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Fiber Access Networks: Reliability and Power Consumption Analysis

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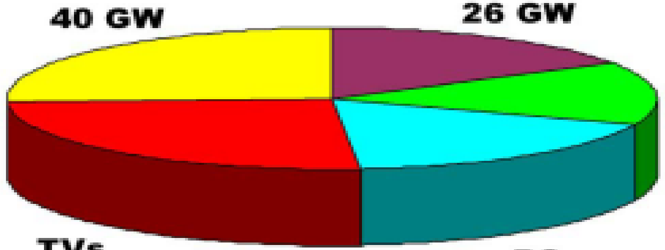
Outline

- Introduction
- Motivation
- Addressed problem
- Power and reliability study
- Cost analysis
- Conclusions

ICT Power Consumption

ICT use phase: worldwide today

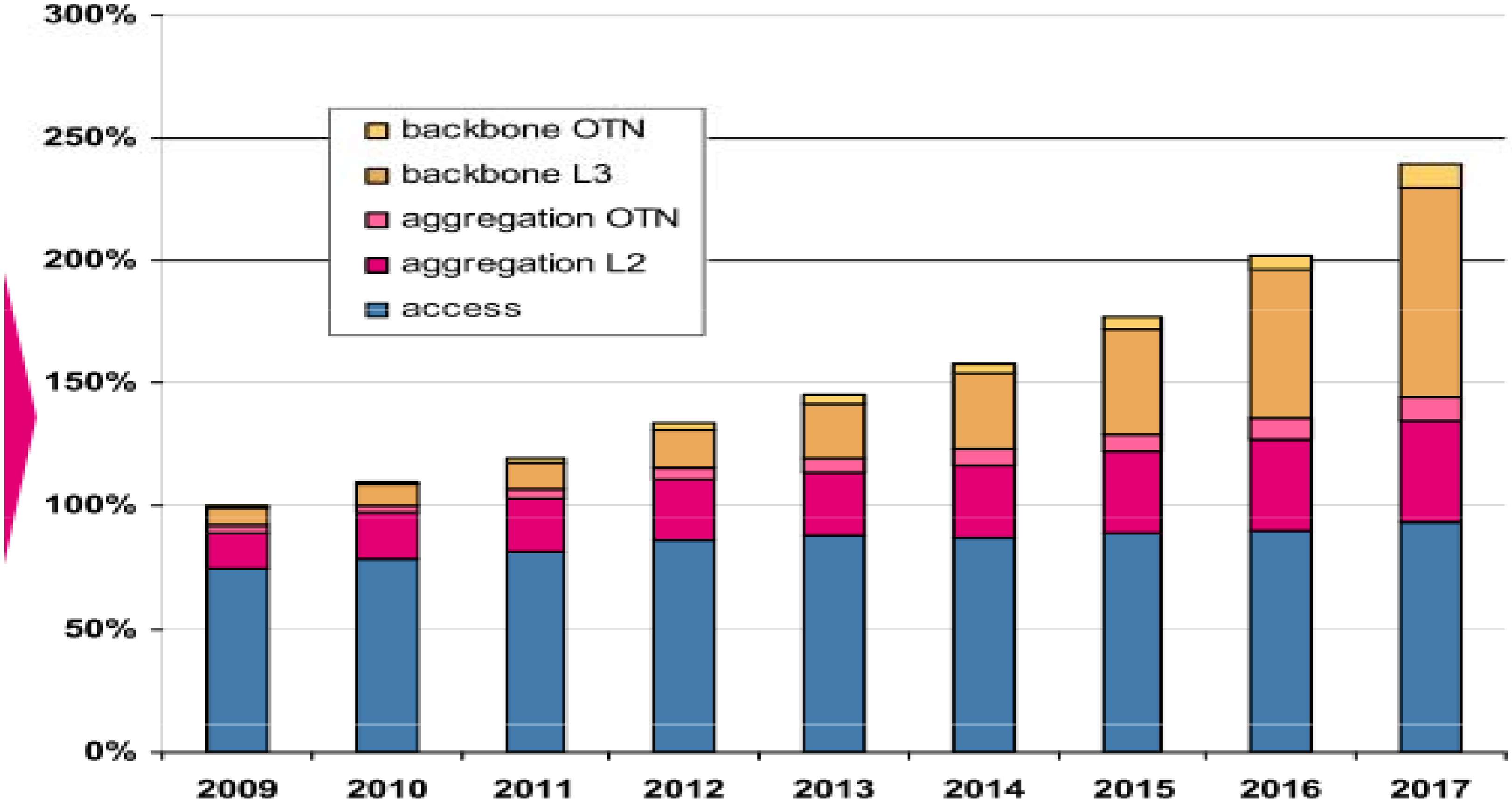


Conclusions:

