Business Aspects of WiMAX Technology in Fixed Telecom Market

Tomislav Majnarić
Lator d.o.o.
Haulikova 4, Zagreb, Croatia
Phone: +385 1 457 3831 Fax: +385 1 457 3883
E-mail: tomislav.majnaric@lator.hr

Domagoj Frank
Odašiljači i veze d.o.o.
Ulica grada Vukovara 269d, Zagreb, Croatia
Phone: +385 1 618 6196 Fax: +385 1 618 6100
E-mail: domagoj.frank@oiv.hr

Abstract - From a pure technical perspective, WiMAX is an advanced wireless system, capable of offering a multitude of broadband services in fixed and mobile telecom markets. Especially in the fixed market, it is expected that WiMAX would compete with wireline broadband technologies, such as DSL and cable. Taking into account the actual situation and competitiveness in liberalized telecom markets, the business aspects of WiMAX have to be thoroughly considered as well. The article analyses the WiMAX technology through the process of techno-economic analysis, identifying the key drivers that could influence the implementation options for WiMAX networks in the fixed telecom market.

I. INTRODUCTION

IEEE 802.16 Working Group on Broadband Wireless Access Standards, established in 1999, has been preparing the standards for Wireless Metropolitan Area Networks. Thanks to the WiMAX (Worldwide Interoperability for Microwave Access) Forum, an Industry Group aiming to promote market adoption of IEEE 802.16 standards, the WiMAX abbreviation has become a widely accepted synonym for these standards.

Backed up by the scientific progress of wireless technology, including OFDM modulation, WiMAX brings better capabilities in wireless data communications comparing to GSM, GPRS/EDGE and UMTS standards. Furthermore, WiMAX is primarily designed for IP based protocols and services. Basic physical layer characteristics of WiMAX enable its implementation through the multitude of spectrum and channel schemes in both time and frequency duplex modes. The recent versions of standard (IEEE 802.16e) also support the users' mobility, which allows operators to position WiMAX technology in both fixed and mobile market segments.

Despite the technical potential that WiMAX brings to the telecom market, its real market potential is highly dependent upon many parameters that influence today's liberalized and competitive markets. This includes regulatory environment, the level of competitiveness in the market as well as the demand for the services WiMAX networks can offer, especially broadband services. Considering this, the WiMAX equipment manufacturers and telecom operators have to examine the major technical and economic parameters that would direct their WiMAX implementation decisions thoroughly.

This article analyzes the most important characteristics of WiMAX technology through the process of techno-economic analysis that relies on bottom-up business model of fixed WiMAX network, focused on European markets. Based on the analysis' results, the article gives an overview of the most important market parameters that influence the profitability of WiMAX networks.

II. TECHNO-ECONOMIC ANALYSES IN TELECOMMUNICATIONS

During the 1990s, when liberalization started in European telecom markets and new technologies emerged (such as DSL and UMTS), techno-economic analyses in telecommunications have become the subject of interest in many scientific projects supported by EU institutions (TITAN, OPTIMUM, TERA, TONIC and ECOSYS [1]). In these projects, among others, the modular framework for techno-economic analyses was defined (Fig. 1). The framework components are described in subsequent subchapters, emphasizing the methods used in the work described by this article.

A. Scenario Description and Definition of the Project

The *project* can correspond to the various business strategies or plans telecom operators can undertake (e.g. implementation of new services, capacity upgrade of existing network, introduction of new technology in network, etc.). Also, the project can match the models built by market regulators for the purpose of carrying out the required regulatory measures, as well as new technology forecasts by equipment vendors.

Besides precise definition of the project scope (e.g. technology and infrastructure to be used, services to be offered, market segments to be covered, time duration, etc.), prior to the start of techno-economic analysis, corresponding *scenario* has to be considered. This mostly includes identification of the market and technology circumstances that would influence the Project (e.g. maturity of used technology, market saturation level with respect to the offered services, etc.).

B. Cost and Market Modeling

Both cost and market modeling involve application of mathematical methods for the prediction of future values of various parameters relevant to techno-economic analysis. These values comprise unit costs for the network components (capital, installation, maintenance and lease costs), regulatory costs (e.g. frequency licences) and

values of relevant market parameters (market size and segments, services penetration, market share and services tariffs). Based on the predicted market parameters, revenues are calculated for the defined project period.

