# NGN Access Network Planning: A Case Study of TOT's Network in Thailand

A Report for TOT Public Company Limited

ITU Asia-Pacific

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***“This project was organised by the ITU with the kind support from the Department of Broadband, Communications and the Digital Economy, Government of Australia. The views in this report are those of the expert and do now necessarily represent the views of ITU and its membership.”***

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## List of Acronyms and Abbreviations

| | |
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| ADSL | Asymmetrical Digital Subscriber Line |
| AN | Access Node located at the access network segment |
| BER | Bit Error Rate |
| CAPEX | Capital Expenditure or network expenses that are capitalized and subject to depreciation |
| CC | Copper Cable |
| CF | Cash Flow |
| CPE | Customer Premises Equipment |
| FO | Fiber Optics |
| FTTH | Fiber to the Home |
| GSM | Global System for Mobile Communications |
| GW | Gateway |
| ICT | Information and Communication Technologies |
| IP | Internet Protocol |
| IPDV | Internet Protocol Packet Delay Variation (jitter) |
| IPER | Internet Protocol Packet Error Ratio |
| IPLR | Internet Protocol Packet Loss Ratio |
| IPTD | Internet Protocol Packet Transfer Delay |
| IPTV | Internet Protocol Television |
| IRR | Internal rate of return |
| ISP | Internet Service Provider |
| IT | Information Technology |

| | |
|---|---|
| ITU | International Telecommunication Union |
| NGN | Next Generation Networks |
| NPV-perpetuity rate: | The net present value of the network, i.e. cumulative discounted cash flow generated to date, including a terminal value based on growth to perpetuity. This is the best evaluator when comparing many heterogeneous solutions |
| NPV-Zero terminal value | The net present value which ignores the value of the equipment at the end and is adequate when no differences in equipment investments appear but not complete evaluator when different investments are done between solutions. (some solutions have more value at the end than others) |
| OPEX | Operation expenses or Operating cost (also called running costs) consider non capitalized costs as maintenance of all installed equipment, administrative costs and direct operation of equipment being in use |
| Operating charge | is used as a more complete view from the financial side that includes not only the direct operation costs but also the operational expenses due to depreciation and amortization at the year at which they appear according to the life cycle and amortization procedure. |
| Operating expenditures | reflect the aggregation of capital expenditure and operating cost per year that is used for the evaluation of cash flows |
| POI | Point of Interconnection |
| PSTN | Public Switched Telephone Network |
| QoS | Quality of Service |
| SLA | : Service Level Agreement |
| STEM | Strategic Telecom Evaluation Model |
| VDSL | Very high Digital Subscriber Line |
| VoDSL | Voice over Digital Subscriber Loop |
| VOD | Video On Demand |
| VoIP | Voice over Internet Protocol |
| xDSL | Digital Subscriber Line |

## Acknowledgement

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# 1 Executive Summary

## *1.1 Background and Objectives*

This report results from a project initiated by the International Telecommunications Union (ITU) into the Access evolution towards NGN and triple play services in Bangkok, Thailand. The action was initiated under the ITU Asia Pacific Regional Initiative 3 with project title as “NGN Planning, Migration and Applications”. In order to carry out the activity, Sameer Sharma, Senior Advisor, ITU Regional Office of Asia and the Pacific and Oscar González Soto, consultant for ITU, undertook a series of interviews with key experts in TOT.

A survey on access network infrastructure has been conducted with field visits to a main PSTN operation centre, Main Distribution Frame, Cabinets and cable plant. Regular meetings have been maintained with TOT engineers responsible for the planning, engineering and operation of the PSTN network, Data network and access segment based on ADSL.

New services requirements and competition drive to a worldwide network convergence towards NGN in IP mode and developing countries are now faced with the challenge of migrating from existing PSTN networks to advanced NGN networks capable to provide multimedia services under limited financial conditions.

As the access network segment is playing a key role for provisioning of Broadband services and is being dominant in required investments with more than half of the total in the network, a focus on this segment with the corresponding network studies and business planning activities becomes essential.

Network Planning works by the ITU-D Technology and Network Development at the Network Infrastructure section, under Riccardo Passerini, are taken into account for this modeling, being the two following documents basic references:

- “*Manual on Network Planning for Evolving Network Architectures”*
- *“Guidelines for Network Planning Tools for Developing Countries and countries with Economies in transition”*

Specific objectives defined within the mission include the following ones:

- To undertake network assessment and audit for the status of the existing copper access network infrastructure in Bangkok

- Analyze target models and architecture for Outside Plant (OSP), network systems and services

- Evaluate dynamic migration models over time towards target solution based on technical dimensioning and business evaluations.

- Recommend network modernization to support triple play services with at least 8 Mbps as well as actions to increase operation efficiency derived from performed studies and evolutions in the market

The generic outcomes from the study will be shared with other countries in the Region.

## *1.2 Key findings and conclusions from access assessment*

From the performed analysis available data and evaluations in the first phase of the project, the following conclusions and recommendations are provided:

- C1) Currently, information on cable types and OSP infrastructure is in paper format (not digitalized and not integrated in a common data base). This fact does not facilitate the knowledge of network capabilities for an efficient planning of BB deployment. ***In order to have a convenient access network characterization for a wider BB deployment it is needed to have OSP information and inventory in digital and integrated form*** by deployment and utilization of the applications associated to the OSS.

- C2) The lack of specific characterization of Local Loops by the main parameters influencing transmission quality: LL length, SNR, etc. for the main urban scenarios creates an additional difficulty for the LL assignment and increase the operational cost. ***It is proposed to realize a statistical characterization by sampling in all LE types while more modern monitoring systems are in operation***.

- C3) From the data analyzed in the BKK Areas 1 and 3 and the observation of the Aerial installations in BKK, ***it is derived a significative proportion of cables with more than 15 years (10% in aerial and 20 % in underground) and more than 10 years (20% and 30% respectively). This fact joint to the high proportion of distribution cables in aerial type (i.e.: 60% to 70 % in Area 3) determine an urgent need for OSP modernization.*** In addition, the direct observation of aerial installation types with low quality practices and mix of up to 5 different types (medium tension electricity, low tension electricity, coax, copper and FO) require the redeployment at the distribution segment in underground type. ***In order to avoid multiple sequential civil works it is recommended to agree among different players for a common deployment in shared mode (i.e.: common works with assigned ducts per operator or even shared ducts options)***

- C4) Monitoring of quality and fulfillment of SLA becomes incomplete and difficult with current fragmented OSS/BSS platform as a function of the original provider of technology. In order to comply with customer requirements and compete with alternative operators, ***it is required to have an integrated platform (as manager of managers or as federated platforms) for an efficient management of all new services***. OSP monitoring applications required to control quality level

- C5) It have been identified up to ADSL 26 services by speed type and tariff structure that implies a high operational cost for minor differences in front of customer. ***It is recommended a grouping in simplified categories*** with significative differences among them to facilitate management, offer and business optimization. When BB services are in place, low speeds disappear or only one is maintained for a low cost option entry strategy.

- C6**) *IP network design and engineering for the access and edge segments should follow the end to end Quality of Service (QoS) criteria required for the SLA with customers that will imply a guarantee of Sustained Bit Rate (SBR) of the order of 80% of the peak rate in contract*** and with a packet loss probability less than 1%, packet delay lower than 100 ms. and jitter less than 10 ms. ***Measurements of traffic flows at the access and edge segments are required to analyze peak periods (ie: 5 minutes) demands and concentration factors from customer activity and transmission times as a function of simultaneous users connected.***

## *1.3 Key findings and conclusions from access business planning*

From the performed analysis with the available data and business evaluations in the second phase of the project, the following conclusions and recommendations are provided

- R1) Access modernization for NGN solutions with OSP enhancement to allow triple play services (at 8 Mbps.) ***show an important increase in the Net Present Value of the network due to the convergence efficiencies*** and position the company for a higher revenues and competition level in the market. NPV starts to have advantage after the year 3 and continues growing over time

- R2) The migration of the network towards ***NGN at edge and core levels in dual play has the benefits of cost decreasing in OPEX and CAPEX*** with better business performance but if no new services are introduced benefits of new revenues are lost

- R3) Introduction of ***IPTV and VOD should be based on negotiations with content providers that provide attractive and high quality content*** in order to assure important customer adoption rates and loyalty.

- R4) The capability to offer triple play to the market allows for a ***Market Strategy with bundle service offering in order to customize tariffs*** per customers category, minimize churn rates and be in good position to lead the market and react to initiatives of competitors

- R5) Although price and speed of BB services is an important factor to attract customer in a competitive market, once a sufficient speed is reached***, it is Quality of Service, Service Availability, Customer Care and Sustained Bit Rate guarantee the decisive factors for a customer to select a new provider or remain at the current one***. Thus attention to quality becomes decisive for a good market positioning and especially for an incumbent operator that has more tradition on quality.

- R6) ***That quality requirements impose the corresponding OSP enhancement for Cable and Ducts*** specially in areas where distribution network is aerial and mixed with other cable layouts and not reaching the standard failure rates and transmission properties.

- R7) ***New and integrated OSS/BSS*** are required both for quality assurance and operational cost reduction. Integrated OSS/BSS will assure an end-to-end view and monitoring of performance for the IP flows and services not possible with a fragmented set of multiple systems. ***Customer Care platform is recommended with traffic dimensioning ensuring rapid response to calls and with differentiation of service per customer class, history of previous customer calls and SLA.***

- R8) ***Further studies*** and sensitivity analysis recommended for the access scenarios in Thailand include the following ones:

- A) ***Lower density cases*** in suburban scenarios in order to analyze up to which density and services mix the current conclusions of this study could be maintained.

- B) New architectures with ***IP closer to the customer at an all IP CPE*** that allows for services end-to-end IP, cost reduction in the node but higher investments in customer CPE renovation

- C) ***FTTH for services requiring 30 or 100 Mbps according to customer density services demand and OSP status vs VDSL solutions***

- E) ***Infrastructure sharing modeling and evaluation for LL unbundling cases as well as for a common underground renovation/installation of ducts at a single shot for all involved companies (Telecom, CATV, Electricity, etc.) in high density urban areas.***

# 2 Telecom context at Thailand

## *2.1 General context*

Thailand with more than 66 million inhabitants and a population density of 127 per Km2 at end of 2008 is considered as a middle-emerging economy with development level, population density and GDP per capita close to the average in the Asia Pacific region.

Information and Communication Technology (ICT) development is characterized by a current high penetration of mobile terminals of 93.34% with a growing rate of 15.40% and a fixed lines penetration of 10.50% with higher values (29%) at Bangkok central area which is considered as above the medium level in the region.

The Ministry of ICT (MICT) is responsible for the national policy settlement and the National Telecommunications Commission (NTC) founded in 2004 is the state telecommunications regulator with responsibilities to regulate all telecommunication services in the country. Duties include the formulation of a Master Plan on Telecommunications Activities, setting criteria and categories of telecommunication services, permitting and regulating the use of spectrum for telecommunication services, and granting licenses to the telecommunications operators.

TOT and CAT have the rights to operate their services and alternative operators provide services in the “concession mode” from incumbent TOT and CAT Telecom while market opening regulation laws are expected in the next years.

## *2.2 Telecom Players*

Main global players:

- TOT Public Company Limited: now at its 55th anniversary is the 100% own state incumbent operator with national coverage in all service types, a revenue of 52,500 million baht and profit: 5,970 million baht. It has the largest fixed line market and is also one of the leader ADSL providers. It is the reference for research and development of the telecoms in the country.

- TOT operates in three different modes on the Telecom market:

  - TOT own operation for Fixed-Line, Public Phone, International Call, Broadband & Multimedia and Data
  - TOT trough concessionaires like TRUE & TT&T for Fixed-Line & Public Phone, AIS for Mobile and others like Com-Link, Jasmine and Thai Long-Distance
  - TOT as Shareholder of companies like ACT Mobile and TAC for mobile, Lenso Datacom, ADC for Data Communication and INET for Internet

- TOT Key Services include the following ones:

  - Fixed Lines : 6.66 Millions subscribers
  - Wireless Services : IP Star, TOT Wi-Fi, Thai Mobile
  - Data Services : Leased line, IP-VPN, ATM, FR
  - International Call: 007, 008
  - Broadband Internet (DSL) : 677.484 operational lines
  - Internet Services : NIX, IIG, ISP, IDC, Netcall
  - Multimedia Content: Talesrunner, e-learning

- Other alternative players:

- CAT Telecom Public Company Limited: is the state-owned telecommunications company that owns Thailand’s international telecommunications infrastructure including its international gateways, satellite and submarine networks. CAT also operates through Concession mode with DTAC, Hutch and True.

- True Corporation Public Company Limited : provides home consumers, small and medium enterprises and corporate with a wide range of cellular, Internet, data and entertainment products and services in customized packages through subsidiaries: TA Orange, Asia Wireless Communication (operator of WE PCT), True Multimedia, True Internet and pay TV operator United Broadcasting Corporation (UBC).

- TT&T Public Company Limited: provides fixed line service to provinces nationwide except Bangkok and metropolitan areas which belongs to TOT coverage. TT&T Provides also ADSL service under brand “Maxnet”

- AIS: Advanced Info Service Public Company Limited: was established in 1989 and has now main participation by SingTel and Shin Corporation. AIS provides mobile services with GSM technology in the 900 Mhz band granted by TOT and 1800 Mhz band granted by CAT in BTO mode with revenue sharing. It has the largest penetration in Thailand with 27.3 million subscribers and more than 97% coverage.

- The market share among the main players for fixed lines at 2008 was distributed as indicated in the Figure 1 with a dominant 56% by TOT followed by True with 27% and TT&T with 17%

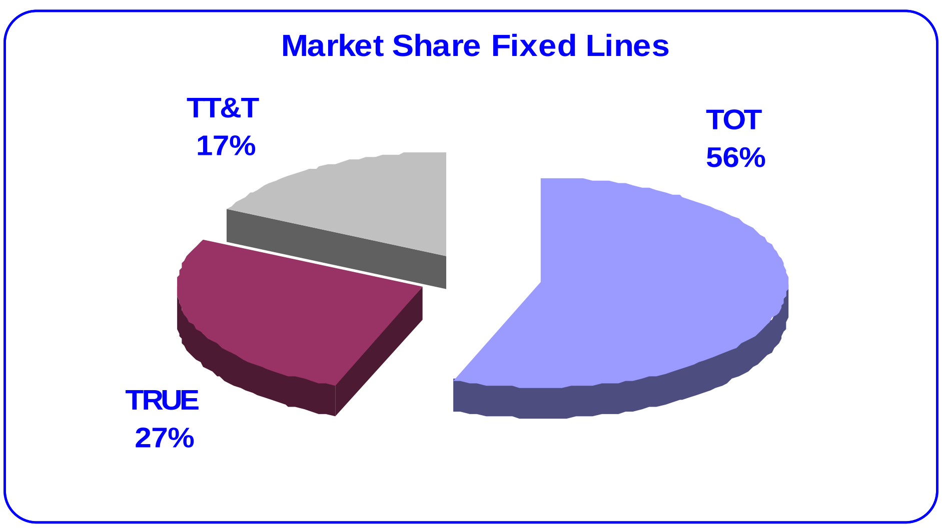


Figure 1: Market share for fixed lines at 2008

- Market share for ADSL at 2008 is more distributed and competitive with TOT and True capturing 36% and 34% respectively, TT&T had 23% and other minor players accumulate the remaining 7% as indicated in Figure 2

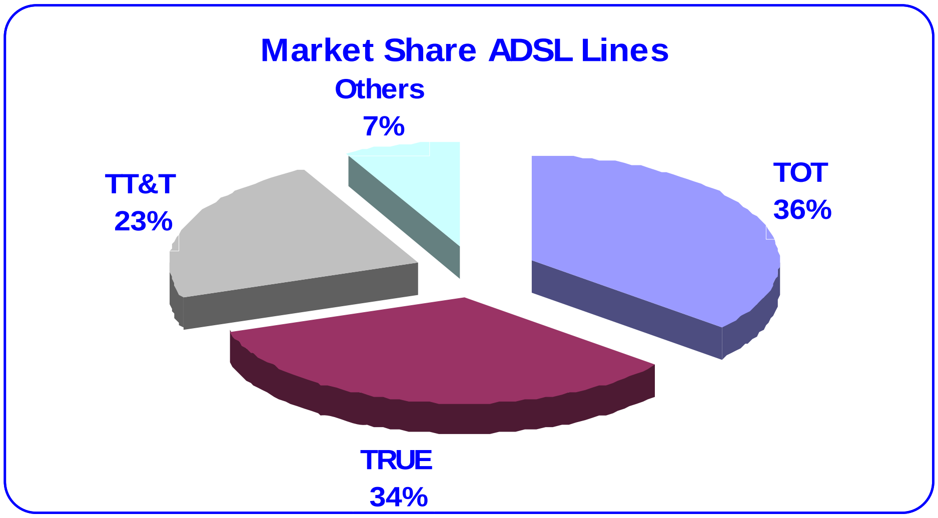


Figure 2: Market share for ADSL lines at 2008

## *2.3 Network Architectures*

- When analyzing current status of networks and services it is interesting to know the network infrastructure at different domains. Following diagrams summarize those structures for the initial networks and the ones being introduced. Initial network architecture at national level follows a multilayer historical structure with PSTN layer over ATM and SDH being IP layer introduced for data flows as indicated in Figure 3

