Economic Feasibility Study of a Mobile WiMAX Rollout in Belgium: Sensitivity Analysis and Real Options Thinking

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Abstract

To enhance mobility in the access network, Mobile WiMAX may offer an appropriate alternative for the current DSL and HFC networks. A key question that needs to be answered is whether the rollout of a WiMAX network is economic feasible. This paper elaborates an extensive business model for the introduction of Mobile WiMAX which is then applied for a rollout in Belgium. A static NPV analysis is performed and several scenarios are compared with each other. As the introduction of such a new technology involves a lot of uncertainties, it is of great importance to determine the most influencing parameters by executing a thorough sensitivity analysis. Such an analysis will also give a good indication of the chance to have a positive business case. Finally, with the aid of real options thinking, it becomes possible to value the capability to anticipate on changing market circumstances.

Introduction

When considering the booming markets of broadband connectivity and mobile phone usage, it may be clear that there exists a great potential for wireless broadband services. In this respect, a promising technology is WiMAX (based on the IEEE 802.16 standards). Today, two important WiMAX profiles are defined: a Fixed and Mobile version, using respectively the IEEE 802.16-2004 and the IEEE 802.16e-2005 standard. It is expected that mainly Mobile WiMAX will be used in the coming years, since it combines the possibilities of Fixed WiMAX with mobility. On the Belgian market, it could be a competitive technology next to UMTS/HSDPA and WiFi. Currently, in Belgium, only some pre-WiMAX networks are being deployed in a few large cities and the coastal area by Clearwire Belgium and Mac Telecom.

Mobile WiMAX typically uses a cellular approach, comparable to the exploitation of a GSM network. Throughout the covered area, several cell sites or base stations have to be installed by the operator. The installation of WiMAX base stations and especially the pylons is a determining cost factor in a WiMAX deployment. It is very important to properly dimension the network by calculating the required number of base stations and their optimal placing. For these purposes, we have developed an accurate planning tool which incorporates the desired services, user density, surface area, terrain specifications, carrier frequency and channel bandwidth, hardware profiles, etc. This model, together with the main technical aspects of the Mobile WiMAX technology, is extensively presented in [1].

In [1], we introduced some attractive business scenarios for Mobile WiMAX. These scenarios were evaluated by using a net present value (NPV) and free cash flow analysis. To further investigate the potential of Mobile WiMAX, a complete business model has been worked out in section 2 of this paper. The basic model from [1] is extended with enhanced adoption models, new rollout schemes, more accurate technical parameters and updated cost figures. Section 3 presents the most important results by applying the model on some well-chosen Belgian cases and performing a static NPV and free cash flow analysis. In section 4, a thorough sensitivity analysis on the most uncertain parameters is performed. To complete the study, section 5 introduces some principles from real options thinking to indicate the most convenient planning solution for one specific rollout area.

Business Model

A generic business model has been developed for the introduction of Mobile WiMAX, and is then applied for a rollout of Mobile WiMAX in Belgium. The considered time period is 2007 till 2016, but the results can easily be projected to any other time period. Note that Belgium counts 10,511,382 inhabitants on a 32,545 km² territory [2]

A. Rollout Scenarios

Three different rollout scenarios were studied in [1], ranging from a limited rollout in the ten most important Belgian cities during two years (*Urban*) and an extension to the Belgian coast in the same time period (*Extended Urban*) to a nationwide rollout performed in only three years (*Nationwide*). After a profound update of some technical parameters however, we have to conclude that the mentioned nationwide scenario from [1] is not anymore economic feasible. With a cell diameter of maximum 2 to 2.5 km, a complete nationwide rollout involves too high investments to cover the rural areas. In this way, the nationwide scenario is reduced to a nationwide urban rollout, which corresponds to all areas with minimum 1000 inhabitants/km^2. In the evaluation, we will consider three rollout speeds for the nationwide urban scenario (fast in three years, moderate in five years and slow in eight years). Together with the urban and extended urban scenario from [1], in total five scenarios are evaluated (Table 1). The urban and extended urban scenarios coincide with the first two years of respectively the 5-year and 3-year nationwide urban scenario.

