A techno-economic evolutionary path for access technologies

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ABSTRACT

This paper presents a comprehensive techno-economic evaluation of two multimedia cases based on xDSL and HFC technologies, illustrating their respective merits and pitfalls, allowing the definition of a reasonable investment policy. The scenarios considered reflect the point of view of both dominant operators and new entrants. Techno-economic results are presented in terms of costs and revenues from the multimedia services, net present value (NPV), cash flows and pay-back periods. The business cases presented here were studied using the tool developed by European Project ACTS 226/OPTIMUM and ACTS 364/TERA. This study evaluates financial results for different upgrade scenarios trying to provide guidelines for future broadband implementation strategies. The sensitivity of the photonic and xDSL equipment to the total investment is analysed taking into account the present value of them and their cost evolution. The significance of this equipment to the success of a business case is presented and the cost breakdown is discussed.

Keywords: ADSL, VDSL, HFC, Access network, techno-economics

1. INTRODUCTION

The telecommunications market liberalization continues across Europe according to the European Union directives and WTO agreements. Forecasts for substantial return, partly due to traditional telecommunication services, but primarily due to new ICT services encourage the entry of new players into the marketplace. Many new advanced services are increasingly being offered, yielding new business opportunities for both the user and the service providers.

Strategies for developing the traditional network, along a cost-effective path, flexible enough to serve a complex set of customer demands are crucial for the operators, service providers and equipment manufacturers [1-3]. Telecom and cable operators as well as electric utilities are installing fiber cables to improve their network and provide new services. Several deployment options are available such as fiber-to-the-curb (FFTC), hybrid fiber/coaxial (HFC) and a combination of both. *The access network is the most cost sensitive part of the telecommunications network, and in addition the one most closely related to service demand*. In a competitive environment, network infrastructure changes have to be viable in the usual economic sense i.e. by enabling a higher penetration or a reduction to the annual charges. With increasing pressure to minimize costs and to maximize revenues, a large variety of access network architectures must be rigorously examined in order to determine the most appropriate ones for the different area types and service demand profiles. Techno-economic evaluation in telecommunication network projects is required in order to derive suitable introduction strategies.

This techno-economic work aims to identify economically viable implementation strategies for an effective use of enhanced copper and fiber technologies, taking into account profitability and technical requirements. An analysis of broadband access network upgrade based on xDSL (ADSL & VDSL) as well as HFC technologies and investment strategies, including techno-economic assessment of the key factors influencing the life cycle costs and net present value of the network is presented.

Two case studies have been elaborated namely broadband access network upgrades based on xDSL and HFC technologies and techno-economic guidelines have been introduced. The multimedia business case analyses take into account the key factors influencing the overall economics of broadband network development, in order to identify the business opportunities The assessment is carried out with the tool and methodology developed by ACTS 226/OPTIMUM. Techno-economic analysis results are presented in terms of costs and revenue of the multimedia services, the net present value, cash flows and payback periods of broadband network architectures.

2. ANALYSIS APPROACH

2.1 NETWORK ALTERNATIVE ARCHITECTURES

Figure 1 illustrates the basic architecture of the ADSL system, which has been evaluated. The ADSL functions of the local exchange are labeled as ADSL Terminal Unit-C (ATU-C) together with the splitter function. Splitter-C may be packaged with the ATU-C and therefore is not shown. The ADSL functions at the customer premises are labeled with the ATU-R. The ATU's contains the modems, multiplexing systems and the terminal unit control. The ATU-C interfaces to the network switching, transport and other multiplexing functions and network operations. It may be located in a central office or in a remote site in the plant and performs the multiplexing, demultiplexing, transmitting, receiving and system control functions as well as it provides interfaces to the loop, network transport and switching and operations systems. The ATU-C function might be integrated within a higher level network element such as a fiber Optical Network Unit (ONU) or an ATM multiplexer [4]. In the local exchange the modems are installed into a DSLAM rack which can support up to 500 ADSL ATU-C cards.