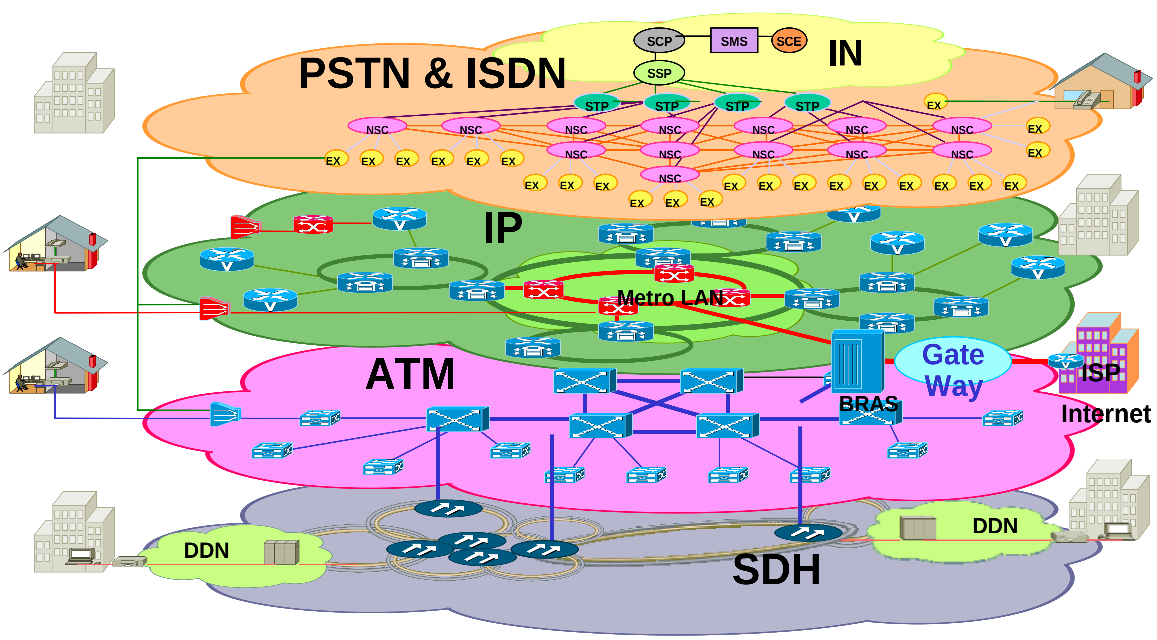

Figure 3: Historical network architecture at national level

For the area to be studied in BKK, the architecture of installed SDH network has an interconnected multiple-ring topology organized in 4 areas as illustrated in Figure 4:

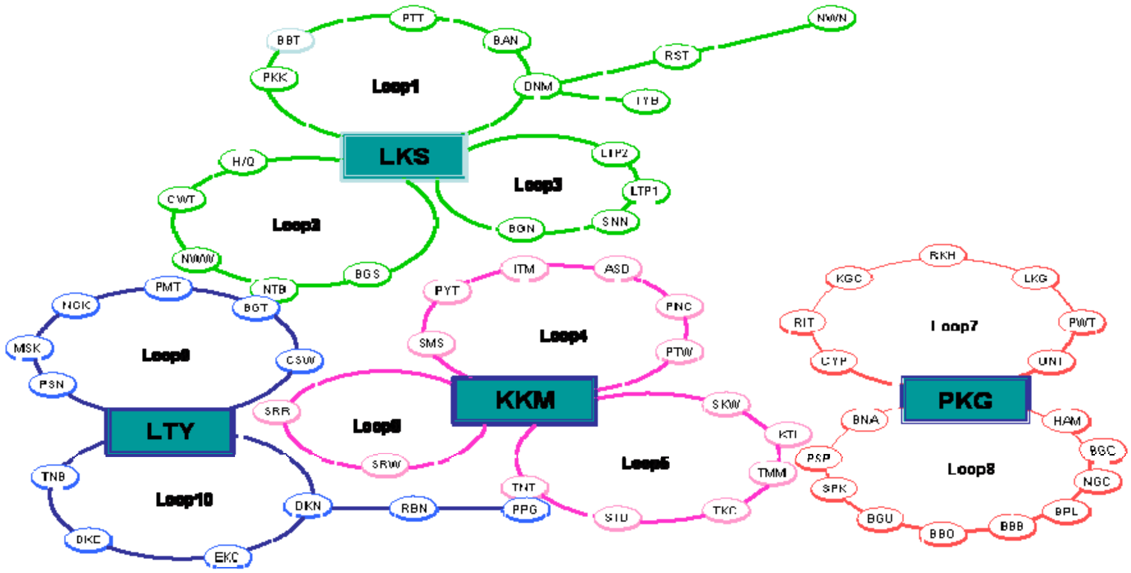


Figure 4: Multi-ring architecture for SDH network in BKK

- A new IP over DWDM architecture is being deployed in BKK areas as illustrated in Figure 5 that has the following architecture that will be the support of future access segment

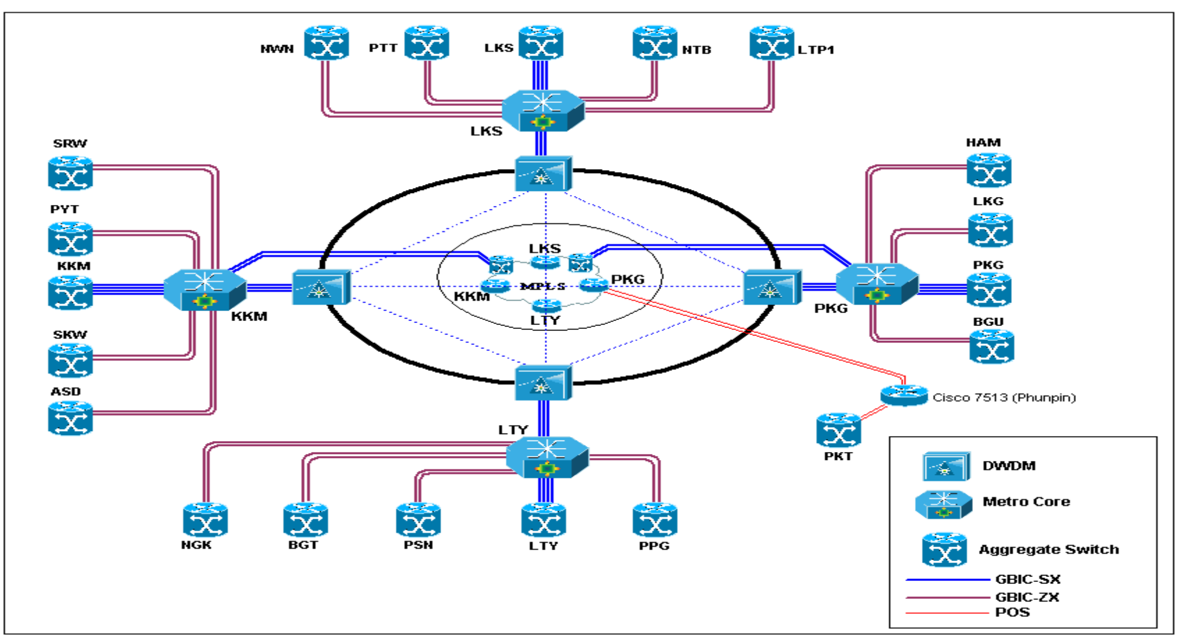

Figure 5: New architecture for IP over DWDM in BKK

- Actual new deployments for ADSL customers are based on the existing PSTN network with data flows over IP metro LAN as indicated in the Figure 6 in order to increase the backhauling capacity

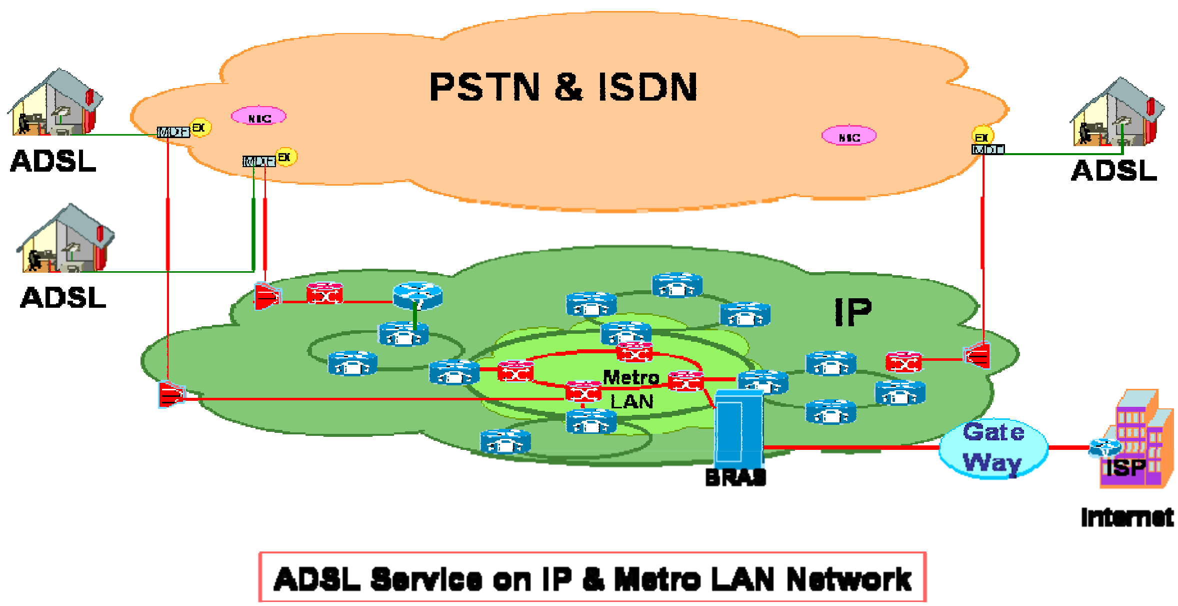


Figure 6: Current architecture for ADSL recent deployments

- Future new deployments of ADSL will receive service through an IP based network with access by DSLAMS and MSANs connected to a metroLAN and an IP Core towards the Gateway to Internet as described in the reference diagram in Figure 7

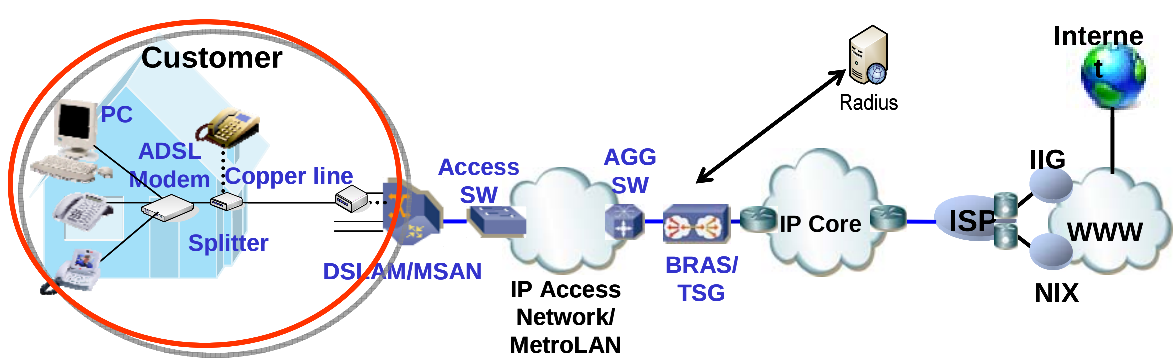


Figure 7: End to end architecture for future ADSL with higher capacity

- Planned network architecture at national level will follow a multilayered structure in line with the NGN trends and standards as indicated in Figure 8

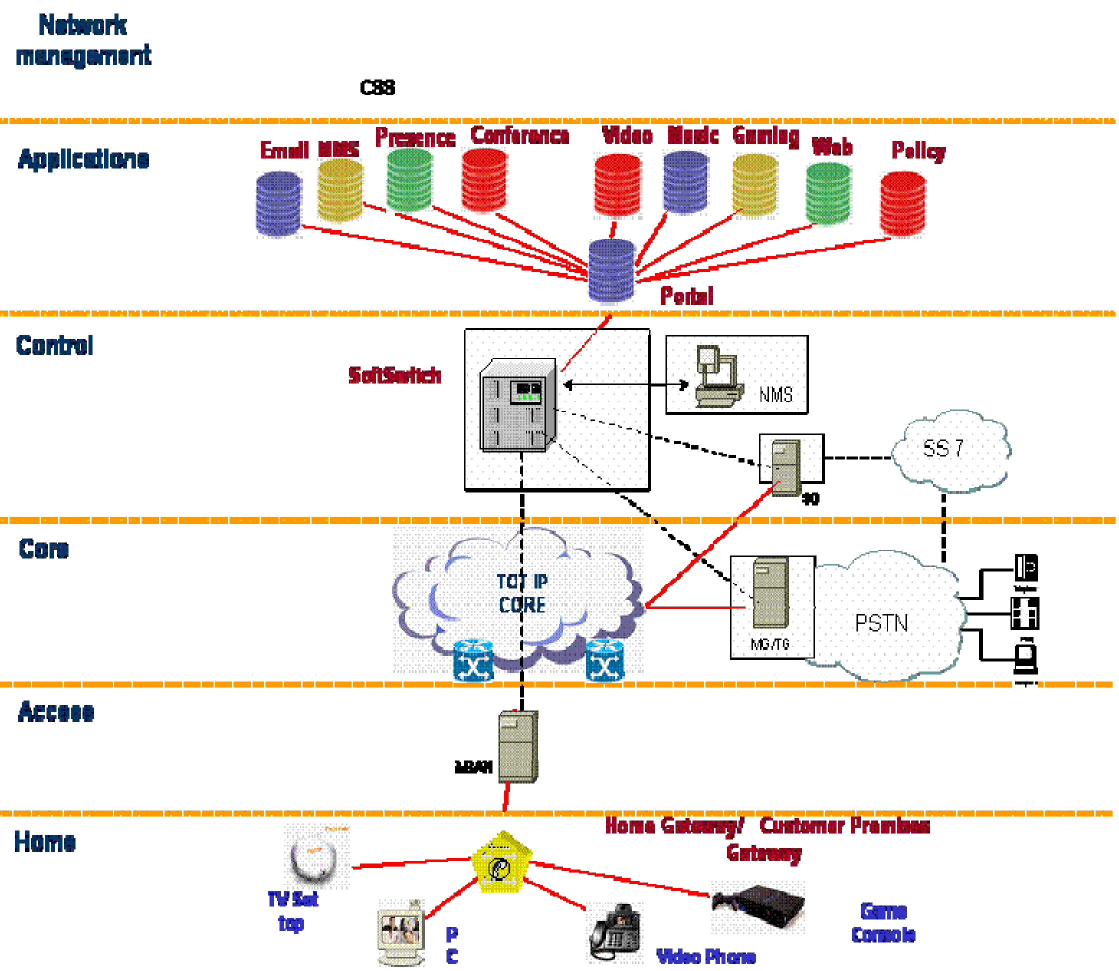


Figure 8: Planned multilayer network architecture for NGN at national level

- Actually the dominant service offered for internet to the public has a speed of 1 Mbps by 590 bahts. In total and including the VPN services with fixed IP addresses, 26 different service offers are provided to customers by various speeds and tariffs from 256/128 to maximum of 5120/512 (9200 bahts)

- Additionally other specialized services are offered as:

- Y-TEL1234
- PSTN 1222
- ISDN 1288
- IP VPN
- IP VPDN
- L2 VPN (Metro LAN)

# 3 Assessment on access

Project objectives for the assessment of current access network infrastructure were defined for an urban area within Bangkok in order to analyze capabilities of the physical network for a further provisioning of broadband services and to value the required enhancements. Bangkok had 6.5 million inhabitants at 2008 with a growing rate of 14% and is served by TOT in 4 telecom areas as indicated in Figure 9:

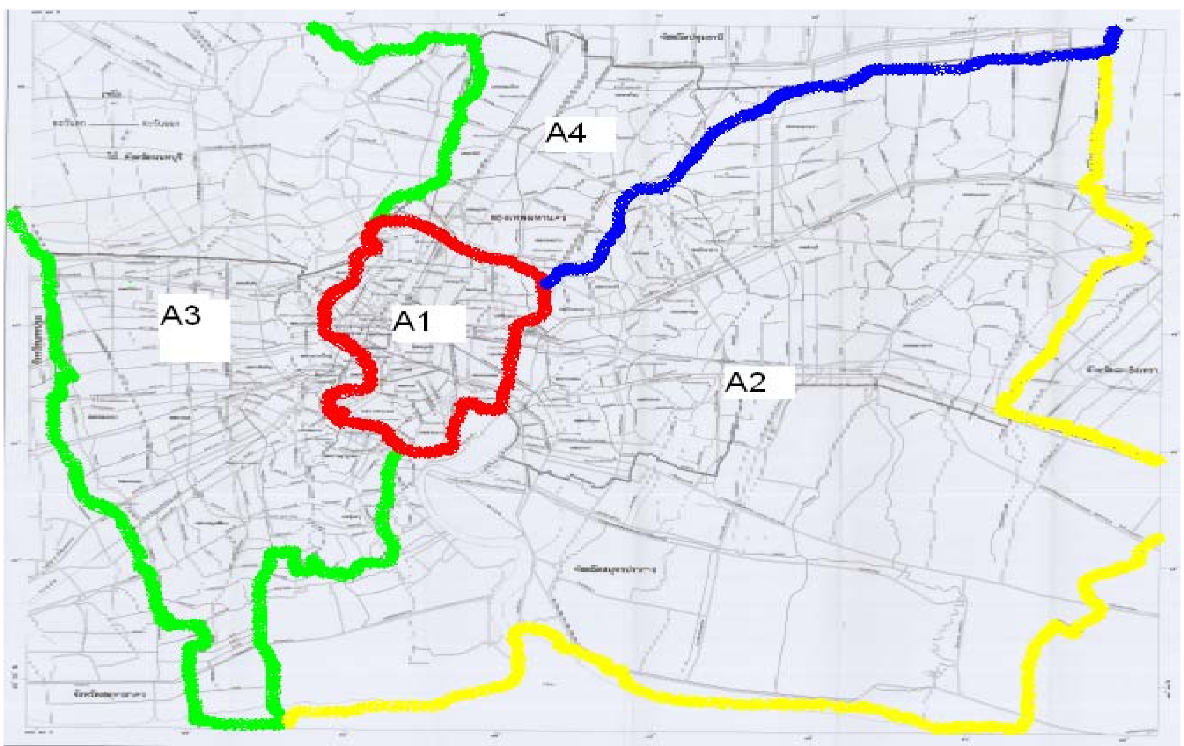


Figure 9: Four TOT service areas in BKK

- A1- Bangkok for urban central
- A2- Samut Prakan for south-east
- A3- Nonthaburi for west
- A4- Pathum Thani for north-east

- A visit was played to selected network locations in BKK in order to have a direct observation of network elements, equipment practices and aging status. A summarized graphical sample of three locations is given in Annex 4 with main cables and MDF of the largest exchange in central BKK (age 26 years), Example of aerial distribution cables, digital switching elements and a RSU/DSLAM cabinet. Equipment practice follows the good practices at the installation time except for the aerial distribution cables that is under the average conditions of other countries and of the required quality levels.