It is supposed that the nationwide scenarios are following a gradual scheme, starting in the largest cities and moving on to the less populated ones. To illustrate this,

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Figure 1 shows a complete rollout scheme for the 8-year nationwide urban scenario. It is clearly noticeable that the percentage of covered households (final value of 35.5%) increases much faster than the covered areas (final value of 7.5%). Figure 1 also depicts the required number of cell sites, which is the outcome of our planning tool.

Table 1: Five different rollout scenarios.

Scenario	Area (% covered)	Population (% covered)	Rollout period
Urban	4.2%	24.6%	2 years
Extended Urban	5.3%	26.6%	2 years
Nationwide 3Y	7.5%	35.5%	3 years
Nationwide 5Y			5 years
Nationwide 8Y			8 years

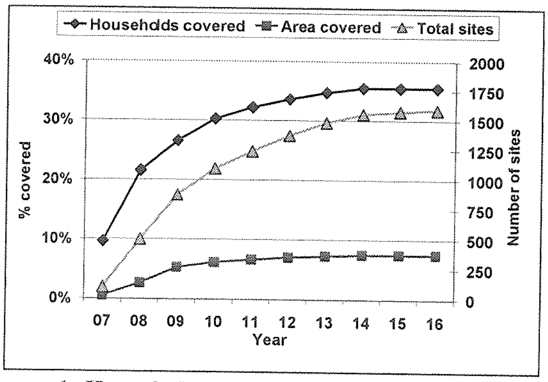

Figure 1: Households and area covered, related to the number of cell sites (8-year nationwide urban rollout).

B. Offered Services

The proposed business scenarios in [1] contain four different service packs for offering Mobile WiMAX: *Stand alone wireless broadband* (WiMAX used as broadband connection, instead of HFC or DSL), *Second residence pack* (mainly intended for users that need a second connection, but with limited capacity and no extra features), *Nomadicity pack* (a light version of the previous product, comparable with the current subscriptions to a hotspot) and *Prepaid pack* (a prepaid card grants the user a limited number of hours for using the WiMAX network). The stand alone wireless broadband and second residence service offer a bandwidth of 3 Mbps downstream and 256 kbps upstream, and the other two services have a bandwidth of 512 kbps downstream and 128 kbps upstream. As there is a high differentiation in the four described services, this paper will focus on a business scenario where the operator offers the four service packs to its customers.

C. Market Forecast

The most crucial part in the model is associated with the market forecast - residential as well as business users are considered. For predicting the number of residential customers, the analysis starts from the total number of Belgian households. Taking into account the number of broadband connections, a forecast can be made for the targeted number of customers. Business customers are also interested in these services, especially the nomadicity pack and second residence pack for offering mobile subscriptions to their employees.

A market forecast based on the Gompertz model is made for the service take-up. According to [3], this model is well suited for the forecasting of broadband penetration, and it was also used in [4]. The model is determined by three adoption parameters that have to be predicted: the saturation point *C* (i.e. maximum adoption percentage), the inflection point *a* (i.e. year between a progressive and degressive increase) and the take rate b (i.e. indication of the slope of the maximum increase). Separate adoption parameters are defined for the different services and the different user groups (residential and business users). Note that the curve for stand alone wireless broadband will somewhat differ from the Gompertz curve, since we assume a decrease in the take rate after some years, due to the fact that the foreseen bandwidth will not be sufficient enough as primary broadband connection when triple play services will be offered. Besides, for the areas that are not covered with WiMAX from year one, the Gompertz curve will be shifted in time so that it starts from the introduction year in that area. However, this time shift will be a little smaller (maximum one and a half years smaller) than the difference in rollout time so that a faster adoption will be modelled in the areas that are later covered. This can be motivated by the fact that the WiMAX service will already be better known in the rest of the country after some years.