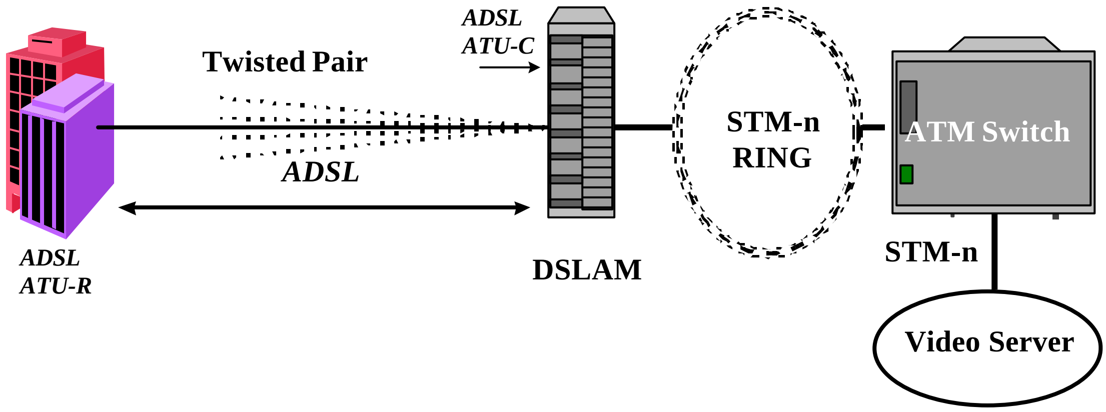

Figure 1: Representative ADSL architecture

Figure 2 illustrates a simple model of VDSL. The broadband and narrowband services may be transmitted over a common optical access network, before final distribution over a metallic distribution network. Alternatively, in the case where broadband signals are provided by an overlay network, the ONU is co-located with an existing copper network flexibility point where the broadband and narrowband services are combined for transmission over the existing metallic distribution network.

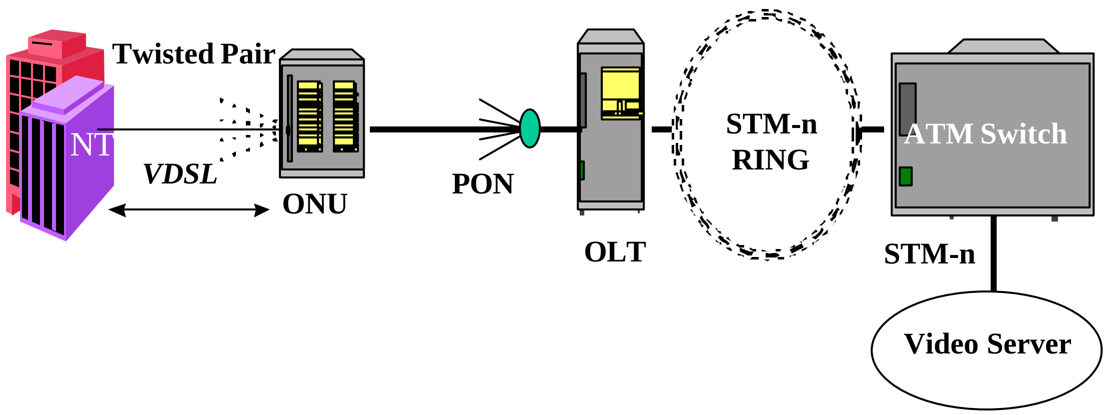

Figure 2: VDSL architecture based on FTTC deployment

VDSL architecture is a complement to a FTTx deployment. The need for a PON (Passive Optical Network) with an OLT (Optical Line Termination) is the common point of every attempt for VDSL deployment. The difference originates from the position of the ONU (Optical Network Unit). Since the maximum copper length for a 52-Mbits VDSL system is 300 meters and for a 26-Mbits system is 1000 meters, ONU must be placed near to the customer [5]. The ONU may be sited in the street (fiber-to-the-Cabinet: up to 1500 m from the customer, fiber-to –the-curb: up to 500 m from the customer) or in the served building, e.g. an apartment block (fiber-to-the-building, up to 500 m from the customer).