According to the project objective, general data were gathered for two areas A1 with population density and customer density per Km2 of 10520 and 3200 respectively and A3 with 3870 and 570 respectively. A3 was selected for the study due to the fact that more detailed information was available on the OSP infrastructure and also was considered to be representative of the most frequent urban network status, customer's density and services deployment.

Data gathered was focused on the key factors influencing network structure and cable characteristics critical for Broadband services as indicated in Template 2 of Annex 3. Transmission for the utilization of high frequencies in access copper cables is characterized by the Signal to Noise ratio (SNR) measured in dBs. The attenuation of transmission signal increases as a function of following characteristics in order of importance:

- The length of cable
- Cable gauge and material
- Amount of crosstalk between adjacent cables (function of cable age, isolation, humidity and filling degree)
- Cable discontinuities through the path (function of the historical connection practices)
- Noise gathered by induction of electromagnetic sources at customer premises or along the cable path (i.e.: radio emission, electrical power, etc. as a function of the Electromagnetic Compatibility practices)

- Due to large variety of cables and cable conditions, it is recommended to use measurements with proper sampling techniques for a first step characterization. Specific testing equipment for massive measurement may also used for a better loop pre-qualification with results of the order of 95% certainty. Final qualification has to be done always on a per customer base at installation phase.

- From the data gathered in Areas A1 and A3, the characterization of main influencing parameters is given in the following charts:

- LL length distribution within the A1 and A3 of Bangkok in dark blue shows a relatively good shape in line with most European countries as indicated in Figure

10 due to the good practices at network topology design and its correspondence to population settlements around nucleus.

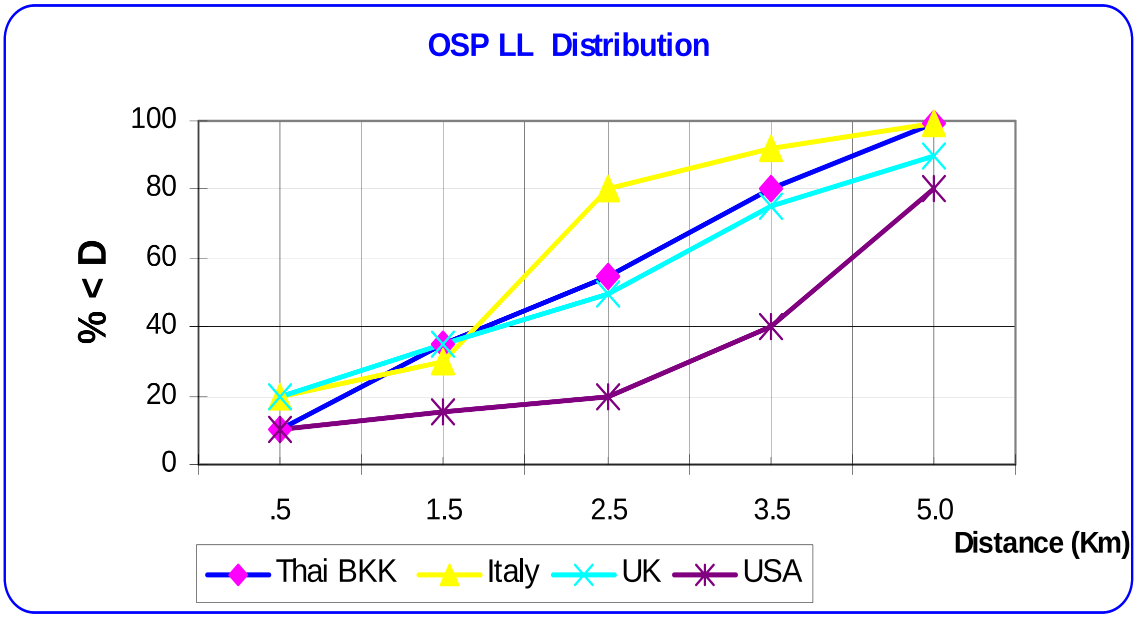


Figure 10: LL length distribution in BKK areas A1, A3 as compared with other typical countries

- Cable ages in A1 and A3 follow the distribution indicated in Figure 11 with significant proportion of cables at the end or close to the end of life cycle (more than 15 years) to be renovated both at the underground and aerial cases in short term as well as important values with more than 10 years that should be renovated at medium term

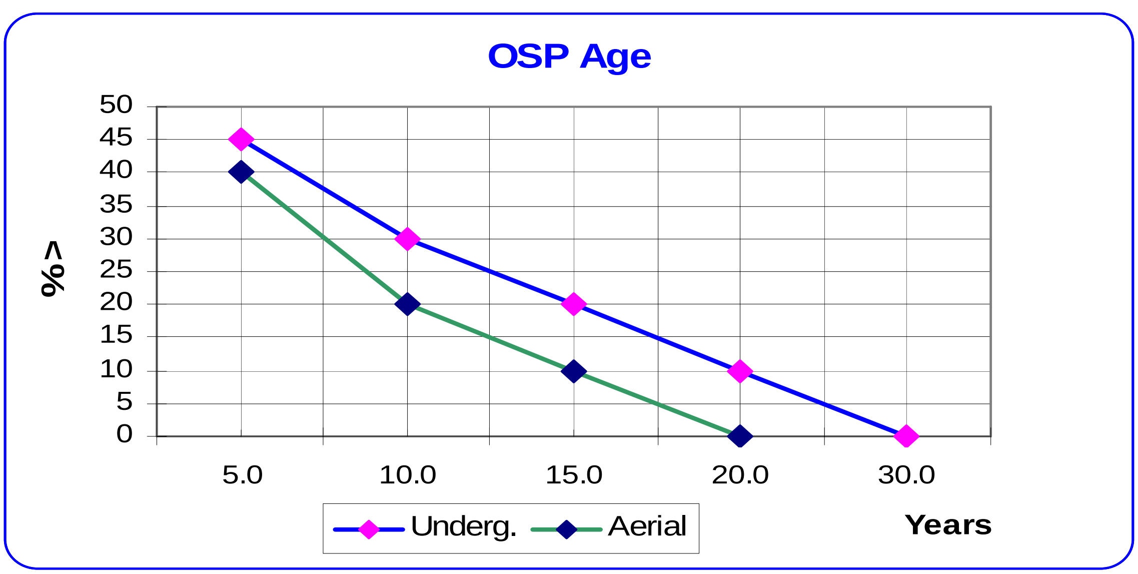

Figure 11: Distribution of cable age for underground and aerial cases

- Cable gauges in A1 and A3 are dominant for .4 and .5 mm as indicated in the Figure 12 thus limiting the data rates specially for cables with .4 mm at the high end of the loop

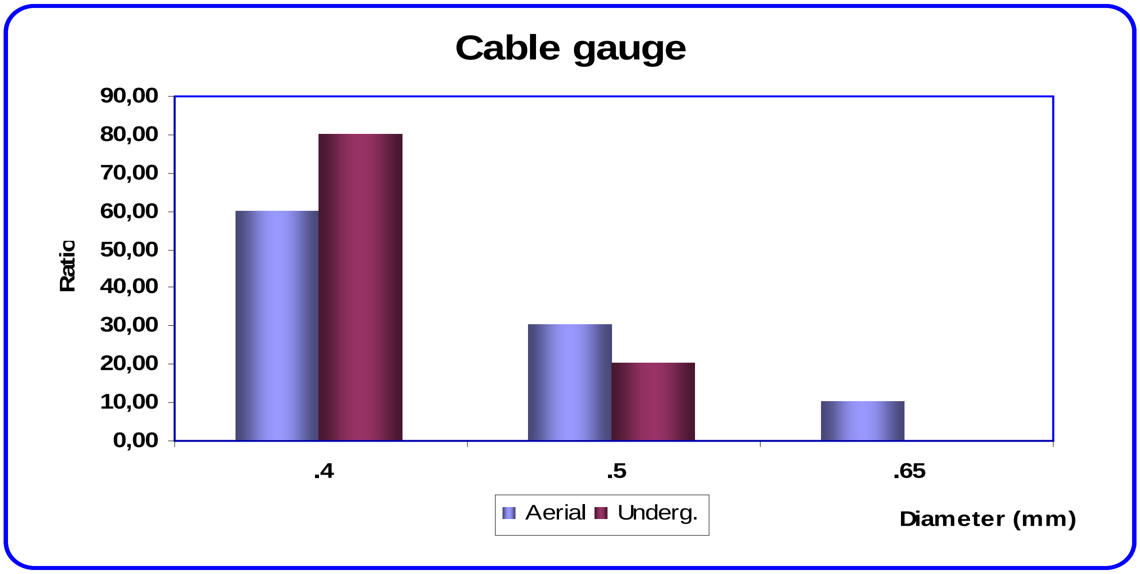


Figure 12: Cable gauge distribution per installation type

- A good metric for the analysis of the access infrastructure is the ratio of the different network elements as compared to the *"operational lines"* which are defined as those active lines associated to a customer and to the generation of revenues. These lines are the more important from a business perspective and the analysis of profitability. Taking as a base the *"operational lines"* at the BKK Area 3 the following Figure 13 illustrates the ratios of different Network Elements (NE) as a characterization of the access structure at current year. Ratio of available installed cables is 1.86 that is considered as adequate from the long term perspective as timing for cable installation is much higher than the required for electronic equipment. The ratio of installed lines or lines available at switching equipment is 1.24 that also is considered as adequate taking into account the modularity associated to the racks and cards in switching. Also the ratio of ADSL installed lines is adequate in view of the new technology to be installed.

- An important parameter for the ADSL quality is the fill-in degree or ratio between operational lines and available cable pairs in the same cable, that is in average:

8% and is far from the fill-in degrees in which cross-talk starts to be important: 60% for medium frequencies and short distances and 25% for high frequencies and longer distances. Although this factor is not expected to be influencing until higher ADSL penetrations take place in several years ahead, a more detailed analysis should be made to know the dispersion of fill-in degrees in different zones as compared to the average.

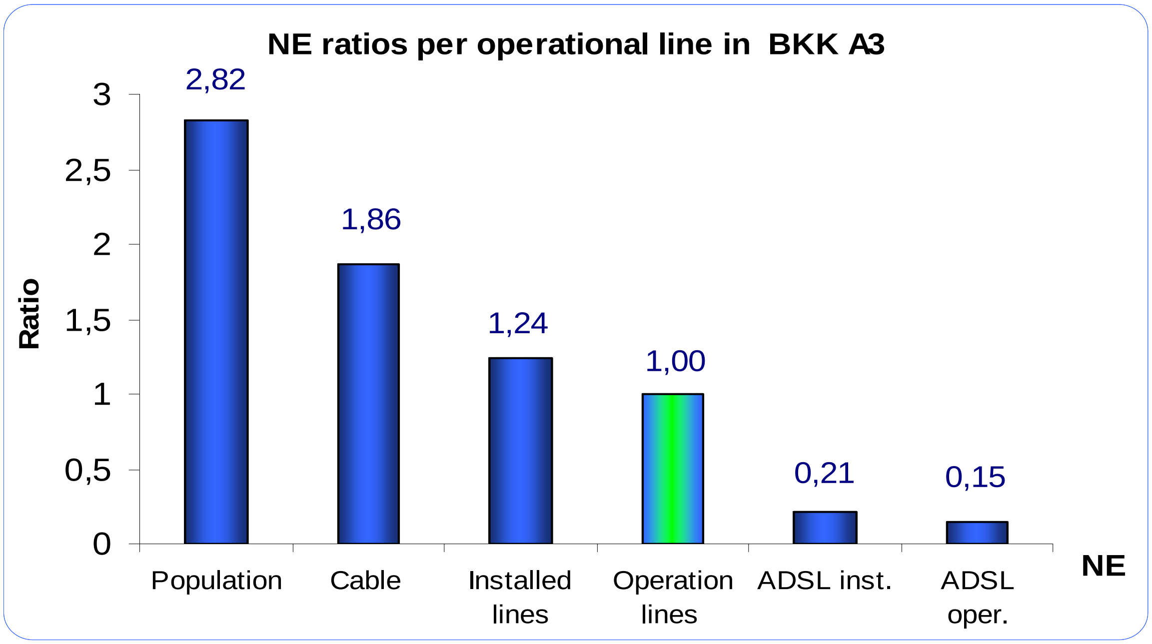


Figure 13: Access infrastructure ratios as a function of operational lines

- The level of cable plant modernization will be a function of previous characterization and the Mbps capacity reachability by the xDSL technologies which depend on the cable distance to the MDF or FDF. From analysis in lab cables and experience in existing networks, the following Figure 14 summarizes the xDSL technologies including both ADSL and VDSL capacities as a function of the distance: Blue line gives the maximum theoretical capacity in Mbps with cables at lab conditions while the red line illustrates the engineering capability at real conditions of the field where many practical details of actual cable installation decrease the maximum theoretical reached distance. In order to assure the contract capacity in a commercial offer, the dimensioning has to be done with the engineering capacity in such a way that at least more than 98% of lines fulfill the capacity in the peak periods.

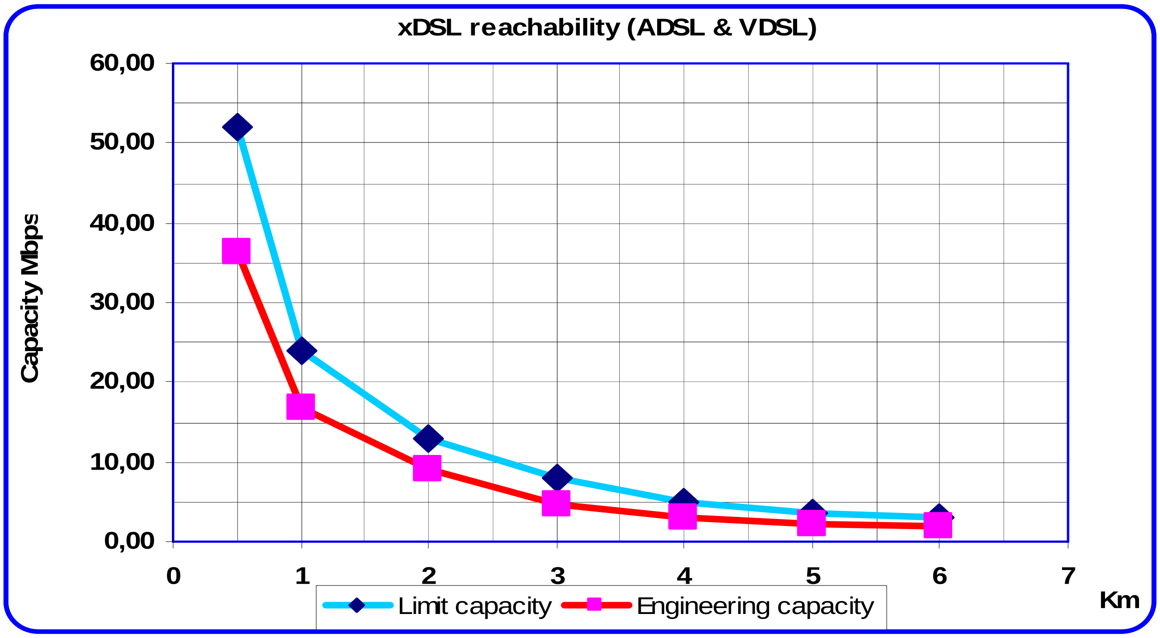


Figure 14: Speed reachability for xDSL technologies as a function of cable distance

- A series of speed measurements on existing ADSL lines today across the country provides the results in Figure 15. Behavior in this case shows the same generic shape (for ADSL) than the reference in Figure 14 until Km 2.5 with a higher decrease after that distance probably due to the cable aging factor.

