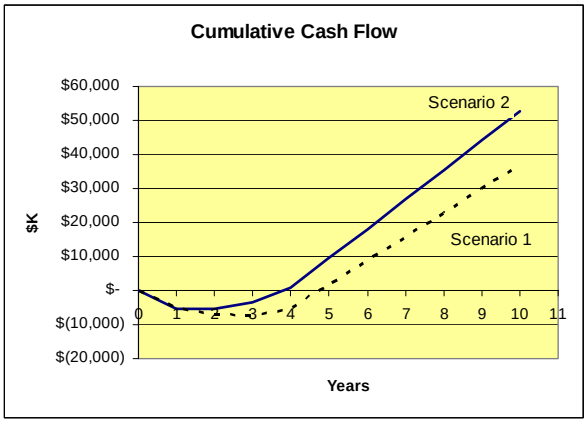
In both urban scenarios, the network build-out is assumed to take place over a four year period with each base station getting to full capacity within a year and no further customer growth after the fourth year. To handle growth beyond this point would require that additional base station channels, at a cost of $7K per channel, be deployed to increase base station capacity. These channels do not need to be added uniformly to all base stations but can be added as needed in those sub-regions where further market growth is anticipated. From a business case perspective the investment for these capacity additions can be analyzed on a case by case basis.

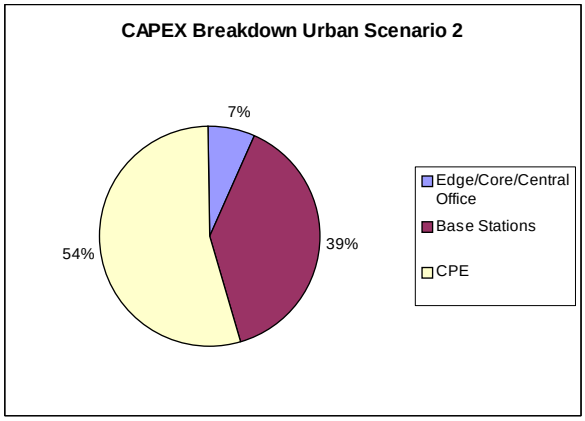




Year	1	2	3	4	5
Residential Subscribers at Yr End	11,268	22,536	33,804	45,072	45,072
Business Subscribers at Yr End	1,260	2,520	3,780	5,040	5,040
Total Subscribers at Yr End	**12,528**	**25,056**	**37,584**	**50,112**	**50,112**
Base Stations at Yr End	12	24	36	48	48
CAPEX per year in $M	$ 5.0	$ 3.8	$ 3.7	$ 3.5	$ -
Annual Cash Flow in $M	**$ (5.0)**	**$ (2.1)**	**$ (0.1)**	**$ 1.8**	**$ 7.1**

Figure 8: Summary for Urban Scenario 1





Year	1	2	3	4	5
Residential Subscribers at Yr End	10,692	21,384	32,076	42,768	42,768
Business Subscribers at Yr End	1,200	2,400	3,600	4,800	4,800
Total Subscribers at Yr End	**11,892**	**23,784**	**35,676**	**47,568**	**47,568**
Base Stations at Yr End	12	24	36	48	48
CAPEX per year in $M	$ 5.2	$ 3.6	$ 3.1	$ 2.7	$ -
Annual Cash Flow in $M	**$ (5.2)**	**$ (0.2)**	**$ 2.0**	**$ 4.2**	**$ 8.7**

Figure 9: Summary for Urban Scenario 2

Suburban Business Case

The assumptions for the suburban business case are summarized in table 7. Both suburban scenarios assume all-outdoor residential CPEs, but in Suburban Scenario 1 the CPEs are all provided by the operator whereas in scenario 2, it is assumed that 50% of the residential CPEs are purchased by the end-customer in exchange for a 20% reduction in service fees. To meet the base station capacity requirements for an expected market penetration of 4% over a 212 sq-km area requires 36 WiMAX base stations. The business case assumes these are deployed over a three period.