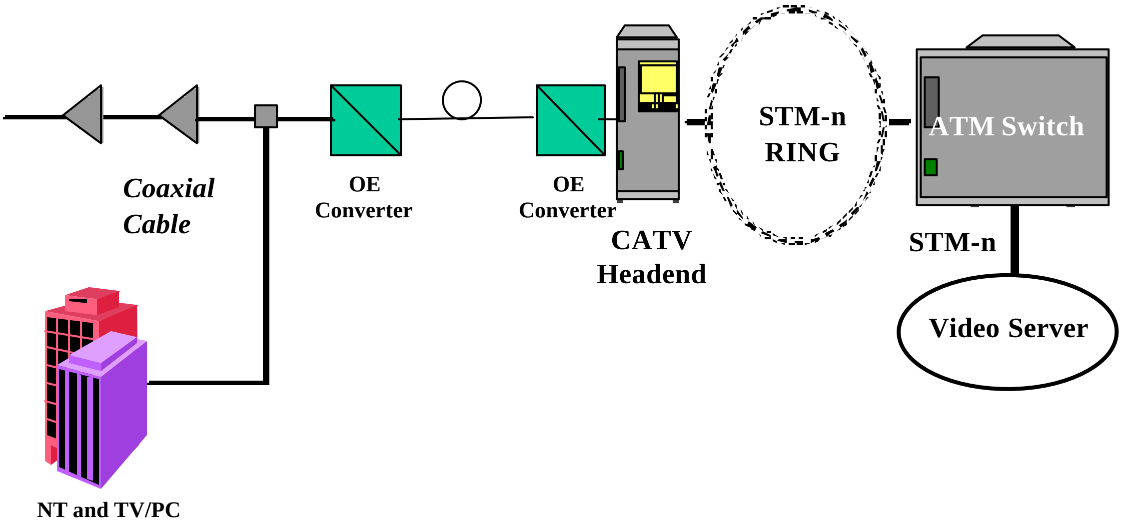

Figure 3: A typical HFC architecture

Figure 3 illustrates a typical HFC architecture. The CATV headend performs the following fuctions: reception of satellite and off-air channels, delivery of analog TV channels transported by existing transport digital network, modulation, combination and E/O conversion of signals and interface to the network.

2.2 THE METHODOLOGY

The techno-economic evaluation of the ADSL and VDSL case studies has been carried out using the methodology and the tool developed by the EU project RACE 2087/TITAN and enhanced by the projects ACTS 226/OPTIMUM and ACTS 364/TERA. The TITAN project [6,7] developed a model predicting the cost evolution of the network components, which is based on a combination of the learning curves and the logistic model. In addition, for each network component the prediction uncertainties have been specified as a function of time. The TITAN methodology and the tool have been enhanced within OPTIMUM to be able to cope with complex multimedia service and network structures. The methodology has been improved in particular in the definition of services and in the assessment of operations, administration and maintenance costs. The maintenance costs are defined separately in the OPTIMUM tool, and are automatically included in the model. The operation and administration costs of the components are user-defined. The life-cycle costs (LCC) of the network are then produced by adding OAM costs and IFC. Finally the overall financial budget is calculated for the various architectures by comparing the LCC to the overall revenue. Currently the tool is used for the techno-economic evaluation of ACTS field trial under ACTS 364/TERA.

2.3 xDSL AND HFC CASE STUDIES

Different density areas have been studied in order to analyse the technology alternatives for upgrading the access network to broadband. These areas are also differentiated due to different deployment strategies and service basket options, usually adopted by operators.