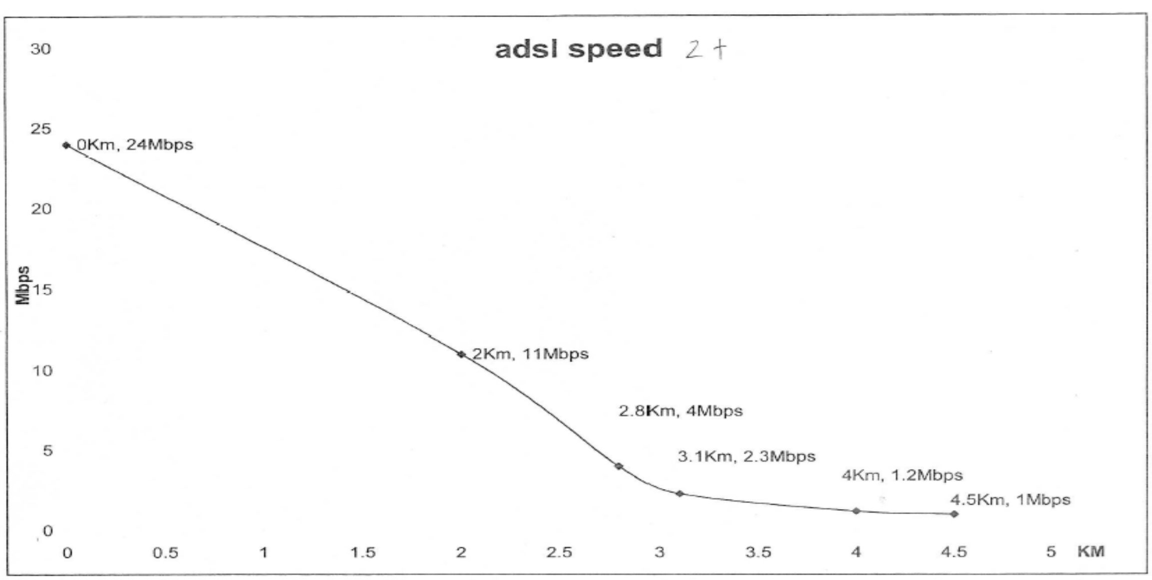


Figure 15: Speed reachability measured for ADSL 2+ as a function of cable distance at country level

Another performed metric at the current DSLAM Network Management System (NMS), for the maximum data rates in installed DSL lines, illustrates the percentage of lines that may provide higher speeds than the values defined in the range from 1024 Kps up to 7168 Kps. This measurement is of the black-box type and do not analyze the origin of the limitation that could be any combination of the ones identified above. It is derived that a value less than 68% of lines are candidates for the triple play services in this specific sample.

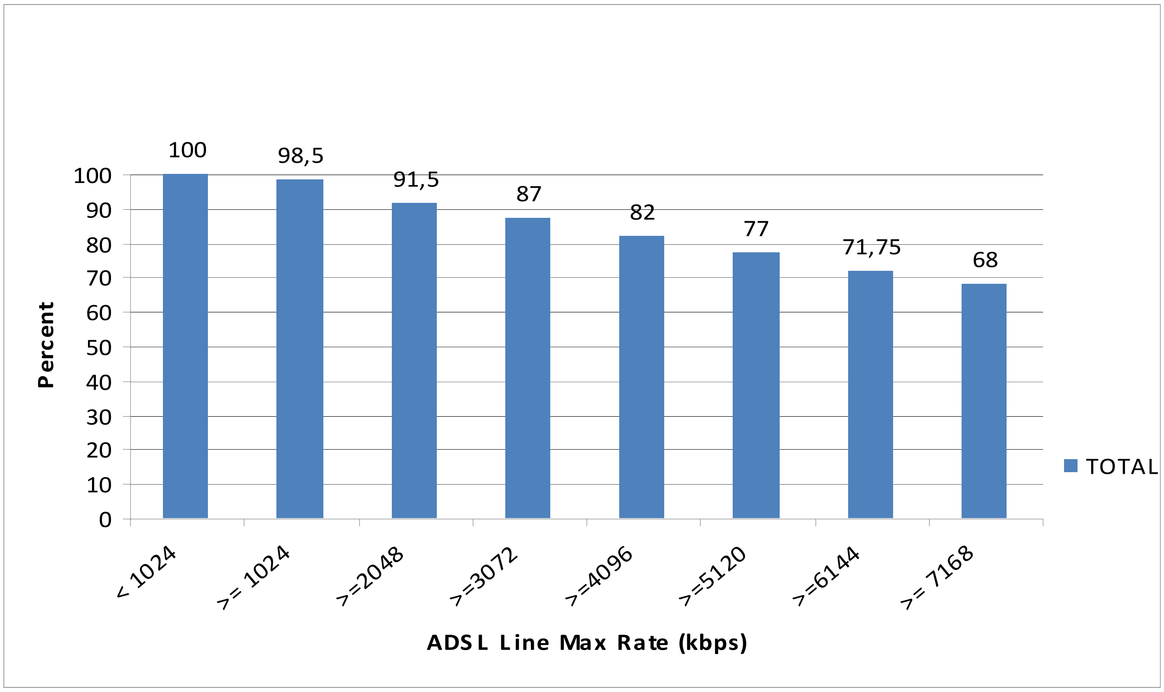


Figure 16: Percentage of Max line rates measured at a sample of current ADSL lines

- When considering the end-to-end access network across the different network elements from the user terminal until the ISP gateway (national or international) data flows capacities should be dimensioned for all transmission and processing elements in the entire path. Current dimensioning is performed by an empiric value of the concentration factor from the user peak rate up to the IP network for residential customers and other value for business customers. In addition an empiric percentage of IP flows are assumed to be international. Some customers' complaint from a decrease of speed at peak hours that may be due to the limit at backhauling capacity and the lack of a well establish path dimensioning.

- It is recommended to follow the concept of Sustained Bit Rate (SBR) in reference 1 or bit rate measured over a well defined period (ie: 5 minutes) with the corresponding Quality of Service parameters and measure those factors in actual access network to have a more realistic dimensioning for the country utilization. A better characterization proposed for network design and planning based on the main influencing factors imply the measurement of the following parameters that will provide the overall concentration factor knowing the cause and behaviour of each customer class:

- **ρ:** Customer connection ratio or percentage of time a user is connected to the network
- **α:** Activity ratio or percentage of time that a connected user is active at any internet application
- ***μ*:** Transmission ratio or percentage of the activity time that the user is effectively transmitting packets according to the application types being used

The overall average Sustained Bit Rate: **τ** (i) generated by a customer of class (i) will be:

$$\tau(i) = \rho(i) \times \alpha(i) \times \mu(i);$$

And the aggregation of traffics for n classes of the same QoS:

$$T = \sum \tau(i) \text{ ; i=1 to n}$$

This more detailed characterization allows for a good knowledge of user behaviour and for a definition of parameters that are either stable over time or a function of customer contract type and access speed. Using the SBR calculated or measured at the same time period, facilitates the aggregation of SBR (i) for different users and classes of the same quality at a given network element (transmission link or node) to assure a correct dimensioning of access paths for the required QoS.

# 5 Techno-economic modeling for access evolution

Being the access segment the more important in required investments, the techno-economic evaluation acquires great relevance and is the key decision factor to select target solutions and migration paths among the many alternatives that the equipment suppliers are offering.

Within the activity, main issues for access modelling are identified as well as key drivers for the evolution, scenario definition and tool based business evaluations. Performed activities are described in next chapters:

## *5.1 Issues and modeling*

The following issues are associated to the planning of the access evolution:

- Knowledge for the total market volume, share with competitors and offered services
- Required Multilayer network characterization with physical and functional levels due to the high interdependency between them and influence on costs of the civil infrastructure
- Selection of Target network architecture and technology within the many alternatives that the suppliers are offering today
- Definition of Evolution path, steps and timing from initial status to target solution
- High impact of physical network status, coverage, quality, etc. that have to be quantified for adequate decision making
- High Investments required high for physical infrastructure that conduct to the need for optimization and sharing
- Investment recovery time higher than in core segment as a function of reusability of existing networks (from none at Greenfield area up to high in areas with a modern and flexible infrastructure) that cannot be recovered by voice service only and requires revenues generated by new multiservices

- Selected access modelling methodology follows the principles defined at the Reference 1) ITU-D - *Technology and network development: "Manual on Network Planning for Evolving Network Architectures"* that is here extended specifically for fixed network of the access segment in an urban area.

- Evaluation methodology is based on the development of techno-economical models and interrelations for the agreed scenarios in order to establish dependencies among customer population, market share, services demand, resource dimensioning, costing, evaluation of operational expenditures and network profitability with the capability to compare equipment installation rates, capacity required, traffics, CAPEX, OPEX, cash flows, NPV, etc.

- Data gathering is structured for inputs related to generic market values, selected scenarios in the Bangkok area from the current infrastructure, cables, local exchanges and access units as well as for future technology to be used following the defined templates at the Annex 3: T1. - Template for data gathering on main Socio-economic inputs, T2.-Template for data gathering on main physical network inputs and T3. - Template for data gathering on main Functional Network inputs

- Due to the need for multiple evaluations and the “what-if” analysis associated, STEM tool (see reference 11) is the selected planning platform for implementation of the variety of access configurations, the dynamic migration from current status to the future one, capability to perform sensitivity analysis and ability to incorporate new market solutions.

- In any techno-economical evaluation it is important to select those key drivers that impact in the solution dimensioning, costing and business results. The following are considered as the main ones:

- Demand related:

  - Deployment geographical area characterization
  - Services penetration at planning year 0 and planning period
  - Traffic in erlangs for voice circuit though time
  - Traffic in Mbs for VoIP, BB internet and IPTV through time

- Equipment and Network Element (NE) related

  - Network demand units (customers, lines, ports, erlangs, Mbps, nodes, platforms, etc.)
  - Capacities of each network element as a function of the dominant capacity driver
  - NE modularities for realistic dimensioning with equipment practices
  - Speed for migration for customers and associated network equipments

- Cost/Revenue related:

  - Capital investment for extended or new equipment
  - Leasing, Maintenance, Operation per NE
  - Generic project and network transformation
  - Tariffs per service associated to a new connection, monthly fee or traffic consumption)
  - Global socio-economic parameters as interest rates, depreciation policy, etc.

### 5.2 Scenario definition

- In order to evaluate the consequences of different evolution directions, a number of alternatives or scenarios need to be defined at the network technology level and also for modernization of the access physical infrastructure.

- The following 5 scenarios were considered significative for the defined objectives of this project and the ICT development level in Thailand:

  - Scenario 1 or Present Mode of Operation (PMO) in which voice and data services are carried as in the historical networks: dual play with circuit mode PSTN for voice and Internet over separate data network. This reflecting the dominant solution today and to be used as basic reference for other cases

  - Scenario 2 or NGN migration with dual play in which services flows continue separated from the user up to the Access node (MSAN) type where flows are integrated in IP mode towards an NGN network in upper layers

  - Scenario 3 or NGN without OSP enhancement and with convergence at triple play. This incorporates to Scenario 2 the IPTV and Video on Demand (VOD) services thus requiring corresponding elements at the network and 8 Mbps capacity at user side. Here only for those users in the area close to the LE and active nodes (< than 2 Km cable length)

  - Scenario 4 or NGN medium OSP enhancement that implies triple play as in the Scenario 3 but extending modernization of the OSP cables and civil infrastructure with additional remote units to cover more easy zones.

  - Scenario 5 or NGN high OSP enhance that implies to install the necessary number of remote access nodes and modernization for OSP cables and civil infrastructure to reach all customers in the area and fulfilling the non-discrimination rule

Simplified functional diagrams associated to these scenarios and used as a base for the modeling of resources to be evaluated are described at following charts:

Historical configuration to be modeled as scenario S1 or Present Mode of Operation (PMO) with separated voice and data networks as simplified in Figure 17

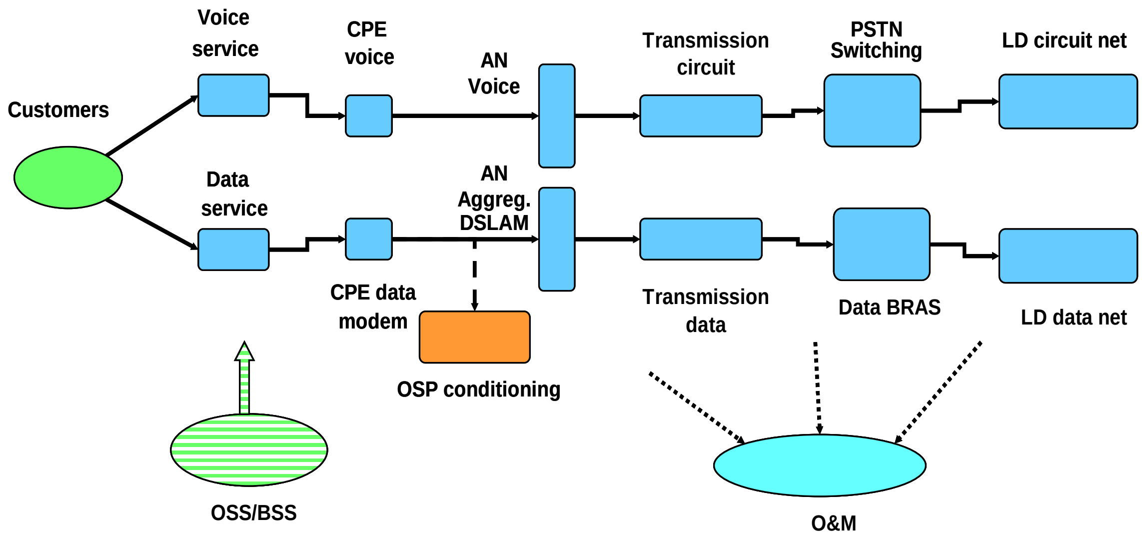


Figure 17: Functional configuration for the modelling of PMO

- Access related equipment is modeled with the corresponding modular dimensioning, costing and substitution at the end of life cycle as a function of the services demands and flows
- Upper network segments are modeled as more generic elements with the associated dimensioning and costing to allow the economic evaluations for NPV and global project value.
- OSP enhancement here implies only LL conditioning for ADSL with the possible speeds per user without changing cables or OSP infrastructure that is calculated in 2 to 3 Mbps for all customers at each cell.
- OSS/BSS considers the continuity and maintenance of existing platforms for services and customer care
- O&M considers operation and maintenance of the involved historical equipment

The new configurations to be modeled as scenarios S2, S3, S4, S5 (simplified at Figure 18) correspond to the  NGN alternatives with convergence of network and services at the access node either with provisioning of dual play: VoIP and BB internet or triple play: VoIP, BB internet and IPTV

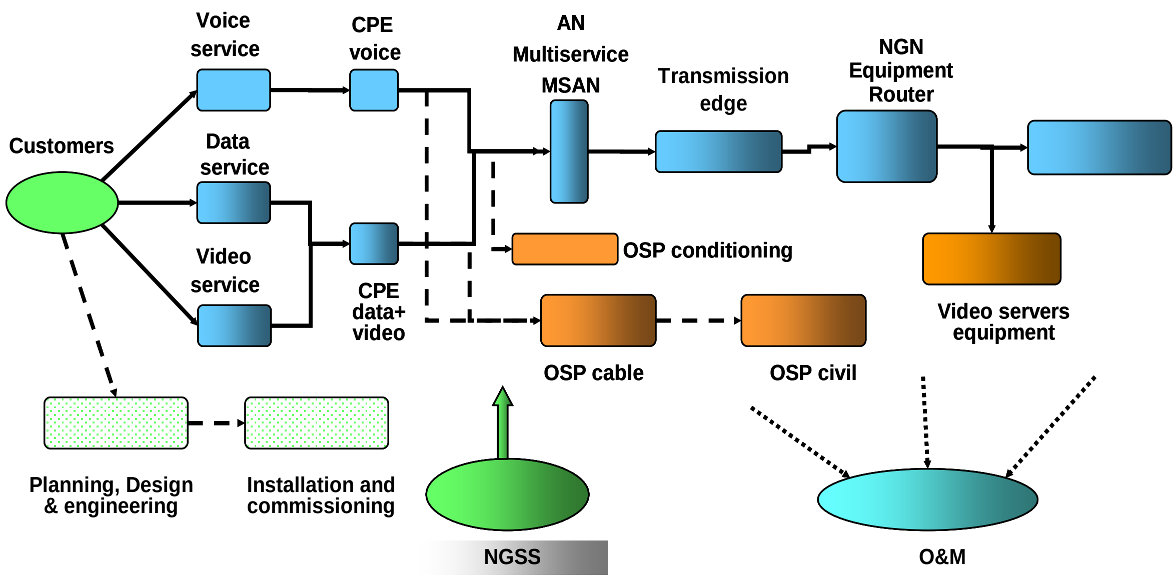


Figure 18: Functional configuration for the modelling of variants in NGN cases

- In all 4 NGN scenarios initial configuration at year 0 starts with the configuration of PMO at Figure 17 and migrates towards the final solution according to the defined rate for substitution of existing equipment and association of new customers to the new technologies (here simplified by the colour intensification)

- OSP enhancement for cable and civil in this case implies modernization of the Outside Plant with the new cables and/or new ducts as a function of the initial status of OSP and reusability to assure the quality and capability of at least of 8 Mbps required for triple play.