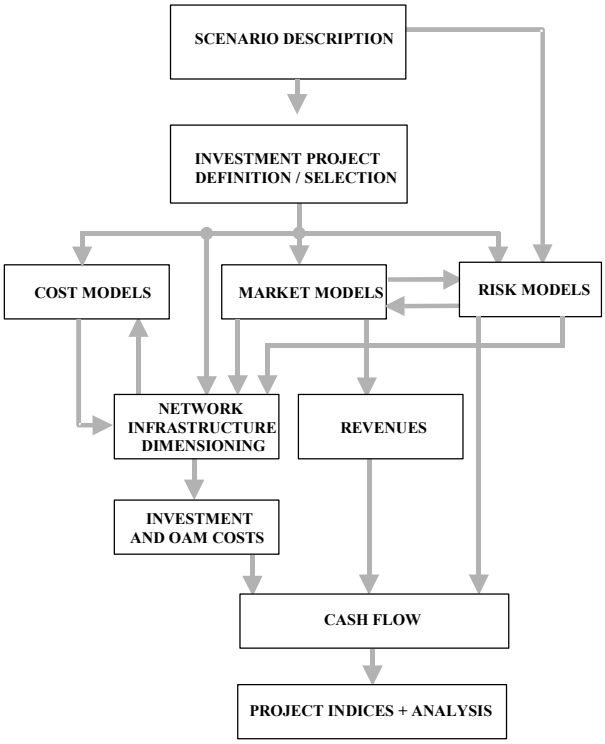

Fig. 1 Techno-economic analyses modular framework

C. Network Infrastructure Dimensioning and Costs

In this framework component necessary rules for the network dimensioning are set. The rules are derived based on real network or laboratory measurements, equipment vendors' datasheets and general data relevant to the used network infrastructure (e.g. service usage patterns, regional disposition of customers, geographical environment, locations of PSTN exchanges, transmission network routes, etc.).

The rules are then combined with predicted services demand and predicted values of unit costs, resulting with aggregated cost figures for the project duration period.

D. Cash Flow, Project Indices and Analysis

As a simple mathematical difference between revenues and costs during the project period T, cash flow (CF) is the base for further project analysis, as an input to other more complex methods that indicate the project profitability more preferably. The Net Present Value (NPV) is the most common method used for such purpose. Apart from CF values, NPV introduces discount rate parameter r, which defines the price of the investment money throughout the project period (1). Discount rate can be interpreted as the interest rate for the funds that are borrowed to be invested into the project.

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} \tag{1}$$

Projects with $NPV>0$ are considered to be profitable for the given project period T.

E. Risk Modeling

Risk modeling component comprises methods which estimate the reliability of the results obtained by techno-economic analysis (e.g. NPV value), aiming to determine the correlations between the variations of analysis' input parameters and results. Such correlations also indicate on which input parameters the project profitability is dependent at most (also known as key drivers).

Scenario analysis is risk modeling method in which input parameters are set into groups with discrete values, representing various project environment cases, out of which two can be considered as the best and the worst case scenarios (e.g. low and high service demand scenarios).

Unlike scenario analysis, the sensitivity analysis method checks the correlation that continuous variation of single input parameter has with the results of techno-economic analysis.

III. WiMAX BUSINESS MODEL

This chapter gives an overview of principles and methods applied to the construction of bottom-up business model of WiMAX network, which is considered as the *project* for techno-economic analysis, as described in the previous chapter.

A. Business Model Environment

As work in this article focuses specifically on Europe, relevant market environment in European Union (EU) and EU accessing countries is considered.

WiMAX Forum and equipment vendors have been marketing WiMAX as the wireless alternative to other wireline broadband technologies, such as DSL and cable. From the business perspective, WiMAX enables alternative operators to directly access end customers, avoiding the necessity for lease of local loop infrastructure from incumbents through various regulatory schemes (e.g. local loop unbundling or bitstream access). Furthermore, WiMAX is presented as the cost efficient solution for broadband access in rural areas, where deployment of other broadband technologies is limited by high costs of upgrading existing or construction of new infrastructure.