In comparison with [1], we have adapted a few adoption percentages that were somewhat overestimated. Especially the figures for the business users are reduced, which has its impact on the total adoption of the nomadicity and the second residence pack. On the other hand, for prepaid cards, we have slightly increased the usage in the first years (by changing the a and b parameters from the Gompertz model), on the assumption that the barrier to buy a prepaid card is much lower than the barrier to take a monthly subscription. By combining these considerations, we obtain e.g. Figure 2 for the 3-year nationwide rollout (residential and business users are merged). This is thus an updated version of the curve presented in [1].

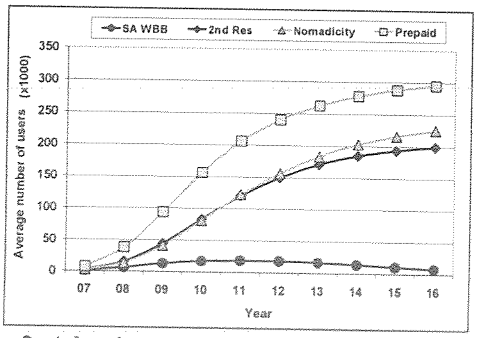

Figure 2: Adoption curves (3-year nationwide rollout).

D. Costs

Capital Expenditures (CapEx) are the long term costs which can be depreciated. They contain the rollout costs of the new WiMAX network, which is dimensioned by using our developed planning tool. After ten years, the number of needed base stations varies from respectively 1000 and 1200 for the urban and extended urban rollout to 1600 for the nationwide urban rollouts. A site sharing of 90% is assumed in urban areas (in less populated areas this would be lower), as regulation declares that pylons for e.g. GSM or UMTS must be shared between operators. For the remaining 10%, new sites will be built, equipped with a pylon and a WiMAX base station. Owned pylons can also be let to other operators, which will result in revenues for the operator. The equipment cost per base station contains the WiMAX main unit & sector units, as well as backhaul costs for connecting to the backhaul network. In addition, an investment must take place in central infrastructure (core equipment) such as WiMAX Access Controllers, routers or network operation centre infrastructure. The equipment will be renewed every five years (economic and technical lifetime) and the sites will be depreciated over 20 years.

Operational Expenditures (OpEx) contain the yearly recurring costs. Mostly, they are underestimated and determine in a large extend the total costs of networks. A thorough analysis is essential as all important factors must be taken into account. A model that can be used for this analysis is described in [5]. The most important network OpEx are the WiMAX spectrum license, operations & planning (depends on the growth of the network), maintenance, costs made for owning and leasing the sites and backhaul traffic costs. OpEx specifically related to the service contains marketing costs (making the users familiar with the service), sales & billing and a helpdesk.

E. Revenues

Starting from the forecasted number of users, we can calculate the total revenues per service. Assumptions have been made about the tariffs of the different services and are summarized in Table 2. Nomadicity and second residence service are vouching for 80% of the overall revenues, while the other two services are relatively less important. Note that price erosion has also been taken into account as we assume that the tariffs will lower in the future due to competition.

Table 2: Overview of the tariffs per service.

Service pack	Tariff (incl. VAT)
Nomadicity	13 €/month
Second residence	23 €/month
Prepaid	9 €/3-hour card
Stand alone wireless broadband	40 €/month

Static Analysis

Based on the input parameters, together with the costs and revenues from the previous sections, the five rollout scenarios from Table 1 are extensively compared to each other. Figure 3 shows the results of the cash flow analysis for the three rollout scenarios that are most different from each other. In the first three to four years, costs for rolling out WiMAX base stations will generally dominate the result as revenues cannot compensate the investments. After this period some extra investments are still required to satisfy the user needs or to cover the rest of the nationwide cities in the 8-year rollout. However, from now on, the number of users has increased to create enough revenues to cover this.

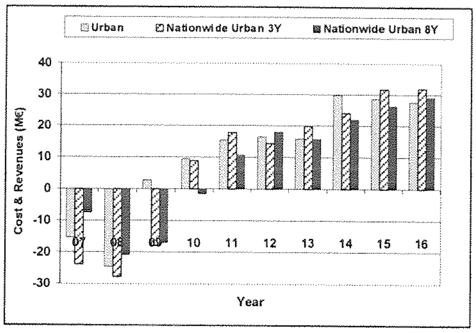

Figure 3: Cash flow analysis.