- New Generation Support Systems (NGSS) or integrated OSS and BSS applications in a platform for all services within the NGN

- O&M here considers operation and maintenance of the mix for involved historical equipment and new equipment according to the assignment of new technology to new customers and substitution of the existing ones.
- Transformation project activities and costs that include the activities of Planning, Design and Engineering as well as the installation and Commissioning for new technologies

# 6 Business evaluation results

The simulation for the scenario evolution from the PMO towards the selected one is modelled for the services demand, network resources, traffic flows, dimensioning, costing, tariffs and business quantification with all necessary modelling objects to represent dynamically the parameters as a function of time and simultaneously for the existing scenario and the introduction of the new ones. In total more than 60 different network objects were represented with an average of 8 parameters each.

In order to facilitate the evaluation for all cases and the what-if analysis for changing assumptions models are implemented in STEM tool (at reference 11). Data gathered with templates at Annex 3 were used for the tool running after the corresponding testing and validation process for each scenario. Main assumptions used and obtained results are summarized as follows:

## *6.1 Assumptions for evaluation*

General assumption for the evaluations

- Analysis period for the evaluations was selected as 10 years in order to be able to see the life-cycle effects of different network element types.

- Standard reference financial parameters were used for discount rates of 10% during the evaluation period and long term perpetuity rate to evaluate terminal values of network (3%)

- Standard linear assumptions for the depreciation and amortization rules were considered

- Life cycles modeled for the different NEs were: 4 years for CPEs, 6 years for ANs, 6 to 8 years for core nodes and 20 years for OSP

- Existing installed equipments were considered not to be at the end of life-cycle at the start of the period thus requiring substitution at the corresponding life cycle expiration

- Specific assumptions for BKK Area 3

- Population of 2,383.811 inhabitants at end 2008

- Population density of 3.833 at year 2008

- Customer density: 569 customers per Km2 at 2008

- Customers: 354.090 at end 2008

- Potential market volume in lines for TOT 460.000 at year 10

- ADSL LL length for 8 Mbps guarantee: 2 Km for cable length or 1.43 geographical radius

- Average number of installed cables per operational line 1.86

- Proportion of reachable LL for BB 8 Mbps at initial period by distance factor: 45%

- Proportion of aerial/underground installation at the distribution network: 70/30

- Migration speed towards NGN at a medium pace in 3 consecutive years with rates of 20/60/20 that is feasible in a region (note that is not feasible in all regions at the same time for financial and know-how limitations). It should be emphasized that a quicker speed is difficult to implement for a new technology first time and a lower speed will imply longer period of both technologies working in parallel that do not facilitate saving in OPEX

- Tariffs for voice service decreasing 5% per year in average

- Tariffs for data service of 1000 baths/month for BB access at 8 Mbps and decreasing at 3% per year in average

- IPTV service using MPEG2 digital quality with an average speed of 3.5 Mbps. Tariffs for IPTV service equivalent to current market value of silver type: 750 bahts

- Pricing Access Nodes calculated for an initial configuration of voice /data ports of 80/20 due to the different costs of voice and data cards.

- Company financed CPEs for users: 30% for traditional modems and higher values for new terminals due to the modernization promotion: 50% for new voice/data CPEs and 60% for new IPTV set-top box.

## 6.2 *Business results for evaluated scenarios*

- A high number of results were obtained for all scenarios and alternatives analyzed. The most important results for comparison of solutions and decision making are summarized below and include: Net Present Value (NPV), demands, revenues, CAPEX, OPEX and Operating Charges.

- Figure 19 illustrates the best global project evaluator when very different life cycles coexist in a project (from 4 to 20 years): Net Present Value at perpetuity rate that shows a gain for the migration towards NGN even maintaining only the dual play services mainly due to the savings in OPEX. Note that here and in all next diagrams year 0 is considered for a common initialization of the simulation cases and do not has a specific meaning.

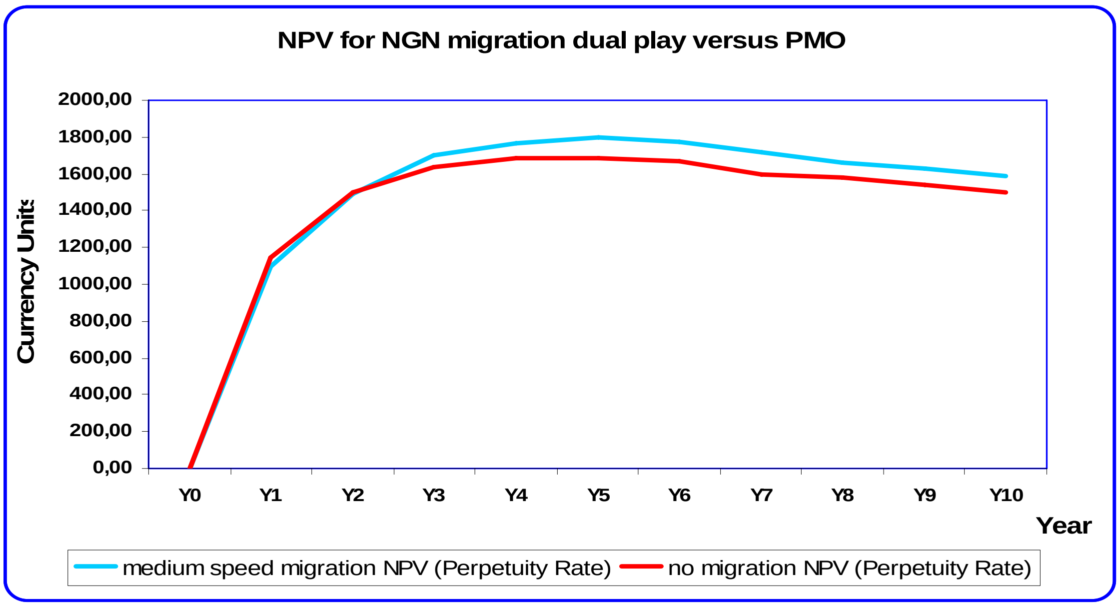


Figure 19: NPV at perpetuity rate for PMO and dual play NGN

- Differential NPV at perpetuity rate trough time at Figure 20 shows gain after year 3 that justifies by itself the modernization with NGN but do not exploit the capabilities and revenues of new services:

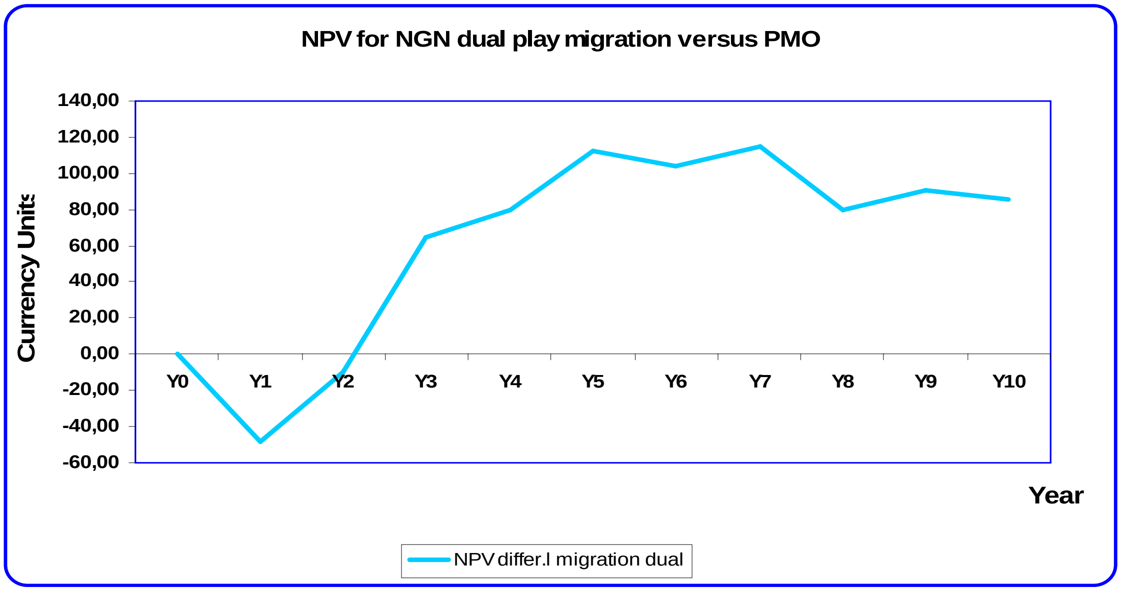


Figure 20: Differential NPV at perpetuity rate for PMO and dual play NGN

- Operation Charges (including all financial charges: depreciation and amortization) trough time for PMO and NGN dual play show important savings that increase trough time mainly due to OPEX savings

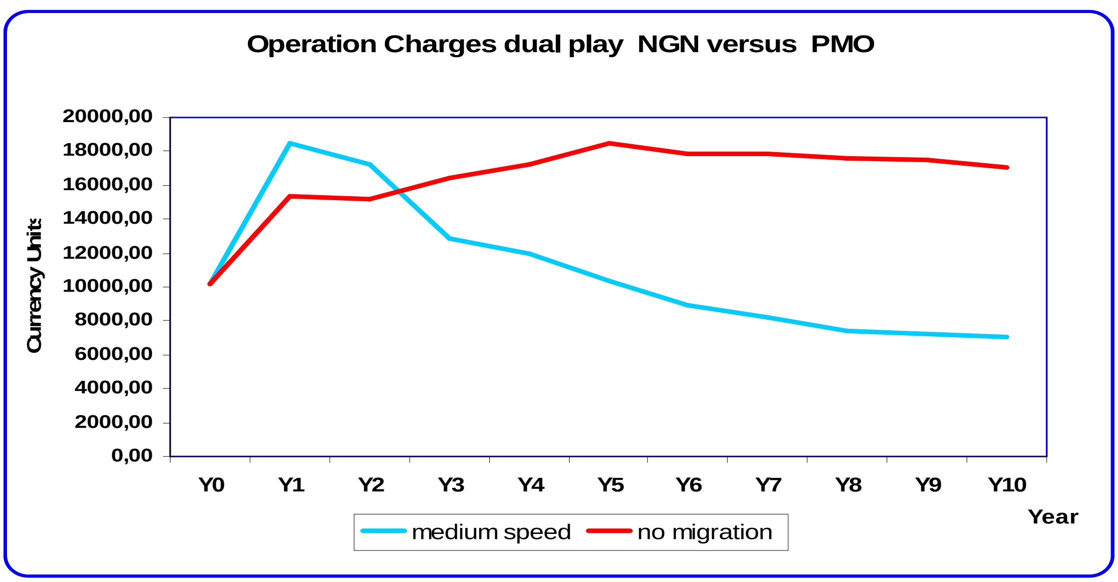


Figure 21: Evolution of Operation charges for PMO and dual play NGN

- When introducing new services for triple play, the evolution of services demand projected with the mentioned assumptions for voice, BB internet and IPTV with VOD is given in Figure 22 as a function of 3 assumptions on customer geographical coverage that depends on the level of OSP enhancement.

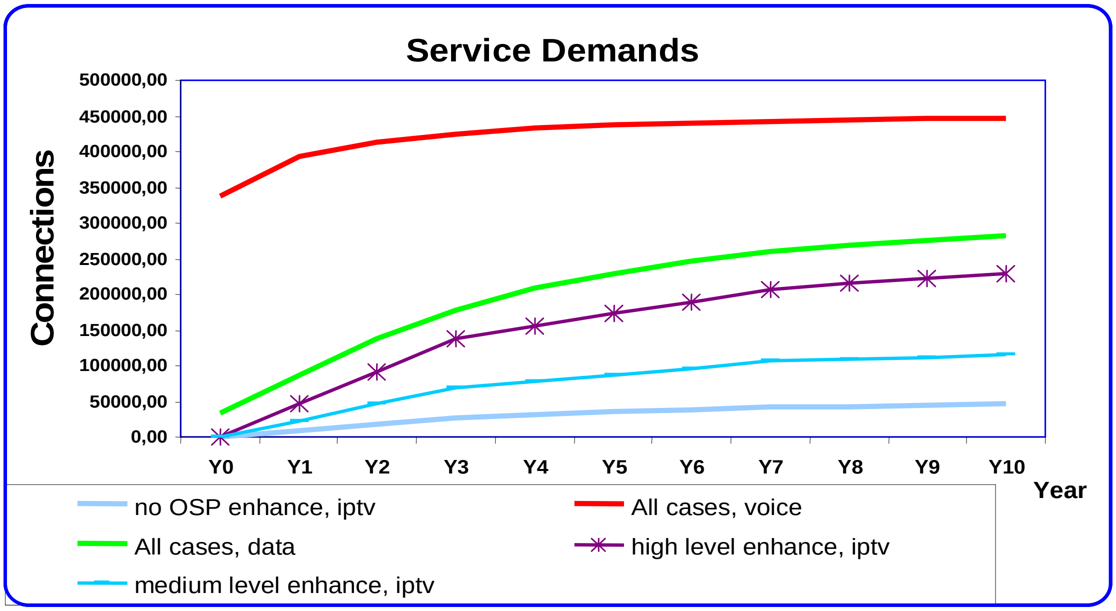


Figure 22: Service demands for NGN triple play scenarios in function of customer's reachability

The Figure 23 illustrates the global project evaluator: Net Present Value (NPV) at perpetuity rate for all simulated scenarios: PMO and NGN alternatives. It shows a gain for all NGN alternatives that is higher as wider enhancement of OSP and more customers reached for BB services and IPTV. This is due to the new revenues and convergence by economy of scale that largely compensate the high OSP investments. That level of OSP enhancement would not provide positive results if based only in voice and internet at speeds lower than 2 Mbps

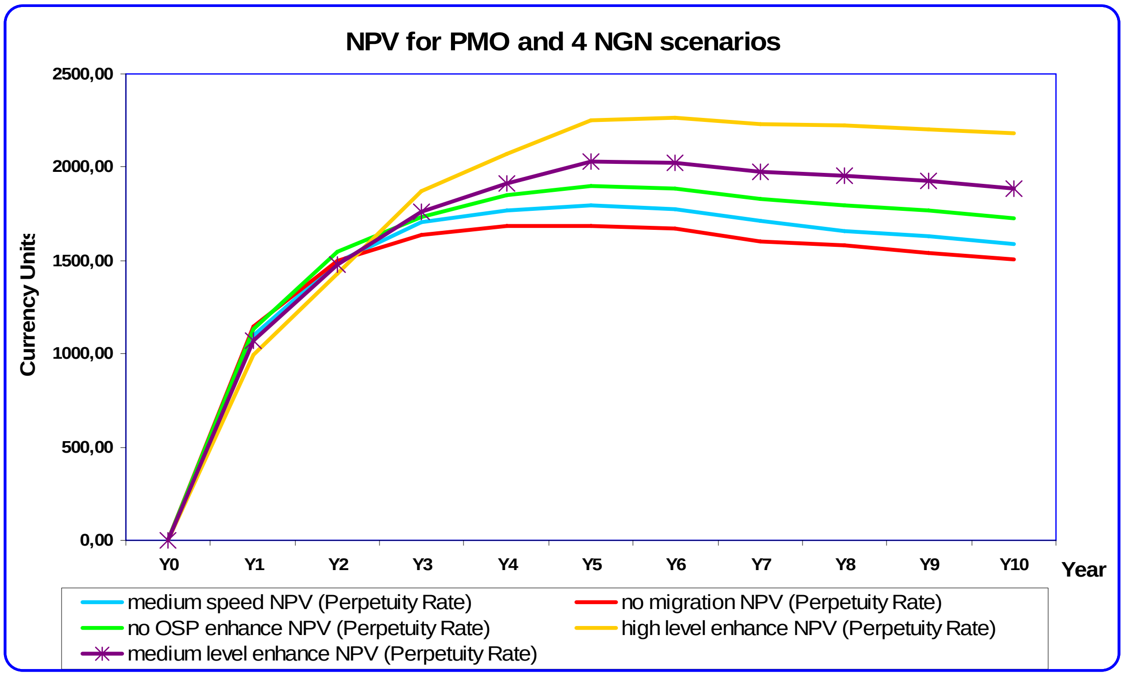


Figure 23: NPV at perpetuity rate for PMO, dual play and triple play NGN scenarios

Differential NPV at perpetuity rate trough time at Figure 24 indicates a gain at year 3 that justifies the important investments in OSP and access modernization with NPV increasing through time in proportion to the number of reachable customers that generate new revenues