Average rate of broadband penetration (in population) within EU countries is 18,1% in 2007, with average annual growth of 4,3% from 2004. DSL is dominant broadband technology in EU with 82,3% of total broadband lines. Due to the significant market liberalization efforts, competitiveness in EU market has been increasing, with 53,7% of total retail broadband lines operated by alternative operators [2].

Considering harmonized approach regarding spectrum allocation in EU countries, National Regulatory Authorities (NRA) allow implementation of fixed wireless access services in 3,5 GHz spectrum, which is also suitable for WiMAX. Other parts of the spectrum that are suitable for WiMAX (e.g. 2,6 GHz) are still reserved for the extension of UMTS band. In this way, services offered over WiMAX networks are currently limited to only fixed ones, preventing usage of WiMAX mobile capabilities.

B. Business Model Definition

Business model of WiMAX network is based on offering fixed broadband services in non-line-of-sight (NLOS) conditions in urban and suburban areas that have population density higher than 100 inhabitants per km^2. It has been indicated by [3] that in these areas WiMAX has much better profitability characteristics when exploiting NLOS capabilities, comparing to the rural areas. Although line-of-sight (LOS) capability extends geographical coverage comparing to NLOS, the actual area coverage percentage will be highly dependent on landscape shape and other obstacles present, requiring application of complex propagation models for its precise calculation. Furthermore, as also shown by [3], in common market environment radio network infrastructure in suburban and urban areas tend to be capacity driven, limiting the cells radius and the possibility for exploiting LOS.

Apart from the broadband access services, WiMAX network model offers voice services as well (dual service packages). Considering WiMAX throughput capabilities, the services are offered within residential and small company market segments (companies with up to 10 employees [6]).

The techno-economic analysis is carried out through the period of seven years.

Although actual width of allocated 3,5 GHz frequency band can vary among EU countries, it is assumed that WiMAX operator has 21 MHz of spectrum available.

C. Market Modeling

Market and market segment sizes have been modeled with relative values. Accordingly, the total market size for offered services is 1, residential segment (represented by the number of households) 0,95 and small companies (represented by the number of companies) 0,05. These ratios have been set based on statistical data [4], [5], [6] and [7]. The average population density of areas covered is estimated at 320 inhabitants per km^2, based on [4]. The actual population density in urban and suburban areas vary among different European countries, but as this parameter is only significant during the 1st and the 2nd year of business model, when build out of network infrastructure is coverage driven, its impact on final results is minor, which has been proved by sensitivity analysis.

The market penetration of services offered over WiMAX network has been modeled based on average broadband penetration rate in EU during the last 3 years [2]. These values have been the base for the extrapolation of the logistic model for broadband penetration development in population *BP* (2).

$$BP(t) = \frac{29{,}0}{1 + e^{-0{,}75(t+1{,}6)}} \tag{2}$$

In order to distinguish various analysis results regarding the initial and final penetration values throughout the period of seven years, the start moments for WiMAX business models have been set to t_A=-4, t_B=-2 and t_C=0, as shown in Fig. 2, forming three different techno-economic analysis scenarios. It should be noted that t_A, t_B and t_C correspond approximately to the end of 2003, 2005 and 2007, respectively, when considering the average EU broadband rate development.

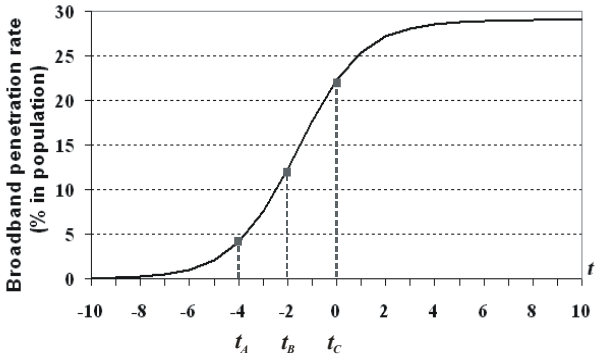

Fig. 2 Market penetration of broadband services with market entry scenarios considered

The market share MS_A of the alternative operators that offer fixed broadband services is modeled with linear function (3), where MS_{A0} is the market share at the beginning of analysis period and k_{MSA} is the increment of market share per year.

$$MS_A(t) = MS_{A0} + k_{MSA}t \tag{3}$$

Similarly, the number of alternative operators N_A is also modeled with linear function (4), where N_{A0} and N_{A7} are the numbers of alternative operators at the beginning and at the end of analysis period, respectively.

$$N_A(t) = N_{A0} + \frac{N_{A7} - N_{A0}}{7}t \tag{4}$$

Taking into account the interdependence of MS_{A0}, N_{A0} and N_{A7}, these parameters are assigned with different values in scenarios A, B and C, according to the corresponding data among EU countries [2], [8], which is presented lately in the article.