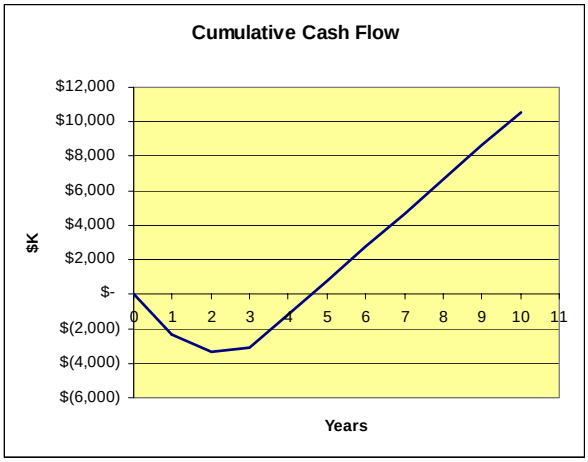
The edge, core, and central office investment in this case is assumed to be $300K, primarily to add core capacity and to extend an existing metro-area network.

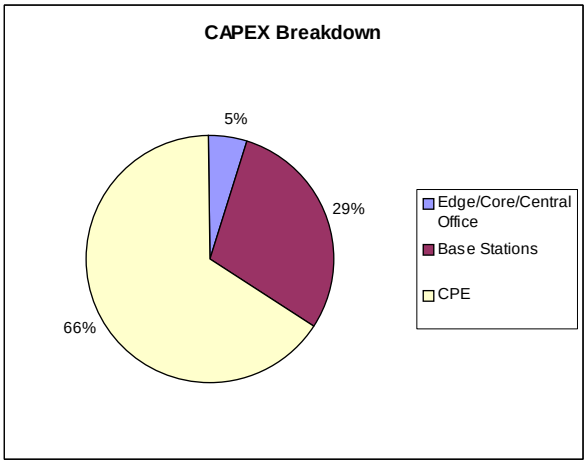
Assumptions for Suburban Business Cases	
Market Segment	Residential + Business
Household Density	2,000 HH per sq-km
Business Density	100 Businesses per sq-km
Expected Market Penetration	~4%

Assumptions for Suburban Business Cases	
Coverage Area	212 sq-km
Base Stations	24 WiMAX base stations at an average spacing of 3.2 km
Network Build-Out	3 Years (12 base stations per year)
Edge/Core, Central Office	$300K to extend metro-area network and add capacity
Base Station	3-Channel base station at $71K (WiMAX equipment = $21K, Backhaul = $15K, Civil works, etc. = $35K)
Business CPEs	2005 Price at $500, ~10% per year price erosion
Outdoor Residential CPEs	2005 price at $350, ~20% per year price erosion
Suburban Scenario 1:	
Operator supplies 100% of the CPEs (would also require 1 or 2 year service contract)	
Suburban Scenario 2:	
50% of Residential CPEs are purchased by customers in exchange for 20% reduction in monthly rate, i.e. $12/month for Internet access, $4/month for VOIP and waiver of long term service contract.	

Table 7: Assumptions for Suburban Business Case

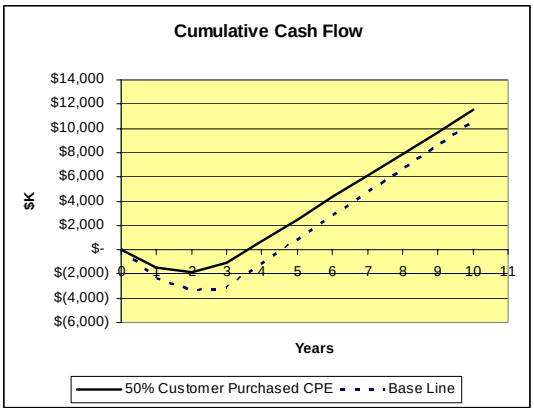
The results for the two suburban scenarios are summarized in figures 10 and 11. Providing a 20% service rate reduction as an incentive to encourage customers to purchase their own equipment improves the payback by almost a year. Both suburban scenarios result in positive cash flow in the third year.