Several scenarios can be considered, reflecting the views of both dominant telecommunication and CATV operators and new entrants as well. From the telecom operator's point of view, three business scenarios can be considered. In a first scenario, ADSL services are quite popular and PNOs are considering an upgrade towards VDSL. In this upgrade case, slightly increased tariffs for VDSL-based services can be applied. In a second scenario, ADSL services are considered as less popular and PNOs are focused on increasing the penetration due to competition. In this case, same tariff for ADSL and VDSL can be applied, but the goal is to increase the penetration rates for broadband services. In a third scenario, which represents a green-field situation, a business case can be evaluated, taking into account same tariffs and penetration rates for both technologies. This scenario is adopted in the present work.

From the CATV operator's point of view, new services can be offered on top of cable TV network using cable modems for two-way data connections. Therefor, new fiber cables are needed in order to divide the HFC network into small enough segments for bi-directional cable modem services.

For all case studies, two different penetration scenarios have been studied. In scenario 1, the penetration varies from 2% (the project's 1st year) to 20% and the annual fee from 480 to 300 Euros. In scenario 2, the penetration varies from 3% to 30% respectively with the same tariff evolution.

Case Study 1: Urban Area

The first business case concerns an urban area dominated by apartment blocks. The majority of the subscribers are living in apartments and the minority in single houses. The existing copper infrastructure is assumed modern and enough for serving the present and the foreseeable demand for POTS. The duct availability is assumed 80% for the fiber cable and the additional civil works costs must be included in the techno-economic analysis.

Usually in an urban area the penetration of POTS is saturated. In most cases there is competition and demand for broadband services, which are the driving force for replacing/upgrading the existing access technology.

Case Study 2: Suburban area

The second business case represents a suburban area where the majority of subscribers are living on single houses and the minority in apartment blocks. The existing copper infrastructure is modern and capable to support future demands for POTS services. In this case, the distribution ratio per ONU is smaller than in an urban area. This happens due to short cable distances, arising from VDSL restrictions for higher bitrates.

3. RESULTS AND DISCUSSION

For all case studies, the cost of access equipment is dominant (Figures 4). Especially in the ADSL cases, the cost and deployment strategy for the modems is the crucial element for a profitable business enrollment.

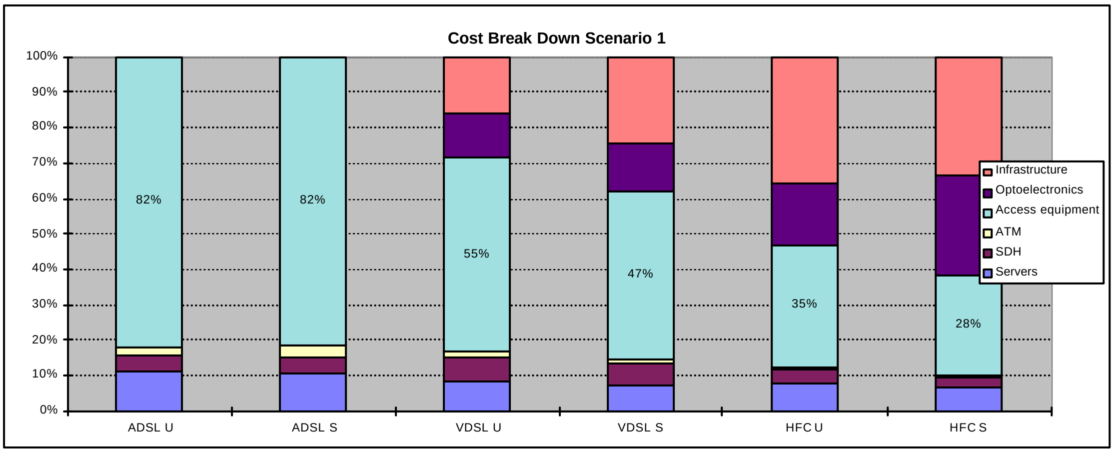

Figure 4: Cost breakdown analysis for alternative technologies into different density areas.