Figure 3 indicates some differences between a fast 3-year rollout and a more gradual 8-year rollout. The former requires very high investments in the first years, which involve a high financial risk for the operator. From year 4 the costs are more and more related to the increasing customer base: on the one hand OpEx which will more and more determine the total costs and at the other hand new investments to meet the needs of the customers. Also renewing of equipment is important from year 6, which reflects in a small decrease of the cash flows in year 6 and 7. As can be seen in Figure 3, the 3-year nationwide rollout clearly generates a positive cash flow from year 4. The same is valid for the urban rollout, and since the covered area will not be further extended after year 2, the costs and revenues are already balanced in year 3. Concerning the 8-year nationwide rollout, during the first two years, its cash flows are less negative than the other scenarios. So, the yearly investments and related risks are much smaller than in case of the fast rollout. However, it now takes a year longer to generate a positive cash flow.

Next to the above free cash flow analysis, a net present value (NPV) analysis is more suited to assess the financial feasibility of long-term projects. Figure 4 shows the results of the NPV analysis for the five proposed rollout scenarios (discount rate is set at 15%). As could be expected from the free cash flow analysis, the NPV reaches its minimum in year 3 or 4, with the lowest NPV at that time (-61.7 M€) for the 3-year nationwide urban rollout scenario. This again confirms the large financial risk for such a rollout. After approximately eight years, the NPV of both urban scenarios becomes positive, while the three nationwide scenarios do not show a positive NPV before year 10 (i.e. a discounted payback period of respectively eight and ten years). Note that the high investments in the 3-year nationwide rollout are still noticeable in the NPV results after ten years. So, from the NPV analysis, we could conclude that a slow or moderate rollout speed is more suitable than a fast rollout and that the high investment costs to cover the less populated cities are not yet compensated after ten years.

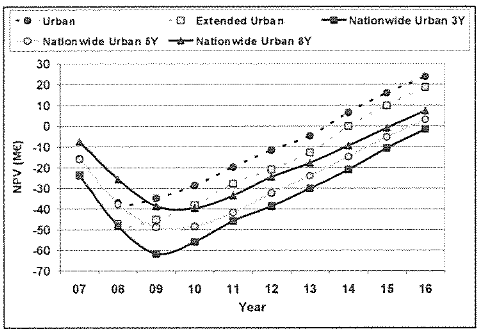

Figure 4: NPV analysis (discount rate = 15%).

Although the NPV analysis clearly shows that the best strategy for an operator consists of a (slow) rollout limited to the big cities, in some cases, an operator might decide to extend its target area. The main reason to move to a nationwide urban rollout is to create a higher customer base. As can be derived from the cash flow analysis (Figure 3), the cash flow in year 10 is higher for the nationwide rollouts than for the urban scenario, which will involve that the NPV will rise faster in the years afterwards (on the assumption that the network is still sufficient for the user needs in this year or can be upgraded with limited extra investments). An analogous reasoning is valid for the difference between the 3-year and 8-year rollout. Furthermore, it could even be possible that a faster rollout will lead to a higher adoption, while a slower rollout has the opposite effect. An example is given in Figure 5, where a slightly adapted adoption results in an equal NPV after 10 years for the nationwide scenarios. So, a static NPV analysis shows some important shortcomings to take a well-considered decision about the most appropriate rollout choice. This proves the need for additional tools as a sensitivity analysis and real options thinking, used in the next sections.

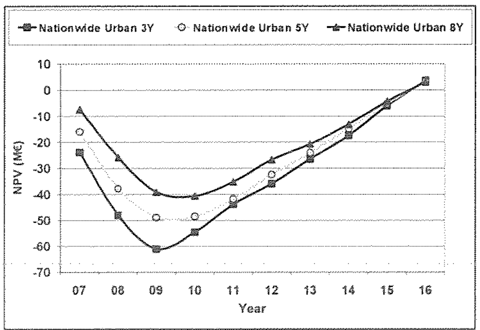

Figure 5: NPV analysis for a slightly adapted adoption.