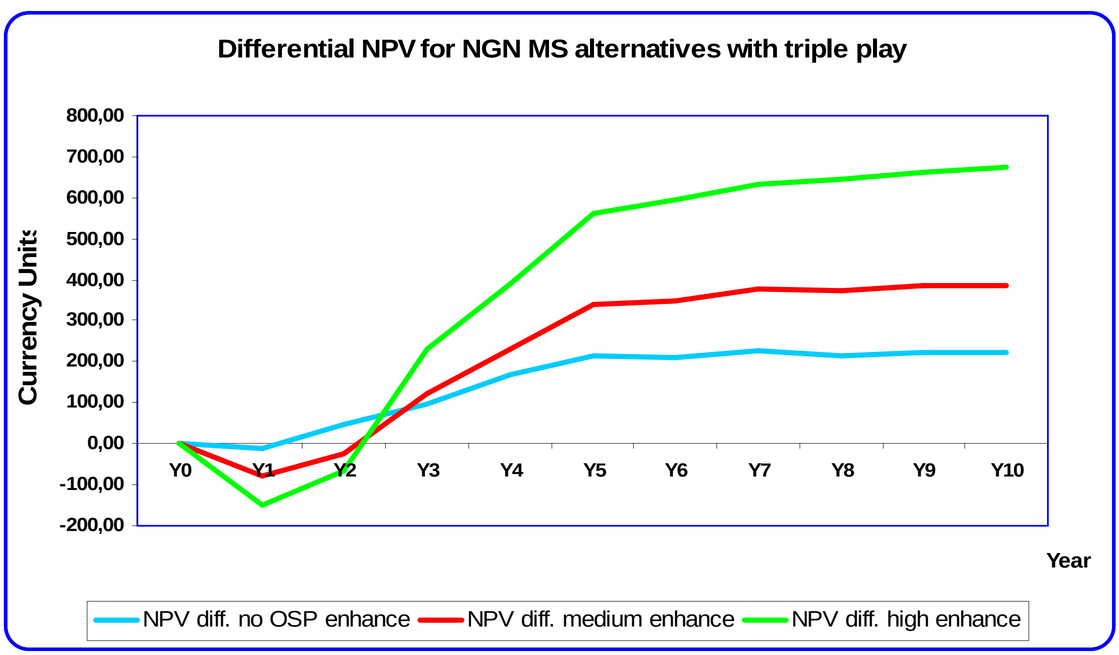

Figure 24: Differential NPV at perpetuity rate for NGN triple play alternatives respect dual play

Capital expenditure at Figure 25 shows a different profile at the 4 scenarios due to the important investments at the transition years in OSP modernization, new integrated Access Nodes and renovation of multiservice CPEs but converging at medium term when modernization completed. Main differences at long term are due to the higher number of CPEs substitution at life-cycle end

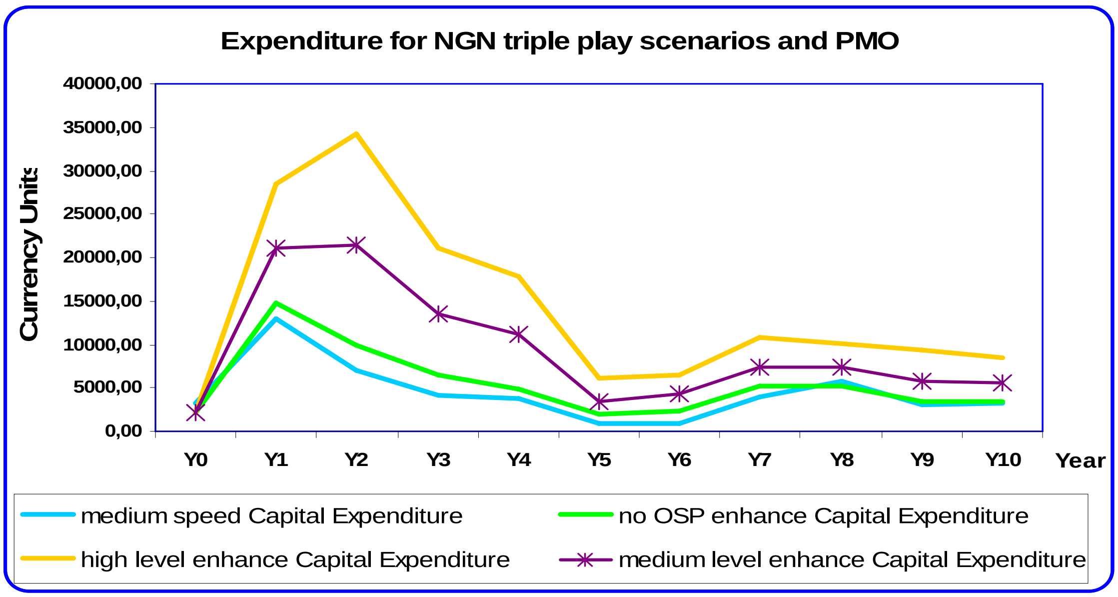


Figure 25: Capital expenditure for the NGN triple play scenarios and the PMO

Differential expenditure and revenues with the PMO at Figure 26 illustrates the importance of migration towards NGN with a high capacity access network in order to benefit from the new revenues and positioning for market competition increase. Advantage for multiservice solutions in future market equilibrium will be higher than the ones identified here due to the loosing of customers for non bundle offers for the non-multiservice ones

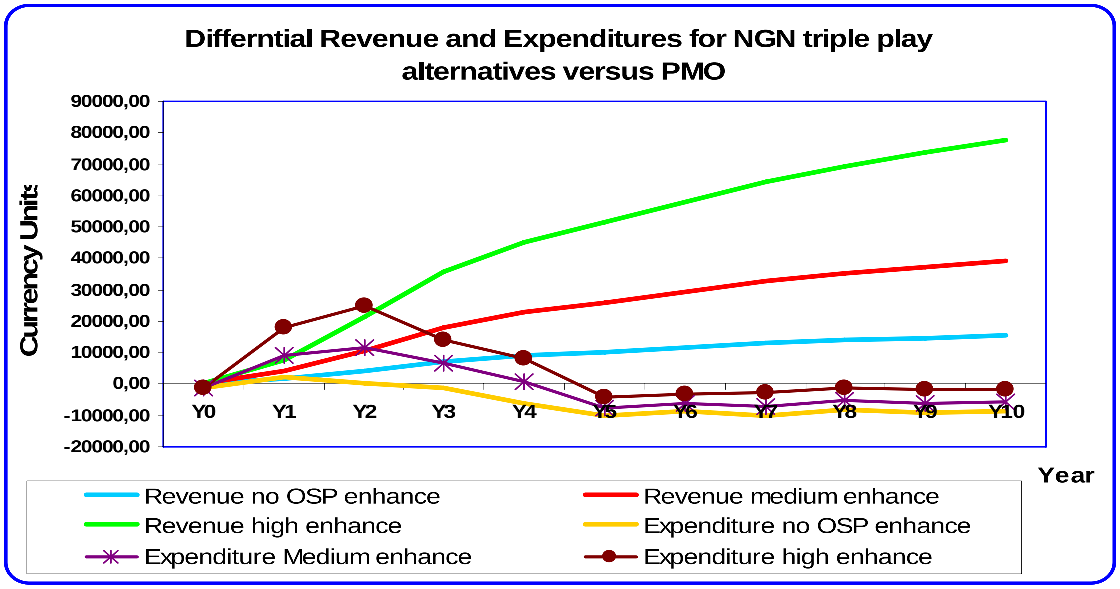


Figure 26: Differential revenues and expenditures for NGN triple play alternatives respect PMO

Diagram at Figure 27 provides the overall services revenues evolution through time as function of the assumptions taken. Voice revenues will decrease due to tariff deterioration by high competition while BB internet and IPTV will increase due to the number of incorporated customers. IPTV is as much higher as reachable customers in the area.

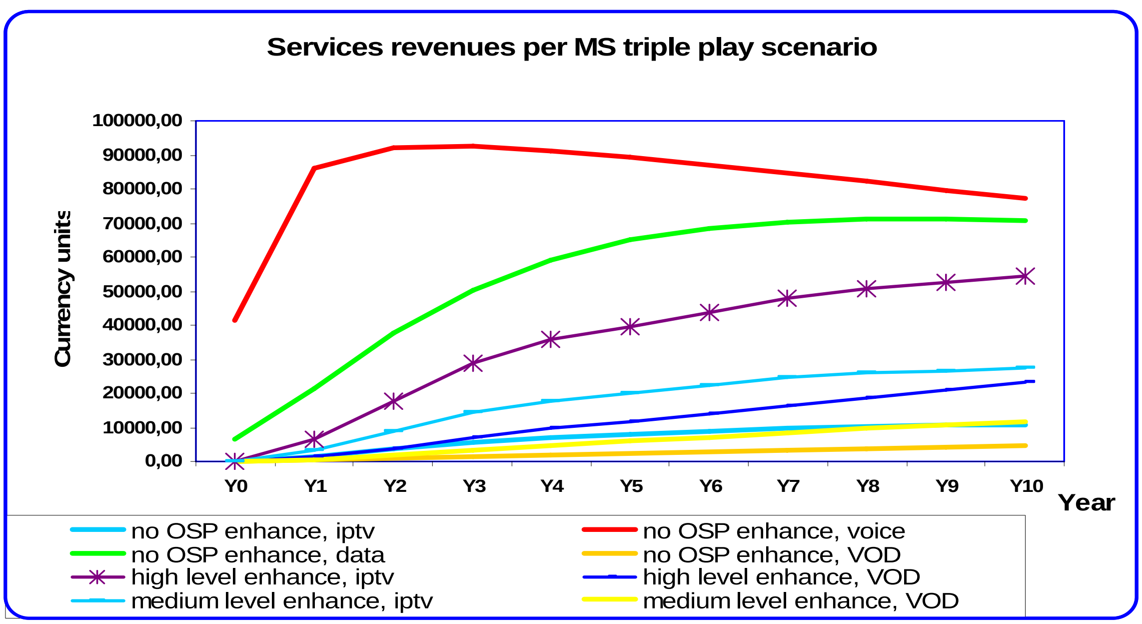

Figure 27: Evolution of service revenues for NGN triple play alternatives

Diagram at Figure 28 illustrates the investment per category of network elements in percentage for the accumulated value in the 10 years period in the scenario of full network enhancement that implies higher investments in OSP. It has to be taken into account that different time periods apply to old and new technologies due to the substitution rhythm during tree years.

The three main investments correspond to the modernization of secondary network, the provisioning of new CPEs with video capability and the remote multiservice nodes to reach all population. Investment in video platforms here has been considered associated to the core network although according to the network design and location could also be associated to the edge.

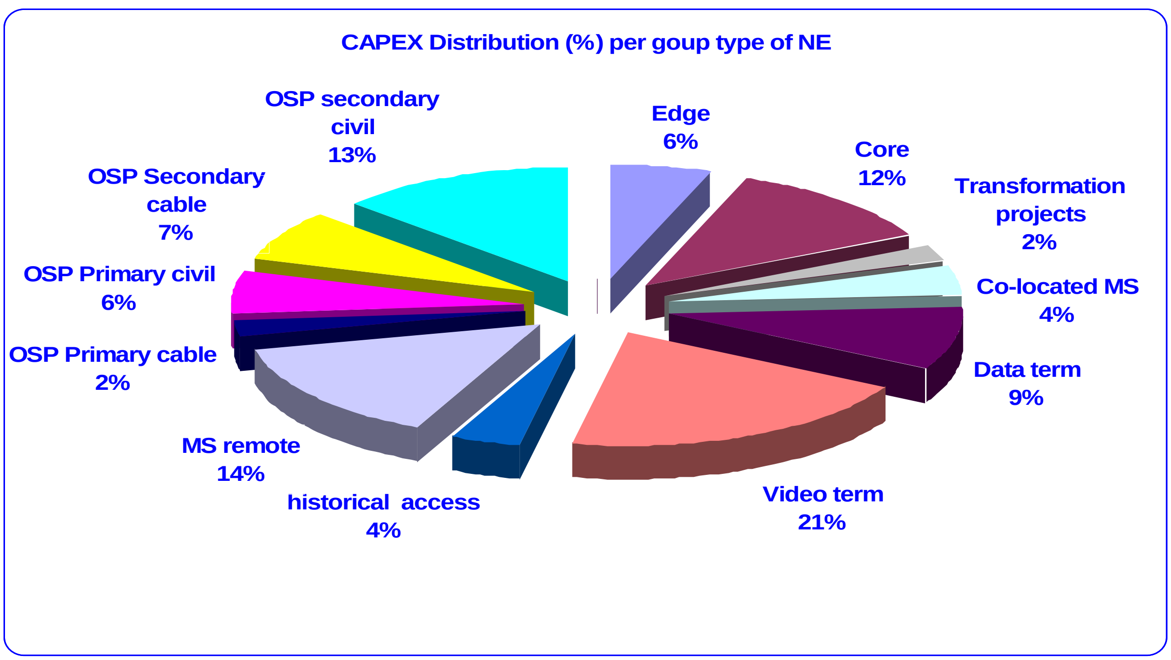


Figure 28: Distribution of CAPEX accumulated for all analysis period when full OSP enhancement

A more detailed investment per year and access network element for the full network enhancement is given in the diagram at Figure 29. (See template T3 for interpretation of resources). Civil ducts and cable for secondary OSP are significative at first years and remote access nodes with new IPTV capable CPEs also have significant impact due to the involved network modernization.

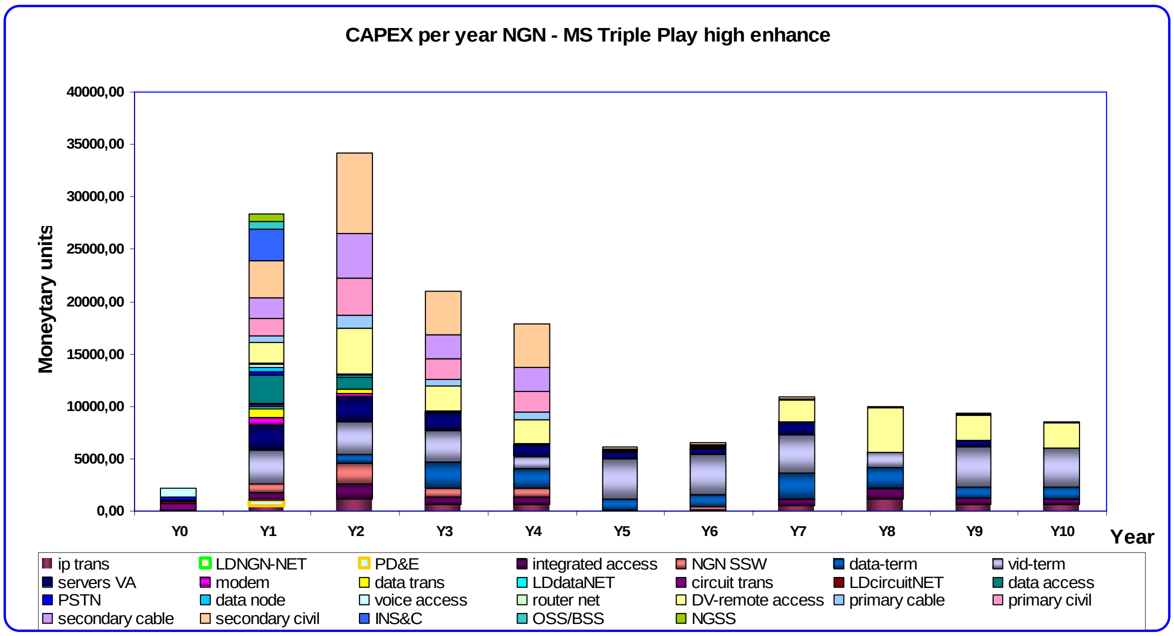


Figure 29: CAPEX investment per year and considered NE when full OSP enhancement

Figure 30 illustrates the operational costs in percentage per category of elements subject to operation and maintenance expenses accumulated for the 10 years period in the scenario with full OSP enhancement takes place. It has to be taken into account that different time periods apply to old and new technologies due to the substitution rhythm during tree years. Operation and maintenance for the equipments and activities at the network periphery are the main contributors to the expenses with customer service and remote nodes taking the lead. Historical access has also an important contribution due to the higher operations required even if with fewer years in operation

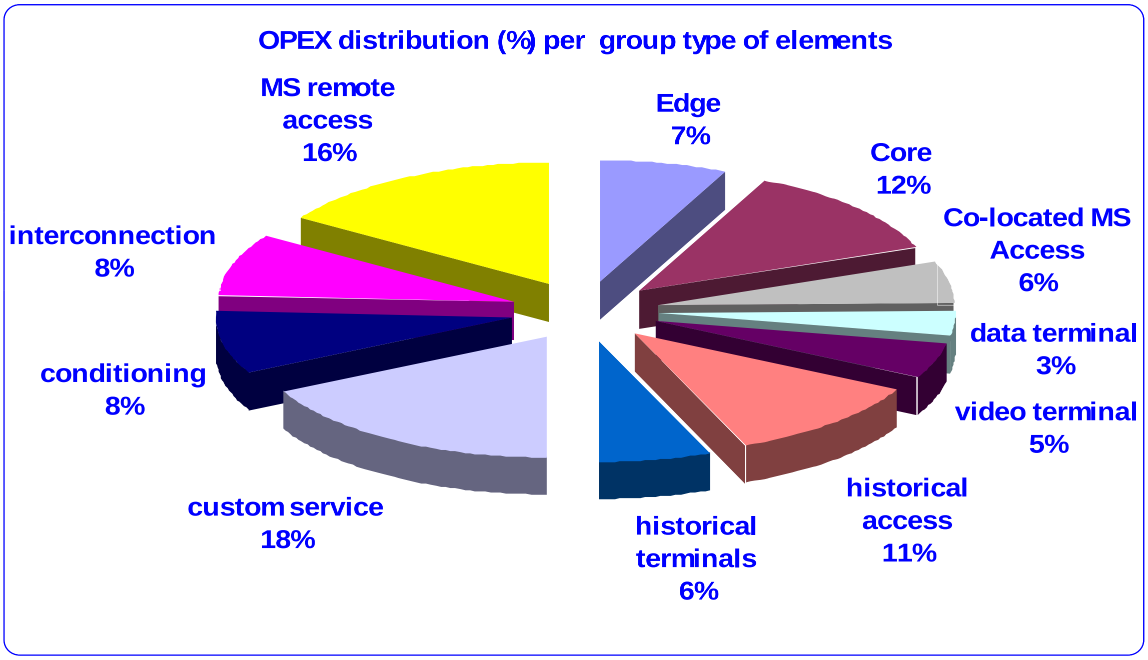


Figure 30: Distribution of OPEX accumulated for all analysis period when full OSP enhancement

A more detailed operational cost per year and access network element is given in the diagram at Figure 31. (See template T3 for interpretation of resources). Local Loop conditioning and historical network operation are high at the start of period while remote access nodes operation and customer service are siginificative through the whole period and require maximum automation process in order to decrease its contribution in the future.