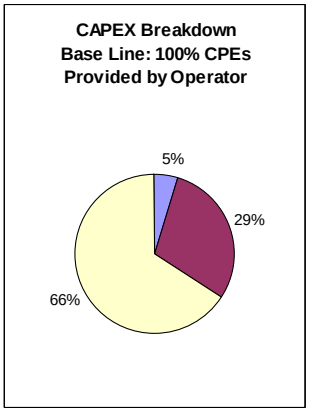


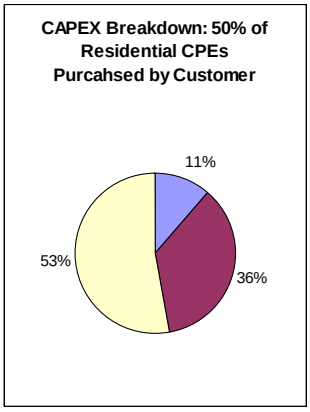


Year	1	2	3	4	5
Residential Subscribers at Yr End	6,032	12,064	18,096	18,096	18,096
Business Subscribers at Yr End	320	640	960	960	960
Total Subscribers at Yr End	**6,352**	**12,704**	**19,056**	**19,056**	**19,056**
Base Stations at Yr End	8	16	24	24	24
CAPEX per year in $M	$ 2.3	$ 1.8	$ 1.8	$ -	$ -
Annual Cash Flow in $M	**$ (2.3)**	**$ (1.0)**	**$ 0.2**	**$ 2.0**	**$ 2.0**

Figure 10: Summary for Suburban Scenario 1







Year	1	2	3	4	5
Residential Subscribers at Yr End	6,032	12,064	18,096	18,096	18,096
Business Subscribers at Yr End	320	640	960	960	960
Total Subscribers at Yr End	**6,352**	**12,704**	**19,056**	**19,056**	**19,056**
Base Stations at Yr End	8	16	24	24	24
CAPEX per year in $M	$ 1.5	$ 1.1	$ 1.1	$ -	$ -
Annual Cash Flow in $M	**$ (1.5)**	**$ (0.3)**	**$ 0.7**	**$ 1.8**	**$ 1.8**

Figure 11: Summary for Suburban Scenario 2

Rural Business Case

Rural areas in emerging markets are typically the most underserved. On the other hand these areas would also have lower average income levels and lower penetration of home computers thus reducing the size of the addressable market for broadband services. There are also fewer businesses in these areas. In this example, a residential-only market segment is assumed and it is also assumed that the operator requires the residential end-customers to purchase their own CPEs. This, in addition to reducing the initial investment for the operator can also help reduce churn since the customer has also made a significant upfront investment. The operator may also choose to offer a rebate in the initial promotion of the service as an added incentive to help offset the higher initial CPE costs. Offering a rebate should also result in a more rapid customer adoption thus helping to offset the cost of the rebate.

In this case a single base station can be deployed to cover the rural area of 50 sq-km. A base station with three 120-degree sectors will have sufficient capacity to support the expected market penetration and with 500 eventual customers the base station CAPEX will be $142 per subscriber. For this example it is also assumed that the rurally located base station can be backhauled to an existing core network by means of a single long-haul point-to-point microwave link at a cost of $15K and that no further investment in edge, core or central office equipment is necessary. A more complete summary of the assumptions for the rural business case are provided in table 8.

Assumptions for Rural Business Cases	
Market Segment	Residential Only
Household Density	300 HH per sq-km
Coverage Area	50 sq-km
Base Stations	One WiMAX base station covers ~70 sq-km
Market Penetration and Adoption Rate	2 Years for early adopters growing to 3.3% penetration in 10 years
Edge, Core, Central Office	$ 0K
Base Station	3-Channel base station at $71K (WiMAX equipment = $21K, Backhaul = $15K, Civil works, etc. = $35K)
Residential CPEs (indoor or outdoor)	Operator requires that CPE be purchased by the end-customer
Rural Scenario 1	Operator offers no CPE rebate 300 Customers in 2 Years
Rural Scenario 2	Operator offers $50 CPE rebate over first 2 years 350 Customers in 2 Years

Assumptions for Rural Business Cases	
Rural Scenario 3	Operator offers $100 CPE rebate over first 2 years 400 Customers in 2 years

Table 8: Business Case for Rural Environment

Figure 12 shows the downlink base station capacity for a 3-channel configuration for both a deployment with all outdoor CPEs and one with mixed outdoor and indoor CPEs for the terrain typically encountered in a rural environment. Over the desired coverage area of 50 sq-km, 10% of the CPEs that are deployed can be of the indoor type with a reduction in channel capacity of about 8%. In either case however the 3-channel base station capacity is sufficient to support the 500 anticipated residential customers.