Sensitivity Analysis

We have set several parameters in our model for which we are uncertain whether the values are realistic or not. Adoption parameters, CapEx and OpEx costs and the service tariffs are the most important ones. Therefore, we have performed a sensitivity analysis in which we let fluctuate the respective parameter values around an average value, according to a well-defined distribution (Gaussian, Uniform or Triangular). The sensitivity analysis is done by Monte Carlo simulation, by using Crystal Ball [6]. For each rollout scenario, 100,000 trials with varying parameters were performed to get a realistic view of the uncertain outcome. The influence size of the different parameters (grouped in five main categories) is shown in Figure 6 for three scenarios. The results are compared to each other on the ground of the NPV after five and ten years.

The parameters related with the market forecast are definitely the most uncertain ones in the business model. Two parameter sets are considered, corresponding to the Gompertz model: a maximum adoption percentage (related to the parameter C) and an indication of the adoption speed (related to the parameters a and b, which are supposed to be correlated with each other). A first trend is that the adoption speed is especially important in the first years (cf. NPV after five years), while in the following years the maximum adoption logically becomes the most dominant factor. The tariff setting also greatly influences the results and becomes more and more important during the years, i.e. when more customers make use of the WiMAX network. When considering the costs, CapEx are very important in the first years of the business case, when the WiMAX base stations are rolled out. In a later stadium, OpEx, dominated by the operational costs of the WiMAX sites, becomes more influential than CapEx.

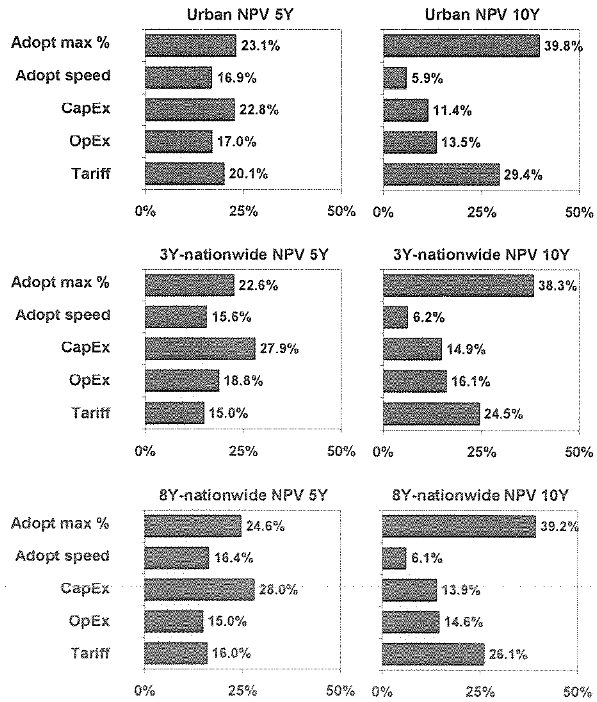

Figure 6: Influence of the model parameters.

When comparing the different scenarios, we see that the CapEx importance is smaller for the urban rollout than for the other scenarios since the more limited network in the former case. Concerning both nationwide rollouts, CapEx have the highest influence in the case of a fast rollout due to the high investments in the first years.

Figure 7 shows a trend analysis of the forecasted NPV for the three most different rollout scenarios. The nationwide rollout scenarios have a more varying outcome after ten years than the urban one (with a range of 155 M€ and 167 M€ vs. 132 M€). Further, the 3-year nationwide rollout not only shows a higher financial risk due to the high negative cash flows during the first years, but it also has the highest uncertainty. We also notice that the lowest NPV is reached each time the respective rollout is finished. For these negative cases however, the NPV remains almost constant in the next years, which means it will be quasi impossible to obtain a positive outcome.