Supposing that alternative operators capture equal market shares in MS_A increment for each year they are active in the market, the market share of WiMAX operator MS_W is calculated according to the formula (5), where $MS_W(0)$ corresponds to the initial market share at the beginning of the analysis.

$$MS_W(t) = MS_W(t-1) + \frac{MS_A(t) - MS_A(t-1)}{N_A(t)} \tag{5}$$

Services offered over WiMAX network are grouped into three residential and two small company packages, distinguished by peak download rate, contention ratio and

the number of voice telephony channels (TABLE I). The packages are constructed based on the comprehensive market analysis performed in Lator, covering Croatia and EU countries. All packages contain flat-rate tariff plans for data. Among residential packages, the low package share is initially 40%, mid 40% and high 20%, while in final year of techno-economic analysis 40% of customers will have mid and 60% of customers high packages. On the other side, 70% of business users have low and 30% high packages in the first year of analysis, while in the last year, 40% will have low package and 60% high package.

TABLE I - SERVICE PACKAGES

	Peak download rate (Mbit/s)	Con-tention ratio	Tele-phony channels	Average monthly revenue per customer (EUR)
Residential low	1	50	1	25,00
Residential mid	3	45	1	32,80
Residential high	6	40	1	46,90
Business low	3	20	2	85,00
Business high	6	10	4	125,00

In order to track market dynamics it is predicted that peak download rates in packages will be increased by 10% per year and contention ration will be decreased by 5% per year as a response to increase of total volume of data traffic. Considering the competitiveness in the market, average monthly revenues are predicted to fall by 5% per year.

D. Cost Modeling

The costs of WiMAX business model comprise base stations (BS) costs, customer premises equipment (CPE) costs, WiMAX regulatory licence costs, transport network costs and routing equipment costs. The costs values within all groups are estimated based on publicly available data from WiMAX Forum [9] and EU [8]. Specifically, the price of WiMAX licence has been derived based on [10].

As the business model considers only fixed access, the predicted prices are based on IEEE 802.16d compliant BS and CPE equipment. Nevertheless the products based on IEEE 802.16e version of standard has recently started to emerge in market tending to fully replace 802.16d based ones, it is assumed the price level for IEEE 802.16e based equipment is the same as IEEE 802.16d, especially considering operation in only fixed access environment.

TABLE II gives an overview of estimated one-off capital expenditures (CAPEX) and annual operational expenditures (OPEX), including predicted cost trend per year. OPEX percentage values are calculated as proportion of CAPEX value of installed units for each year after installation.

CPE units, besides basic WiMAX functionality, contain voice telephony functions, allowing connection of common telephone sets as well as voice over IP (VoIP) operation towards central voice system in the network.

Point of Presence (PoP) refers to IP routing node which aggregates traffic from surrounding BSs and routes it towards other PoPs in WiMAX core network or towards other networks.

Microwave (MW) links and local leased lines (LL) are used for connecting BSs and PoPs.

Regional leased lines connect different PoPs, forming transport part of the core network.

TABLE II – WiMAX BUSINESS MODEL COSTS (in EUR)

	CAPEX	OPEX	Cost trend, per year
BS equipment, 3x7 MHz sectors	22.680	7%	-10%
BS site	8.500	10.000	-2%
CPE, outdoor, residential	615		-20%
CPE, outdoor, business	1.600		-20%
WiMAX licence, per inhabitant, 21 MHz band	0,70		
MW link, per E1	1.150	15%	-5%
Local LL, per E1		800	-5%
Regional LL, per Mbit/s		335	-5%
PoP, up to 50.000 customers	100.000	8%	-5%
Administrative costs, per annual revenue		15%	

Taking into account the complexity of implementation of central voice telephony system that is responsible for switching of customers calls and interconnection towards other operators, the system is assumed not to be implemented within WiMAX network. Instead of that, telephony functions in WiMAX network are realized by leasing corresponding system's capacity in other operator network, based on wholesale agreement. Relevant costs for such arrangement are included in the business model by reducing the voice part of revenues.