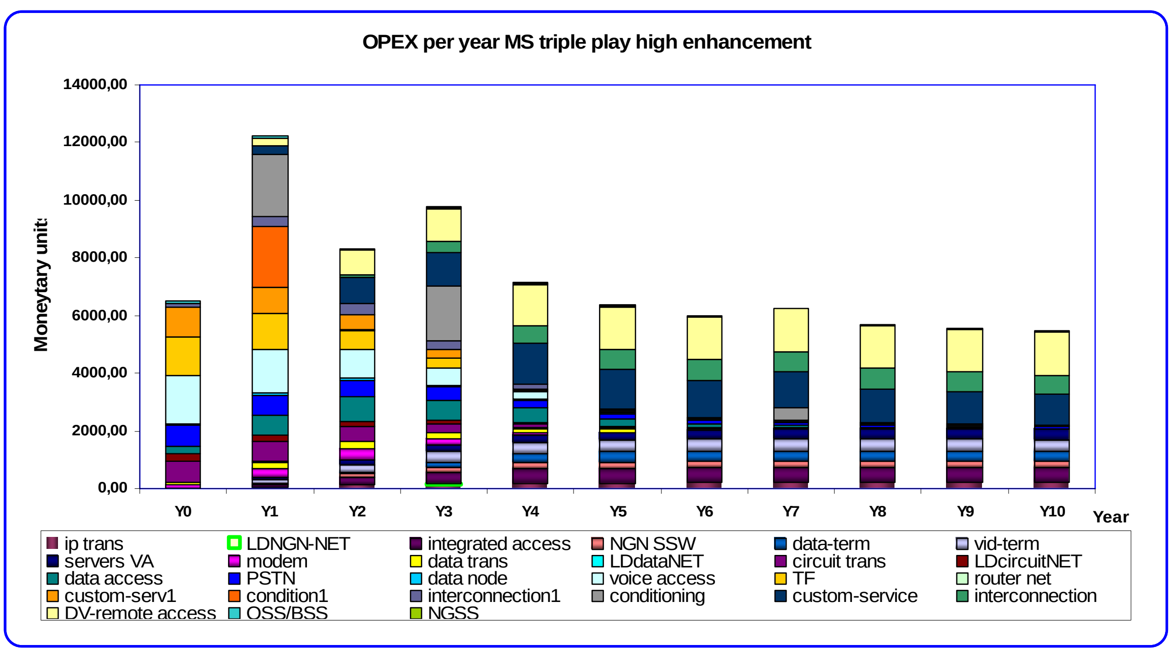

Figure 31: OPEX investment per year and considered NE when full OSP enhancement

From a financial point of view it is interesting to analyze the total operation charges that also consider the amortization and depreciation as compared to the net operation cost more used for the analysis of business profitability and flexibility at long term. The Figure 32 illustrates those values through the observation period for the triple play solutions and the three levels of modernization for OSP. It should be emphasized that both parameters show a trend to decrease at medium and long term due to the lower operation cost of NGN technologies.

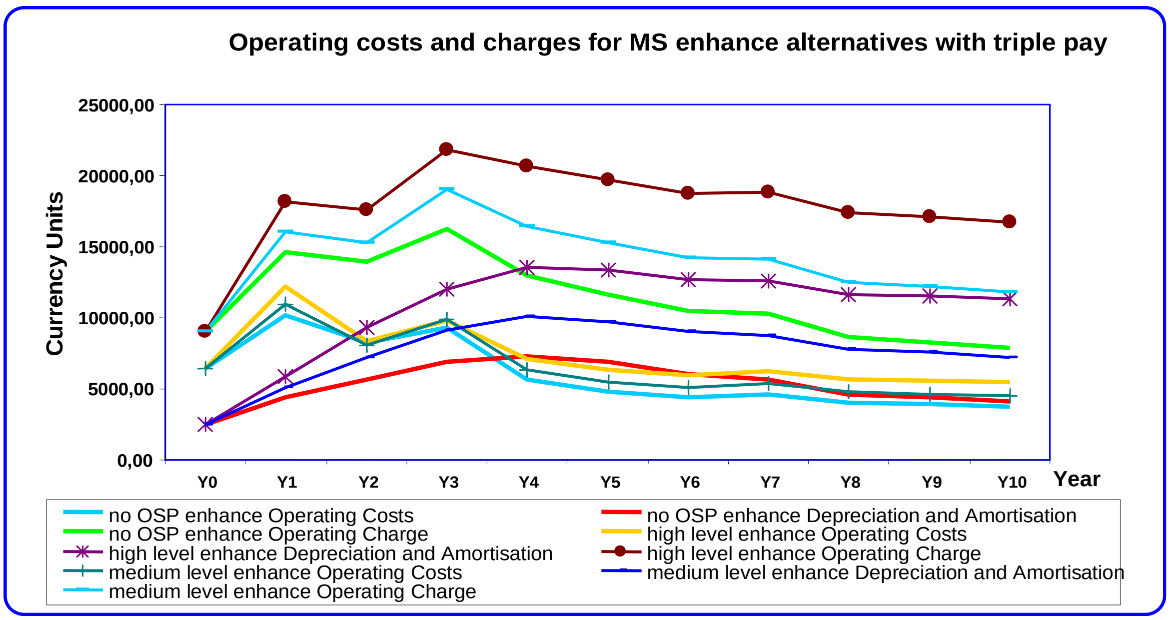


Figure 32: Evolution of operation cost and charges  for NGN triple play alternatives.

Most uncertain parameters for the future are the tariffs that will be feasible according to the market competition level, the payment capability and service attraction for customers. A what-if analysis has been made for several cases as the one in which IPTV tariffs are reduced by 50% due to market pressure. Figure 33 provides the evolution of revenues in that assumption.

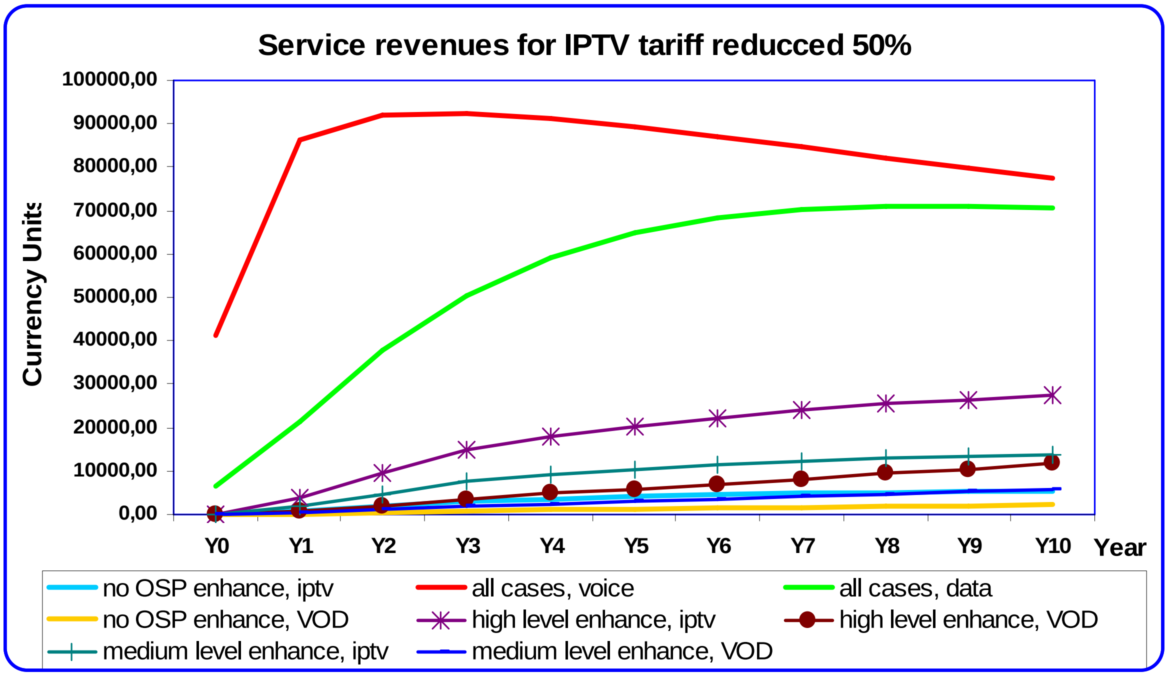


Figure 33: Evolution of service revenues for NGN triple play alternatives with a reduction of 50% in IPTV and VOD services

The Figure 34 shows the differential NPV between the three scenarios per level of OSP modernization for that important tariff reduction in IPTV and VOD services. But even with that reduction (see comparison to Figure 24), project is positive after year 4 due to the efficiency of convergence and economies of scale in triple play.

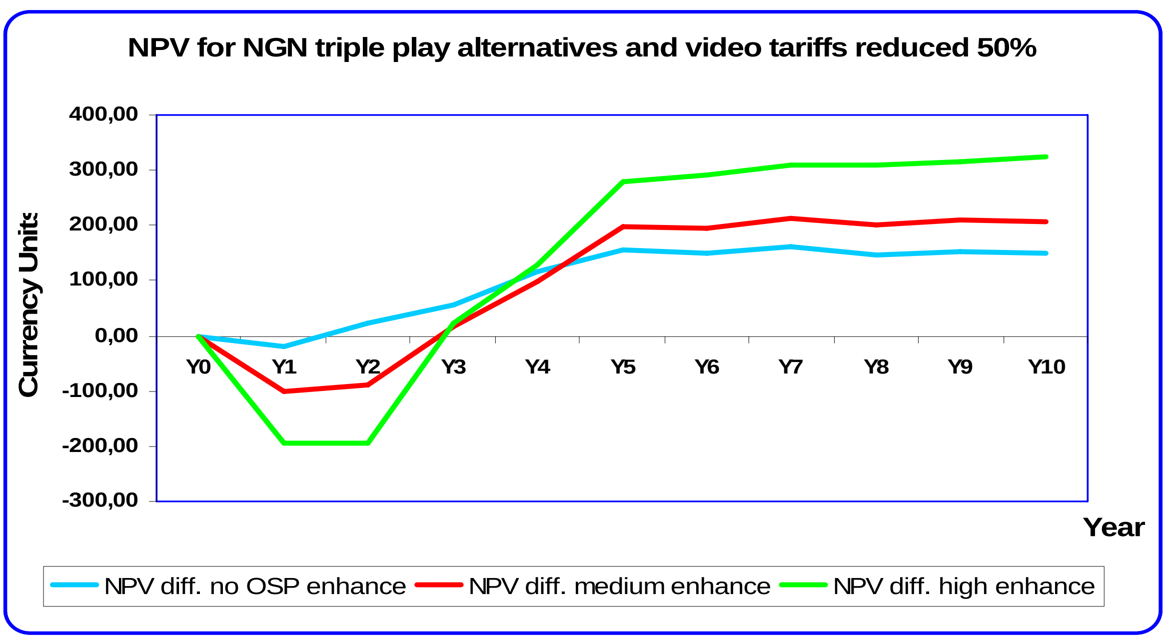

Figure 34: Differential NPV at perpetuity rate for NGN triple play alternatives respect dual play when video related tariffs are reduced 50%

Another interesting what-if analysis is for the case of internet data tariff reduction in 40% (to 590 bahts) that is equivalent to a cheaper tariff today for lower speeds. Figure 36 show a significative reduction in revenues (as compared to Figure 27) due to the influence in high number of customers in internet. The contribution by the IPTV services maintains an acceptable overall income.

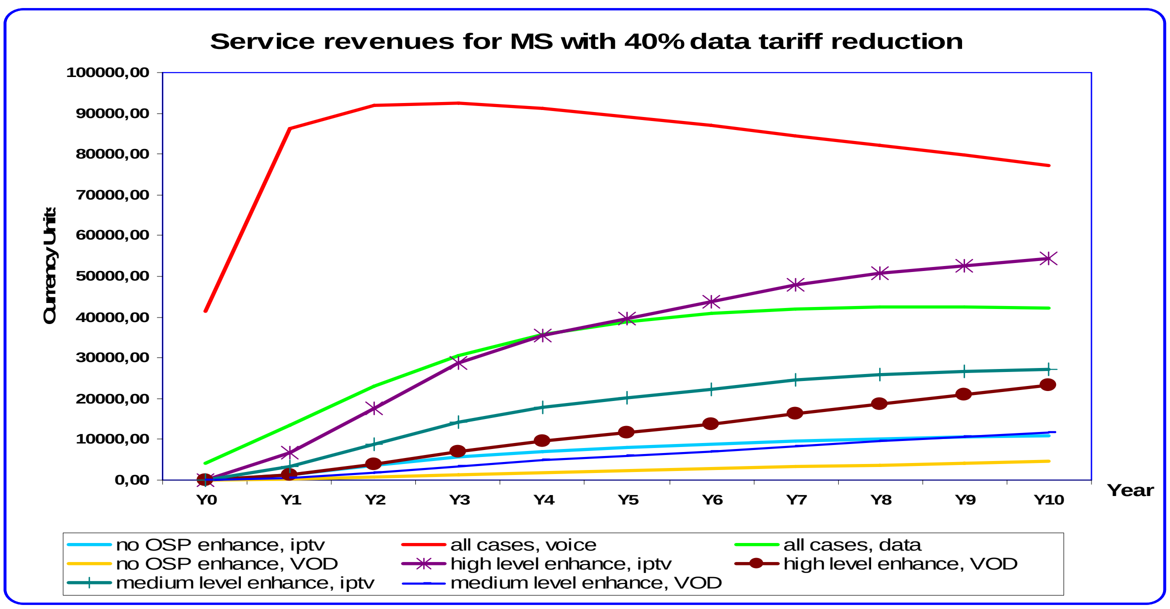


Figure 35: Evolution of service revenues for NGN triple play alternatives with a reduction of 40% in internet tariffs

Figure 36 shows a reduction in NPV values (compared to Figure 23) due to that important tariff reduction but the convergence in triple play maintains the advantage over dual play without other alternative incomes. High enhancement OSP and higher number of customers in IPV show the benefits of a wide coverage multiservice strategy.

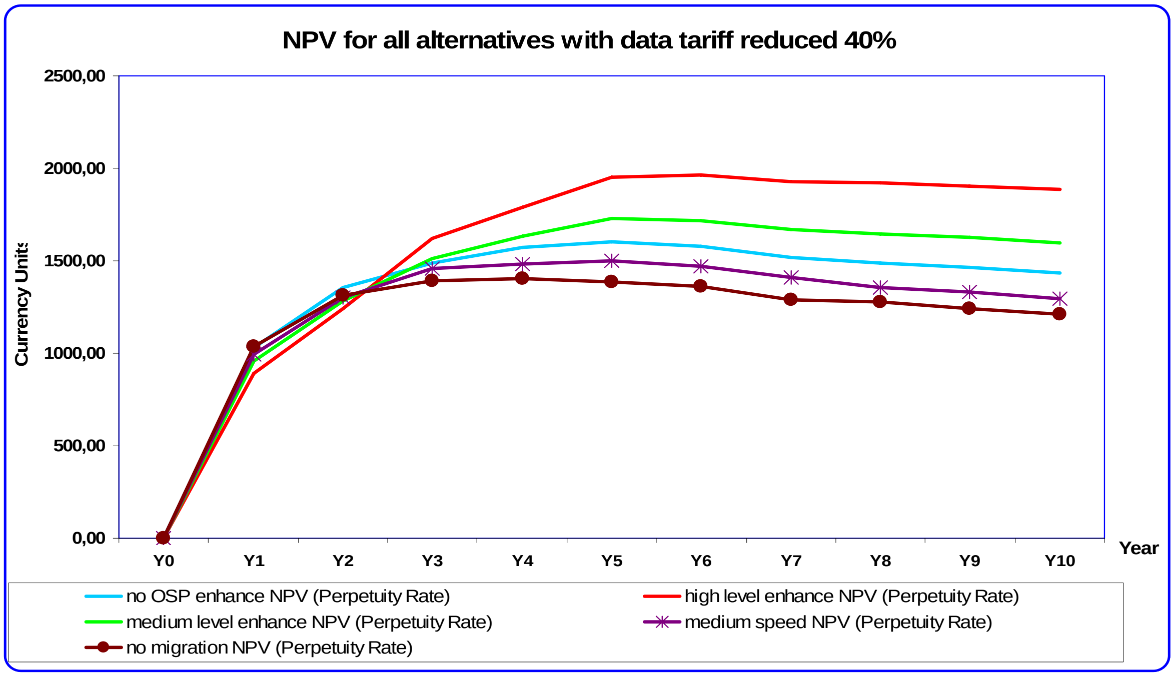


Figure 36: NPV at perpetuity rate for NGN triple play alternatives with a 40% reduction in internet tariffs

The previous sensitivity analysis indicates the powerful capability of the performed modelling and tool for the what-if evaluation of many alternatives. It could be used for the evaluation of combined reductions in a bundle offer or to investigate what are the maximum acceptable reductions in a given market context maintaining a positive business profitability.