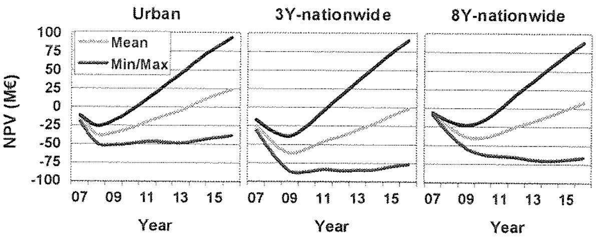

Figure 7: NPV trend analysis.

To end this section, Figure 8 gives the forecasted NPV distributions after five and ten years, for the 5-year nationwide rollout (i.e. the rollout scenario that will be considered in more detail in the next section). The obtained charts approximate the normal distribution.

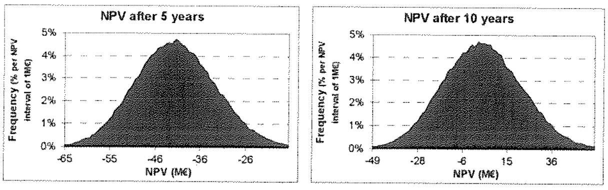

Figure 8: NPV forecasts (5-year nationwide rollout).

Real Options Thinking

In the previous sections, various rollout scenarios are presented and compared with each other. One weak aspect of the used model is that the complete rollout scheme is defined at the beginning of the case and assumes a strict planning without any flexibility. However, imagine that an operator is launching a WiMAX service, and after one or two years, the obtained take rate is much lower than expected, then he will probably slow down the rollout or even completely stop the project. On the other hand, if it is an unexpected success story, and at the beginning, the operator has opted for a slow or limited rollout, then it would be very evident to accelerate the rollout.

Real options thinking delivers an appropriate framework to introduce certain flexibility in our model, which reflects the strategy of an active management. It can be seen as the formalization of the natural valuation for a deployment path with flexibility. Real options theory originates from the financial world, where an option is defined as the right for a limited time, to buy or sell the underlying security for a predetermined exercise price. Exercising the option (i.e. buying or selling the security) is always optional and will only be performed if the market situation at exercise date is favourable (which is unclear at the time the option is acquired). Similarly, in the world of real options, by the time of a new investment phase, the market situation is already more clear, so that a well-advised decision can be taken for the further progress of the project (whether or not to exercise the real option). The introduction of flexibility, will very often involve an extra cost at the beginning of the project. To make it possible that several options can be exercised in the next phases, some measures have to be taken from the beginning. An example is the purchase of licenses to cover all possible scenarios.

A comprehensive introduction to real options theory, with a lot of practical examples, is provided in [7]. Various real options types are classified according to a so-called 7S-framework: invest/growth options (Scale up, Switch up, Scope up), defer/learn options (Study) and disinvest/shrink options (Scale down, Switch down, Scope down). The real options type used for the deployment of a new telecom network as described in this paper belongs to the scale up type since the network will be extended dependent on future market developments. This option is valuable since the operator need not currently commit to undertaking the future investment, thereby limiting downside risks. Note that several option valuation techniques are distinguished in the literature. In this paper we only consider valuation through simulation, which is the most intuitive technique.

The rollout scheme will be adapted at discrete points in time (in our simulation we fix the duration of the different phases at one year) to anticipate on the market changes by accelerating or reducing the planned rollout. Several parameters can be chosen as decision variable to determine the rollout in the next phase. We roughly distinguish two groups: diverse economic evaluation parameters are a good choice (e.g. NPV, free cash flow, payback period, etc), or we can focus on some uncertain input parameters (e.g. based on the sensitivity results depicted on Figure 6). As the evaluation of the project in the previous sections is mainly based on an NPV analysis, a natural decision variable is the NPV at the end of each year. If the NPV follows the expected trend (corresponding to the mean values from Figure 7), the normal rollout speed, as defined in Table 1, is followed. Otherwise a faster or slower rollout is performed.