E. WiMAX Network Dimensioning

Considering NLOS propagation conditions in 3,5 GHz spectrum, the Stanford University Interim (SUI) empirical propagation model [11] has been applied for calculation of WiMAX cells radius. Considering various modulation combinations applied and corresponding link budgets limitations, the average value of cell radius is set to 3,0 km. Each BS can accommodate 3 sectors with 7 Mhz channels, resulting with total average capacity of 42,0 Mbit/s per BS [3].

Connection of BS and PoPs is realized either with MW links or E1 leased lines, simulating practical availability of either of link options. It is estimated that average share of BS that are connected with MW links is 80%.

The network dimensioning, including all relevant capacity and number of equipment units calculations, has been performed by STEM [12], which is a specialized tool for techno-economic analyses in telecommunications (Fig. 3).

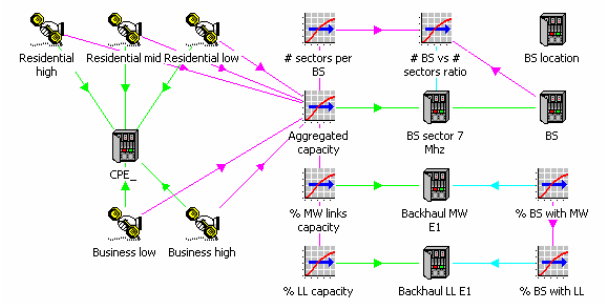

Fig. 3 Simplified overview of WiMAX business model in STEM's graphical user interface

IV. RESULTS OF THE TECHNO-ECONOMIC ANALYSIS

NPV values of WiMAX business model within three scenarios are discussed, assuming discount rate of 10%. The NPV values calculation as well as corresponding graphs construction was performed within STEM tool. The basic results correspond to the market size of 2,8 millions inhabitants.

A. Scenario A – Early Market Entry

As shown in Fig. 4, Scenario A has been analysed with three groups of parameters for market share of alternative operators and number of alternative operators. Considering that increment of broadband rate penetration has not reach its maximum within the first four years of the analysis, the revenues start to compensate the costs lately, causing the business model not to reach its profitability till the end of the analysis period. Furthermore, the negative NPV values are higher as the predicted number of alternative operators increases.

	MS_{A0}	k_{MSA}	N_{A0}	N_{A7}
I	0%	7,9%	0	2
II	0%	9,3%	0	3
III	0%	10,7%	0	4

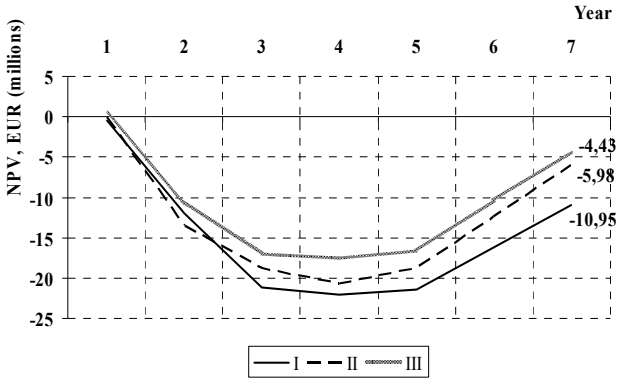

Fig. 4 Net present values, Scenario A

B. Scenario B – Mid Market Entry

When starting the WiMAX business model two years later in comparison with Scenario A, the profitability of the model is being achieved during the 6th or 7th year, as shown in Fig. 5. Also, the earlier moment in which revenues compensate costs causes the total investment funds needed to be approximately 40% lower than in Scenario A.