## *6.3 Project migration steps*

Migration from the PSTN based network solution to the NGN target require a well coordinated set of steps for all network layers that is a function of the administrative practices at a given country and would follow next sequence in the absence of important constraints in the civil works permits:

> -S1) Project design and engineering for NGN path from user to core network including Access Nodes location, backhauling capacities and new OSS/BSS.
> -S2) Project design and engineering for Video servers platform and paths from servers to edge network.
> -S3) Detailed engineering of Access Nodes.

-S4) OSP design for civil and cable.
-S5) OSP enhancement deployment.
- S6) Nodes and transmission deployment
    - Phase 1 for AN collocated at LE premises
    - Phase 2 for AN with reusable civil ducts and/or quick civil works deployment
    - Phase 3 for new and distant ANs
-S7) Video servers deployment
-S8) OSS/BSS deployment
-S9) Equipment integration, testing and validation
-S10) Service trials for advanced customers
-S11) Service deployment for all area and customers
-S12) Overall project management

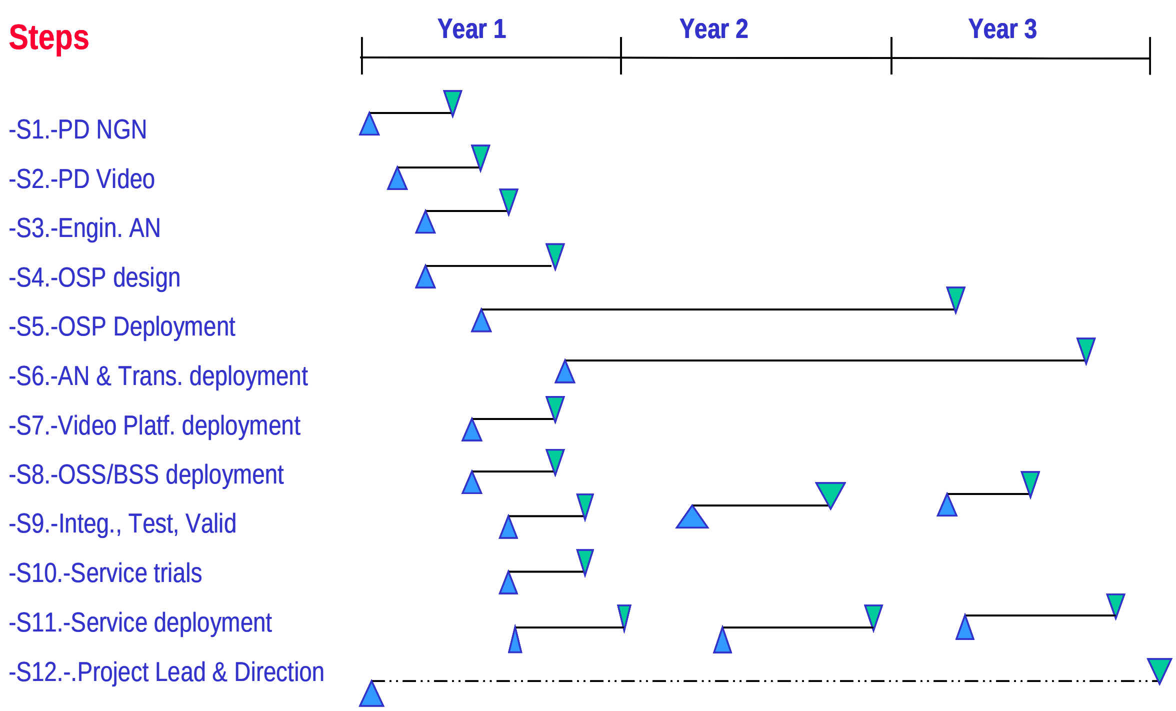


Figure 36: Generic steps for project to migrate access network to NGN with triple play services

## 6.4 Further evaluation activities

From the identified scenarios and analyzed cases, a number of interesting case studies are identified as follows:

*- Lower density scenarios versus high density*

**-** Enhancement of the OSP showed to be economic in urban scenarios with densities of 400 customers per Km2. Due to the high sensitivity of OSP costs to that density it should be identified up to which lower density (i.e. suburban scenarios) those benefits apply and assure investment recovery.

*- IAN versus MSAN*

- Multiservice access nodes prove to be convenient for the current country context and development level. Due to the technological trend to move towards an end-to-end IP solution it will be interesting to analyze under which circumstances and timeframe that solutions based on full IP access nodes produce benefits. A migration towards IAN too early for the market maturity will imply a high investment in the forced substitution by the operator of all terminals that should be all IP for all customers even if no new services are required. When market has high maturity, high proportion of customers will buy terminal themselves and generate higher consumption of new services to compensate the investment

*- Fiber to the Home FTTH versus VDSL:*

- When moving towards higher capacity access (i.e.. 30 or 100 Mbps) and services consuming higher bandwidth like HDTV, two main alternatives appear: a) High capacity VDSL with many more active access nodes closer to the user (distance of 300 to 500 m.) and significative increase in OPEX and b) FTTH of passive type with higher investment as a function of density in fiber, optoelectronic components and optical CPE but with lower OPEX. The interest is in evaluating which is the cross point when one solution is better that the other for the current status of OSP, market demand and technology evolution. Key factors for evaluation of the geo-scenarios with advantage for one or other solution are as follows:

- Customer density
- BB services demand
- Cost of optical CPE
- Cost of civil works and FO cable type per distribution segment
- Cost of optoelectronic components
- Operation & Maintenance  cost for remote AN

- A generic positioning on FTTH derived from other analysis and market trends is summarized:

- *Scenarios with advantage for FTTH*

    - Greenfield areas with medium to high density (i.e.: development poles)
    - Urban areas with high density and high level of ICT consumption customers
    - Easy reuse of installed ducts with spare capacity
    - Obsolete copper cable on ducts allowing for cable pull procedures
    - High manpower operation cost
    - Cost reduced Optical CPE due to economy of scale

- *Scenarios with advantage for VDSL*

    - Urban and suburban scenarios with medium density and mix of new with traditional services.
    - Number of active Access Nodes required (with quadratic rule versus density) under operational cost limit
    - Newly installed copper cable (less than 10 years age) with underground civil infrastructure
    - Low filling degree and high quality transmission characteristics
    - Low economy of scale impact by size at given country
    - Low manpower cost for O&M

An illustrative chart summarizing advantage scenarios for each access solution is given at following chart as a function of customer density and level of services consumption:

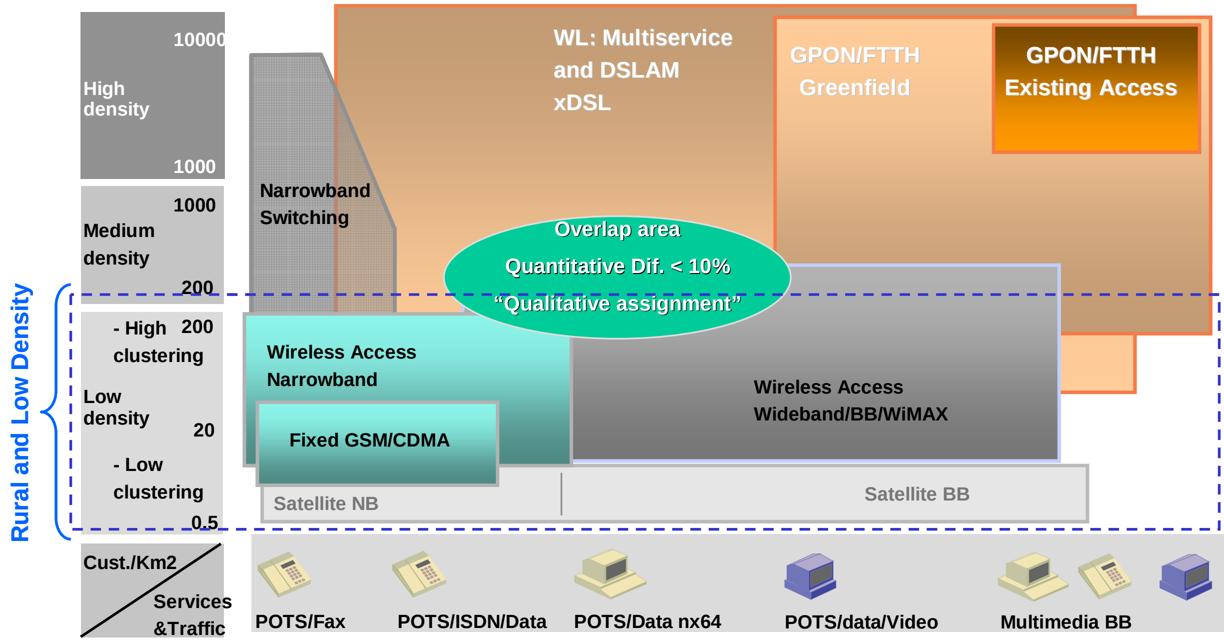


Figure 37: Mapping of best economic access solutions as a function of customer's density and level of ICT demand

# Annex 1 References

1) ITU-D - Technology and network development: “Manual on Network Planning for Evolving Network Architectures”
http://www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexManualNP.html

2) ITU-D - Technology and network development: “Guidelines for Network Planning Tools for Developing Countries and countries with economies in transition” http://www.itu.int/ITU-D/tech/network-infrastructure/Manual/indexGuidelinesINP.html

3) TOT Networks. Network Planning Department. 7/4/52

4) TOT Profile. Corporate department. March, 9th, 2009

5) Access Structure. TOT Network Topology for ADSL

6) Access network parameters. TOT Area1Area3.xls

7) Socioeconomic inputs. TOT BKK areas1, 2, and 3

8) Access cost elements. TOT Access Cost.xls

9) BKK Service areas. TOT service areas. jpg

10) Sample measurement for speeds. TOT ADSL speedVSdistance.pdf

11) STEM business-modelling software for networks. Robin Bailey. http://www.analysys.com/stem/

# Annex 2 Templates for Access data gathering

T1. - Template for data gathering on main Socio-economic inputs

| | | | | |
|---|---|---|---|---|
| | **Socio-economic Inputs** | | | |
| | **Country/Scenario** | | | |
| | **Demand related data** | **Reference year (last)** | **This year** | **Next 5 years (% grow)** |
| S1 | **Population/ scenario and grow rate** | | | |
| S2 | **Population with RPC > survival thereshold** | | | |
| S3 | **Population with literacy (%)** | | | |
| S4 | **Population with College degree (%)** | | | |
| S5 | **Market share for Fixed (%)** | | | |
| S6 | **Market share for Internet (%)** | | | |
| S7 | **Market share for Mobile (%)** | | | |
| S8 | **PC penetration rate and grow** | | | |
| S9 | **Fixed lines penetration rate and grow** | | | |
| S10 | **Mobile lines penetration rate and grow** | | | |
| S11 | **Total Internet penetration rate and grow** | | | |
| S12 | **BB penetration rate and grow** | | | |
| S13 | **Annual phone usage (minutes per line)** | | | |
| S14 | **Peak hour Mbs per internet data line** | | | |
| S15 | **RPC and grow** | | | |
| S16 | **Reference Tariff for BB internet connection** | | | |
| S17 | **Reference Tariff for BB internet per month** | | | |

## T2.-Template for data gathering on main physical network inputs

**Generic Inputs reference case for the physical network**

**Urban Scenario**

| | | Total | LE 1 | LE 2 | ... | LE n |
|---|---|---|---|---|---|---|
| G1 | Number of installed lines | | | | | |
| G2 | Area in Km2 | | | | | |
| G3 | Number of Operational lines (switching) | | | | | |
| G4 | Number of Available cable pairs | | | | | |
| G5 | Number of valid Reserve cable pairs | | | | | |
| G6 | Number of xDSL lines | | | | | |
| G7 | Number of co-located AU | | | | | |
| G8 | Average size of co-located AU | | | | | |
| G9 | Number of co-located DSLAMS | | | | | |
| G10 | Average size of co-located DSLAM | | | | | |
| G11 | Number of remote units (RU) | | | | | |
| G12 | Average size of RU | | | | | |
| G13 | Number of remote DSLAMS | | | | | |
| G14 | Average size remote DSLAM | | | | | |
| G15 | Number of Cable Cabinets (CC) | | | | | |
| G16 | Average size of CC | | | | | |
| G17 | Number of cable Distribution Points DP | | | | | |
| G18 | Average size DP | | | | | |
| G19 | Local Loop distribution per distance (% of loops at < 0.5, <1.5, <3. 5, <5, > 5 Km) | | | | | |
| G20 | LL age (< 5, <10,<15,< 20, > 20 years) | | | | | |
| G21 | % LL for data quality at primary plant | | | | | |
| G22 | % LL for data quality at secondary plant | | | | | |

# T3. - Template for data gathering on main Functional Network inputs

## Tecno-economic Inputs

### Urban Scenario

| | Network Elements | | Capacity | Capex Cost (nominal) | Operation | Maintenance |
|---|---|---|---|---|---|---|
| T1 | CPE-Tf | Telephone terminal existing and associated loop | | | | |
| T2 | CPE-data | Modem existing | | | | |
| T3 | CPEVD | New CPEVD (VoIP and data) | | | | |
| T4 | CPE-video | New CPEVD (video) | | | | |
| T5 | CPE-multiservice | New CPE- for VoIP, data and video | | | | |
| T6 | AN voice- existing | Acces Node for voice in existing PSTN (lines) | | | | |
| T7 | AN data-existing | AN for in data-existing data net (lines) | | | | |
| T8 | AN multiservice at LE | AN for new multiservice capability at LE | | | | |
| | AN multiservice remote | AN for new multiservice capab. at remote sites | | | | |
| T9 | Local transmission: Circuits | Circuit transmission in existing PSTN (circuits) | | | | |
| T10 | Local transmission data | Data transmission in existing net | | | | |
| T11 | Local transmission Eth. Link | Multiservice transmission ethernet | | | | |
| T12 | Local node PSTN | Local node PSTN in existing net (circuits) | | | | |
| T13 | Local node Data (Mbs) | Local node Data in existing net (Mbs) | | | | |
| T14 | Local node router (Mbs) | Local node router at IP mode (Mbs) | | | | |
| T15 | Local node NGN-SSW | Local node NGN-SSW at new network (lines) | | | | |
| T16 | LD circuit NET | Long Distance circuit mode NET (circuits) | | | | |
| T17 | LD data NET | Long Distance data Network existing (Mbs) | | | | |
| T18 | LD NGN NET | Long Distance new NGN Network(Mbs) | | | | |
| T19 | Cable primary | Fiber optic cable at primary per size and type | | | | |
| T20 | Cable secondary | Coper cable at secondary per size and type | | | | |
| T21 | Civil primary | Civil invest.(ducts, manholes, etc,) at primary access | | | | |
| T22 | Civil secondary | Civil invest.(ducts, manholes, etc,) at secondary access | | | | |
| T23 | Primary enhancement | Enhancement of cable and civil at primary access | | | | |
| T24 | Secondary enhancement | Enhancement of cable and civil at secondary access | | | | |
| T25 | Customer Service ex | Customer Service for existing network (lines) | | | | |
| T26 | LL Conditioning ex | Conditioning for connec. of ADSL in existing net (data lines) | | | | |
| T27 | Interconnection ex | Interconnection for external data traffic in existing net(Mbs) | | | | |
| T28 | Customer Service new | Customer Service for new lines (lines) | | | | |
| T29 | LL Conditioning new | Conditioning for ADSL in new lines (data lines) | | | | |
| T30 | Interconnection new | Interconnection for external data traffic in new net(Mbs) | | | | |
| T31 | Applic. servers VoIP | Application servers for VoIP (Mbs) | | | | |
| T32 | Applic. servers IPTV | Application servers for IPTV (Mbs) | | | | |
| T33 | OSS/BSS-NGSS | OSS/ BSS and NGSS platforms, licences and applications | | | | |
| T34 | Planning, design and eng. project | Planning, design and enginering before start the Network Migration project | | | | |
| T35 | Network and OSS migration project | Instalation, migration and cutover for Network and OSS | | | | |

## Annex 3 Photo-illustration of access elements in BKK

Summarized graphical sample of network elements visited at three locations in the areas of Bangkok:

- Main LE at center BKK containing 300.000 switching lines and related transmission equipment. OSP with 54 cables of 3000 pairs and 26 age years. MDF to be renovated at end 2009. Below internal cable distribution and splitting**.**



- 3000 pairs cable in main LE at center BKK. Example of external aerial distribution network at BKK area 4.

- Main LE at center BKK with both sides of MDF and transmission equipment

- LE at BKK with traditional switching equipment and recently installed Soft switch technology

- Remote access unit street cabinet at BKK with 900 PSTN lines and 48 ADSL lines DSLAM

- View of access unit street cabinet and current group of ADSL monitoring applications