Comparing the ADSL cases, the different modularity of the network topology results to additional DSLAM equipment and therefore to additional investments. It must be denoted that

that these DSLAMs are not going to be filled with ATU-C cards and this must be seriously taken into account.

As far as the VDSL and HFC cases are concerned, the civil works (included in the infrastructure costs) are the large percentage if the first installation costs. In addition, investment in SDH equipment is needed in order to a specific quality of service be guaranteed. Thus, special attention must be paid to the civil works and ONU/OLT costs.

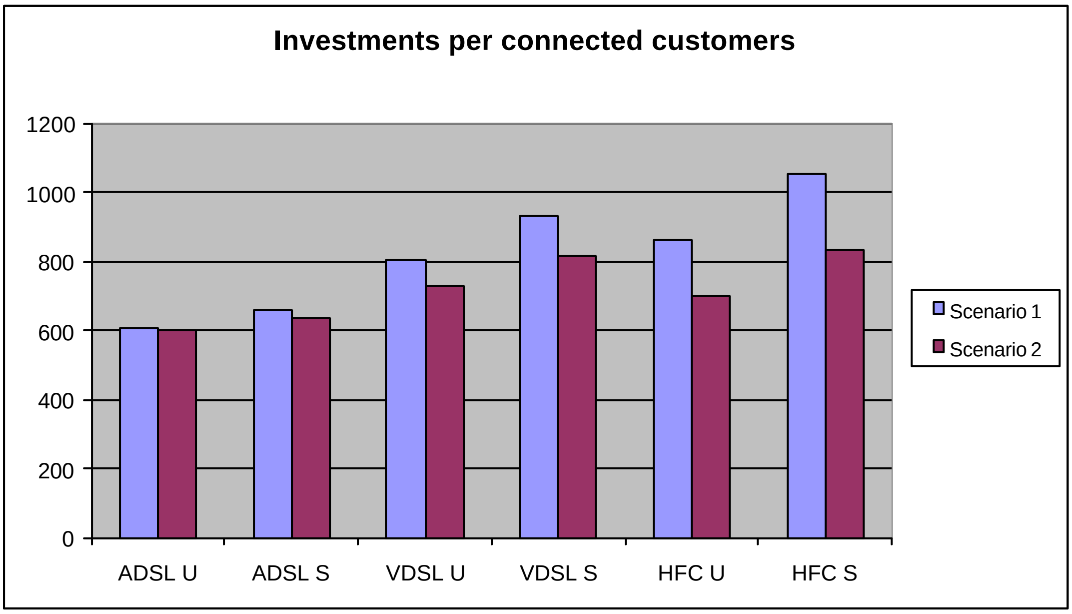

Figure 5: Investment cost per connected customer (Scenario 1)

The difference between ADSL and VDSL cases in urban area is rather low mainly due to the higher percentage of apartment blocks (Figures 6 and 7). Therefore, VDSL can be an attractive technology although it needs larger investments. With the appropriate selection of tariffs and services, this technology can be a revitalizing factor for existing copper infrastructures and future fiber deployments.