	MS_{A0}	k_{MSA}	N_{A0}	N_{A7}
I	10%	7,9%	1	4
II	10%	9,3%	1	5
III	15%	9,3%	2	6

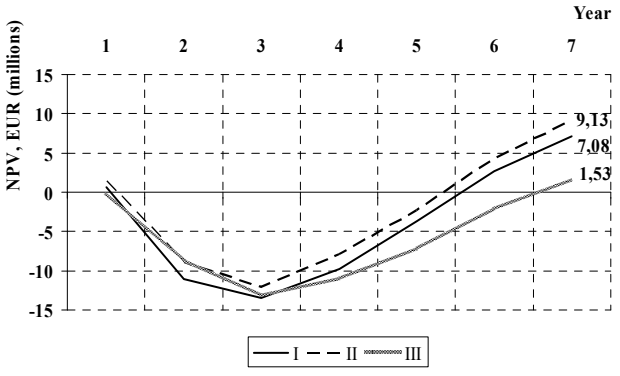

Fig. 5 Net present values, Scenario B

C. Scenario C – Late Market Entry

It has been shown that in the late market entry scenario the profitability can be achieved in some competition cases (Fig. 6). However, it is also obvious that, comparing to Scenarios A and B, the profitability and investments needed are much more dependent on the number of alternative operators and their market share.

	MS_{A0}	k_{MSA}	N_{A0}	N_{A7}
I	20%	6,4%	2	4
II	28%	6,0%	2	5
III	40%	5,0%	3	6

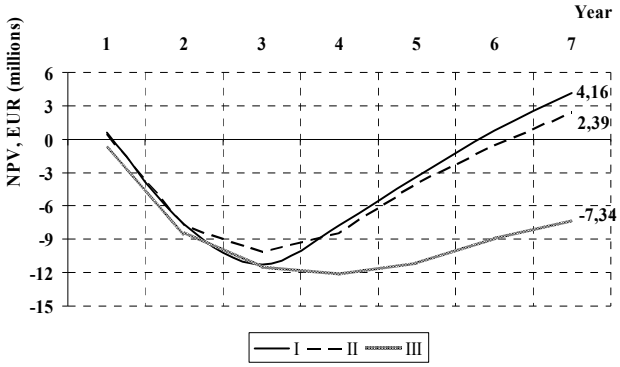

Fig. 6 Net present values, Scenario C

D. Sensitivity Analysis, Peak Download Rate

In order to examine in which way the variations of increase of data traffic in the network would influence the model's profitability, the sensitivity analysis of NPV values, with respect to annual increment of peak download rate within service packages, has been performed. The analysis was done on the best-case scenario B with parameters group II. It can be seen (Fig. 7) that profitability of WiMAX business model is significantly threatened by even slight additional increase of peak data rate within service packages. In practice, the increase of average throughput in the radio access network increases the number of additional BS sectors needed, causing overall costs to rise. Comparing to the other broadband technologies, this could have been a big competitive disadvantage for WiMAX, especially considering emerging video services over broadband connections.

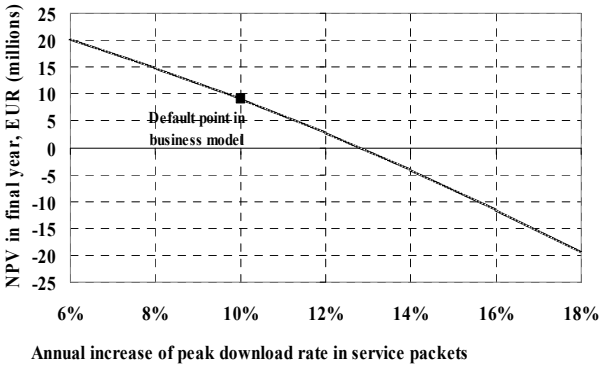

Fig. 7 NPV sensitivity analysis, peak download rate

V. CONCLUSION

The profitability of WiMAX business model, offering broadband and voice services in fixed telecom networks, has been techno-economically analysed by NPV method. It has been shown that the best results of the model profitability are achieved when WiMAX operator enters the market approximately 2 years prior to the moment in which the increase of the demand for broadband services reaches its maximum. Also, it has been shown that in all scenarios with positive NPV values in final years, the profitability is reached after relatively long periods of six or seven years. Furthermore, the profitability of WiMAX operator is weakened as the competition level of the market and number of alternative operators increase.

Considering the market trends and predicted increase of total data traffic volumes on Internet, it is apparent that future capacity assumptions in WiMAX business model are quite challenging. It has been shown that if average annual growth of peak data rates in service packages exceeds 12%, the profitability of WiMAX business model cannot be retained even for the best case scenario. This is primarily caused by costs of capacity upgrades in BS part of the network.

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