We have set up a simulation scheme where we define five different rollout speeds for each next phase (i.e. a decision tree with five branches in each node or decision point). The choice of the most-suited option is determined by the normal distributions for the forecasted NPVs (cf. Figure 8) of which we use both the mean value and the standard deviation. A normal rollout is applied if: $E[NPV] - \sigma_{NPV} < NPV < E[NPV] + \sigma_{NPV}$. In the worst case (i.e. $NPV < E[NPV] - 3 \times \sigma_{NPV}$) there is totally no new rollout and in the best case (i.e. $NPV > E[NPV] + 3 \times \sigma_{NPV}$), the network is immediately expanded to the size that was originally planned for the two coming phases. For the remaining NPVs, two intermediate scenarios are defined.

The above described real options thinking principles are applied to the 5-year nationwide rollout. A faster rollout will tend to the 3-year and a slower to the 8-year rollout.

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Figure 9 shows the results for the NPV after five and ten years. The influence of real options is strongly noticeable in the NPV forecast after five years. The distribution is shifted to the right, since the least interesting scenarios are discarded thanks to the introduced flexibility (e.g. a slower expansion in case of a very low take rate or an unexpected high investment cost). The lowest NPVs are eliminated, but the mean value of the NPV after five years is only slightly increased from -41.4 M€ to -41.1 M€. After ten years, the NPV forecast approximately follows the normal distribution again. This can be explained by the fact that in our model a nationwide urban rollout is still completed in almost all cases by then, which means that no longer any option has to be taken. Besides, the mean NPV after ten years is only increased from 3.1 M€ to 3.2 M€ and the average discounted payback period is still equal to ten years, but the uncertainty range is decreased a little bit. Note that in 87% of the cases, the network is also deployed within five years (in 2%, the rollout is even finished after four years). The remaining 13% is then rolled out in year 6 or 7.

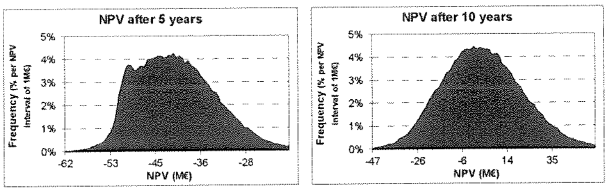

Figure 9: NPV forecasts – real options, example 1.

In the above simulation, the decision variable is compared to the mean value of the original 5-year nationwide rollout, and we see that the final results follow the trend of this fixed rollout. In a following step, we have adapted these NPV reference values, by multiplying the obtained values of $E[NPV]$ and σ_{NPV} by a constant factor in the above formulas. Using a factor which is smaller (larger) than one will reduce (increase) the average rollout speed. A reduced rollout speed can be interesting in projects that require high investments, as within the considered WiMAX rollout. Figure 10 and Figure 11 respectively show the results in case a multiple factor of 0.85 and 0.70 is used.

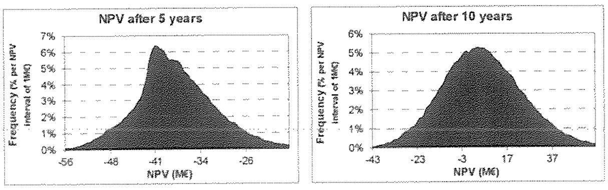

Figure 10: NPV forecasts – real options, example 2a.

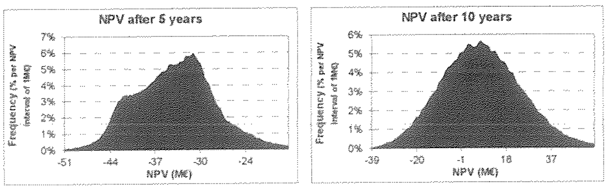

Figure 11: NPV forecasts – real options, example 2b.