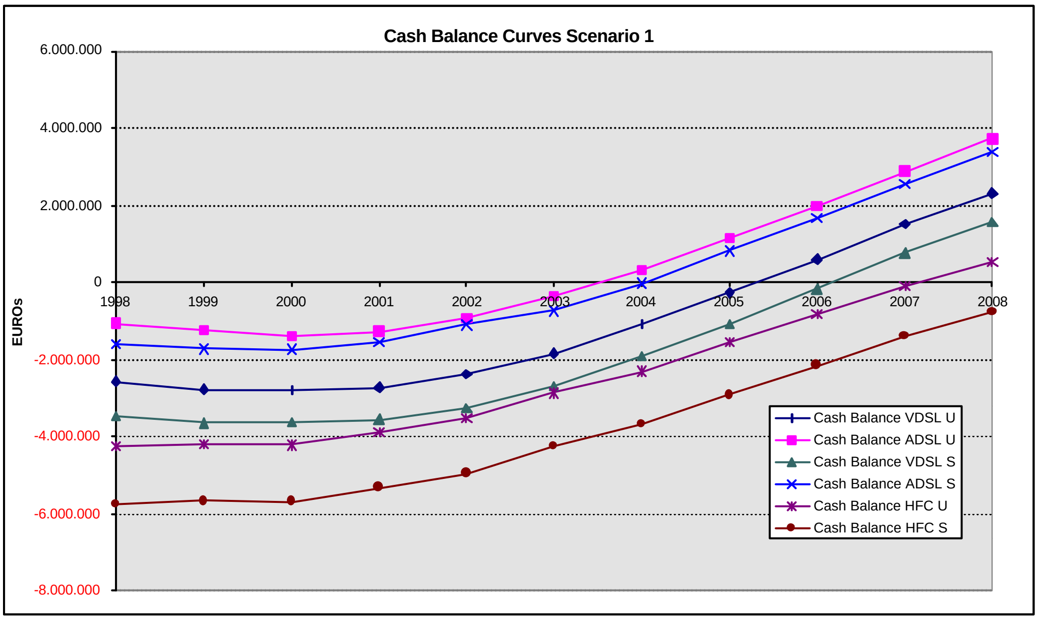

Figure 6: Cash balance for scenario 1

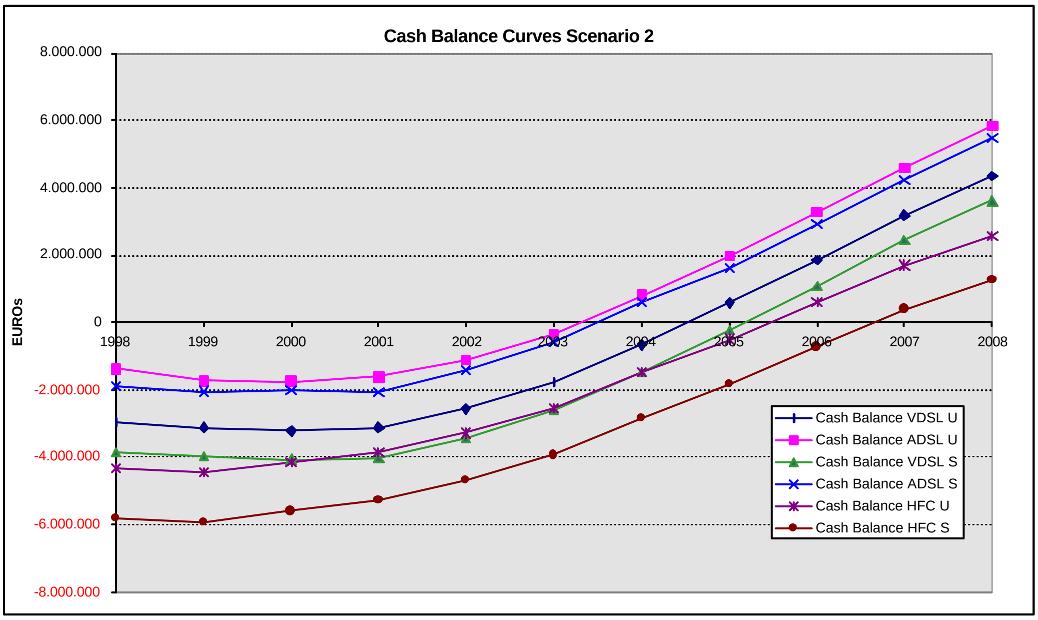

Figure 7: Cash balance for scenario 2

Investment analysis presented in figures 6 and 7, does not favor any deployment of HFC network. This technology can't be profitable for a new entrant, due to the need for large investment and payback periods.