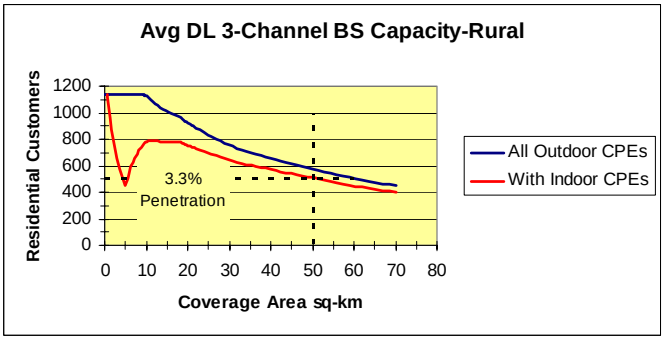


Figure 12: Downlink Capacity for 3-Channel Base Station

The resulting cash flows for the three rural scenarios are summarized in figure 13. For the assumptions made in table 8, the use of a rebate to accelerate the adoption rate does improve the payback.

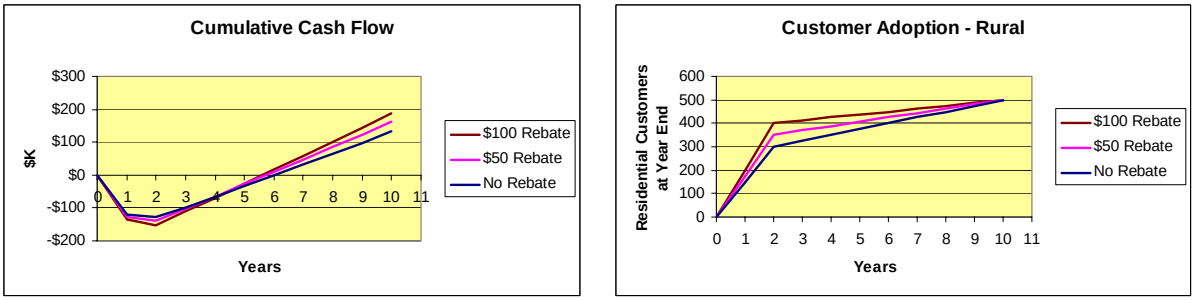


Figure 13: Rural Business Case

Summary and Conclusions

For the purposes of illustrating various deployment options in this paper the business cases for urban, suburban and rural environments were treated as separate standalone scenarios with the exception of the edge, core, and central office investment. In practice a logical WiMAX network build-out would begin with deployment in the high density urban centers and over time, be extended to provide coverage in neighboring suburban and rural areas. The higher density urban and suburban areas can be deployed with base stations operating at or near optimal capacity with modest market penetrations. In low density rural areas the base station infrastructure plays a more significant role with deployments that are more nearly range-limited rather than capacity-limited and with few businesses in these areas, there is a greater dependence on residential revenues. Over time, with WiMAX residential CPEs getting more and more affordable, it is not unreasonable to expect a growing number of residential customers in emerging markets to purchase their own terminals in order to get broadband services thus providing an ever-improving business case for the WiMAX operator.

In addition to providing some alternative business case scenarios this paper was also intended to provide some insights as to how the base station capacity and hence its revenue potential relates to customer type and terminal type. In any deployment it is necessary that the operator understand these relationships so as to make informed decisions as to how to size and deploy base stations and maximize the investment return. The reader is referred to other WiMAX white papers for a more detailed general discussion of these topics.

Clearly WiMAX can be a key enabler for operators desiring to pursue the enormous business opportunities that exist in emerging markets. The availability of spectrum with the support of regulators to facilitate the licensing process coupled with the pent-up customer demand for broadband services offsets some of the other challenges that exist in these markets. Using a wireless solution based on WiMAX will give the operator the necessary tools to implement a cost-effective solution with a winning business case with ARPUs consistent with the prevailing economic conditions.