Now, the NPV distributions after five and ten years are shifted more and more to the right, and after ten years the mean NPVs are increased to respectively 5.8 M€ and 7.6 M€, which is just above the 7.5 M€ from the 8-year rollout. Regarding the rollout itself, in the first example (0.85), in 44% of the cases a nationwide rollout is reached after five years. After year six this is increased to 80%, and after year seven to 98%. In the second example (0.7), only 3% of the cases are finished after five years, then this number evenly increases in the next years, and a rollout of 93% is reached after year eight. On average, this rollout is faster than the static 8-year rollout, and the NPV is just above it. This clearly shows that the 8-year rollout is not the best scenario in any case, which could be concluded after a static NPV analysis.

Conclusions

It is clear that a WiMAX rollout outside the big cities becomes a very risky project. So, it is very important to clearly assess its general feasibility. Next to a static NPV and free cash flow analysis, we have evaluated the rollout of a Mobile WiMAX network in Belgium through a profound sensitivity analysis and by means of real options thinking. The static analyses are essential to start the economic study. However, for a new technology as Mobile WiMAX, the model still contains a lot of uncertainties. By performing a detailed sensitivity analysis, the most influencing parameters are detected and a forecast of the outcome delivers extra information about the overall feasibility of the project. To introduce flexibility in the rollout scheme, some principles of real options thinking have been applied.

Regarding the studied case, a very fast WiMAX rollout involves very high investments and has the highest financial risk and uncertainty. The sensitivity analysis indicates that the most determining factors are related to user forecast and service pricing. By adding flexibility in the evaluation through real options thinking, the worst cases were eliminated, and then, it is clear that the slow rollout is not always the best option, as could be concluded from a static NPV analysis. By this flexibility, the rollout speed is better adapted to the real market perspectives.

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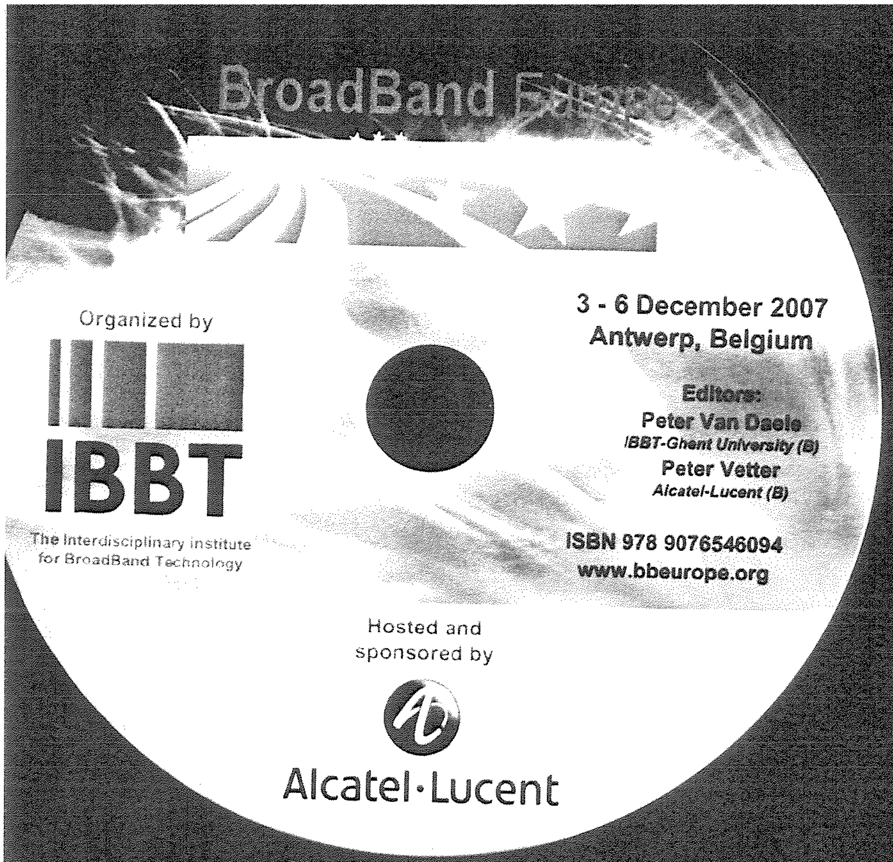

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