In tables 1 and 2, a summary of economic factors calculated in this work is presented. For all cases, the urban cases are demanding fewer investments and are more profitable. For higher penetration (scenario 2) the values corresponding to urban and suburban areas are close enough (Figure 4) and therefore a serious dilemma is still standing for the operators. Since the volume of access equipment is expected to be significant large and its cost will decrease, both xDSL technologies can be a real option for telecom operators. The need for further development in access equipment (especially for VDSL, which is the less mature technology) is obvious, taking into account sensitivity factors such as electronics and OAM costs.

	ADSL U	ADSL S	VDSL U	VDSL S	HFC U	HFC S
NPV	3794015	3318656	1984534	975020	62143	-1592183
IRR	29%	23%	13%	8%	5%	1%
Running Cost / Total Investments Ratio	1.26	1.17	0.99	0.86	1.03	0.87
Total investments	4808957	5219065	6398954	7390362	6813822	8341565
Discount Investments per connected customer	606	658	806	931	879	1076

Table 1: Summary of economic factors for scenario 1

	ADSL U	ADSL S	VDSL U	VDSL S	HFC U	HFC S
NPV	6068389	5599775	4223630	3195676	2473956	819630
IRR	33%	28%	19%	14%	12%	7%
Running Cost / Total Investments Ratio	1.24	1.18	1.06	0.95	1.20	1.04
Total investments	7134286	7553634	8677327	9681570	8309081	9836825
Discount Investments per connected customer	599	635	729	813	714	846

Table 2: Summary of economic factors for scenario 2

The evolutionary path for the access technologies is very cost sensitive and the investment strategy will depend on the capacity demand. Nevertheless, there is a critical break-even point. This is a capacity depended point. Beyond that, capacity demand and willingness to pay for broadband services will counterbalance the cost for deployment of fiber and financing new terminal equipment. Especially, in urban areas which cover important subscribers with high capacity demands as well high willingness to pay, VDSL can generate good revenues because can offer not only one service or a TV channel but a wider basket of Internet services. However, a combination of higher price for higher capacity and a potential increase in penetration (adding new services such as HDTV and rendering multiple channels) can dramatically increase the total revenue.

4. CONCLUSIONS

The presented analysis aims to point out techno-economic issues for access technologies. ADSL seems to be a dominant technology until fiber-to-the-curb and fiber-to-the-home take over. In that case VDSL will be the next step. But even then, ADSL will be deployed until customers ask for additional capacity. Thus, the key differentiator won't be the investments and the operational costs saving but the penetration of the services and consequently the services offered

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] A. Cook, J. Stern, "Optical Fiber Access - Perspectives Towards the 21st Century", *IEEE Commun. Mag.*, vol 32, no. 2, February 1994, pp. 78-86.

[2] W. Pugh, G. Boyer, "Broadband Access: Comparing Alternatives", IEEE Comm. Mag., vol. 33, no. 8, August 1995, pp. 34-45.

[3] A. Zaganiaris, N. Gieschen, B. T. Olsen, K. Stordahl, M. Tahkokorpi, M. Drieskens, A. Ajibulu, "A methodology for achieving life-cycle costs of optical access networks-from RACE 2087/TITAN," Proc. 11th Annual Conference European Fibre Optic Communications and Networks, June 1993, The Hague, the Netherlands.

[4] P Jkyees et . "ADSL: A new twisted-pair access to the Information Highway" IEEE Commun. Mag., vol 33, no 4 April 1995, pp.52-60.

[5] P. Huich et al "VDSL Copper Transport System" Full Services Access Network Conference, London, June 1996.

[6] B.T. Olsen et al., "RACE2087/TITAN: Tool for Introduction scenarios and techno-economic studies for the access network", Proc. RACE open workshop on broaband access Nijmegen, The Netherlands, June 1993

[7] L.A. Ims et al.,"Multiservice Access Network Upgrading in Europe: A techno-economic analysis", IEEE Commun. Mag. , vol. 34, no 12, December 1996, pp. 124- 134