- Total = 156 GW = 8% of global electricity consumption
- No dominating front, several fronts are important

Source [GreenPanelICC2009]

Energy Consumption Growth



Source [DTOFC2009]

Traffic demand drivers

- Services
  - High-Speed Internet
  - VoIP
  - IPTV
  - Gaming
  - Telemedicine
  - E-Goverment
  - Etc

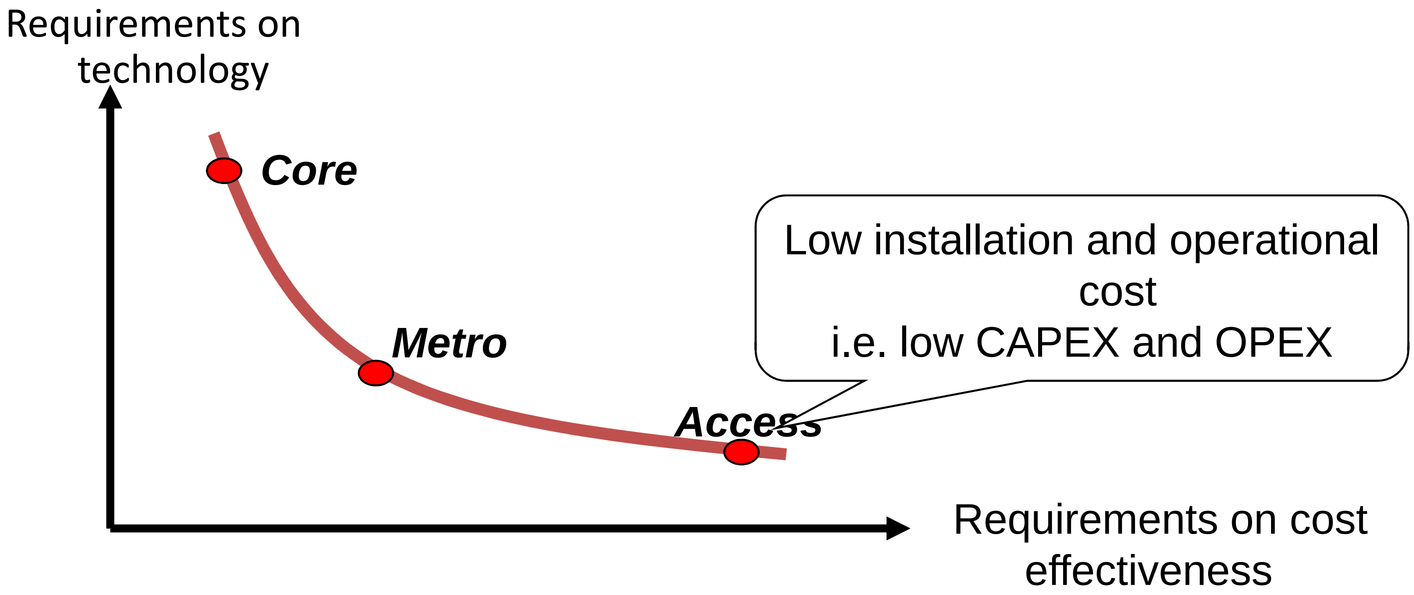
High-Speed Internet, VoIP, IPTV: ”Triple play”

- More users, higher BW, higher reliability required

Traffic increases very rapidly
Challenge for operators!!

Motivation

- Evolution of broadband access networks towards FTTH
- **Power efficient solutions in access networks**
- Growing importance of reliable access to (broadband) network services.
- Access network is very cost sensitive
  - **minimizing the cost for network protection**



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Motivation

- Optical access networks are being widely deployed due to their high capacity and scalability
- Impact of failures on access networks:
  - number of interrupted services
  - significance of the service interruptions for the community

Failures
- More components
- More complex (less reliable) components

Service
- More services interrupted
- Longer interruption times

Penalties
- Higher penalties

Need of protection mechanisms in access networks!!

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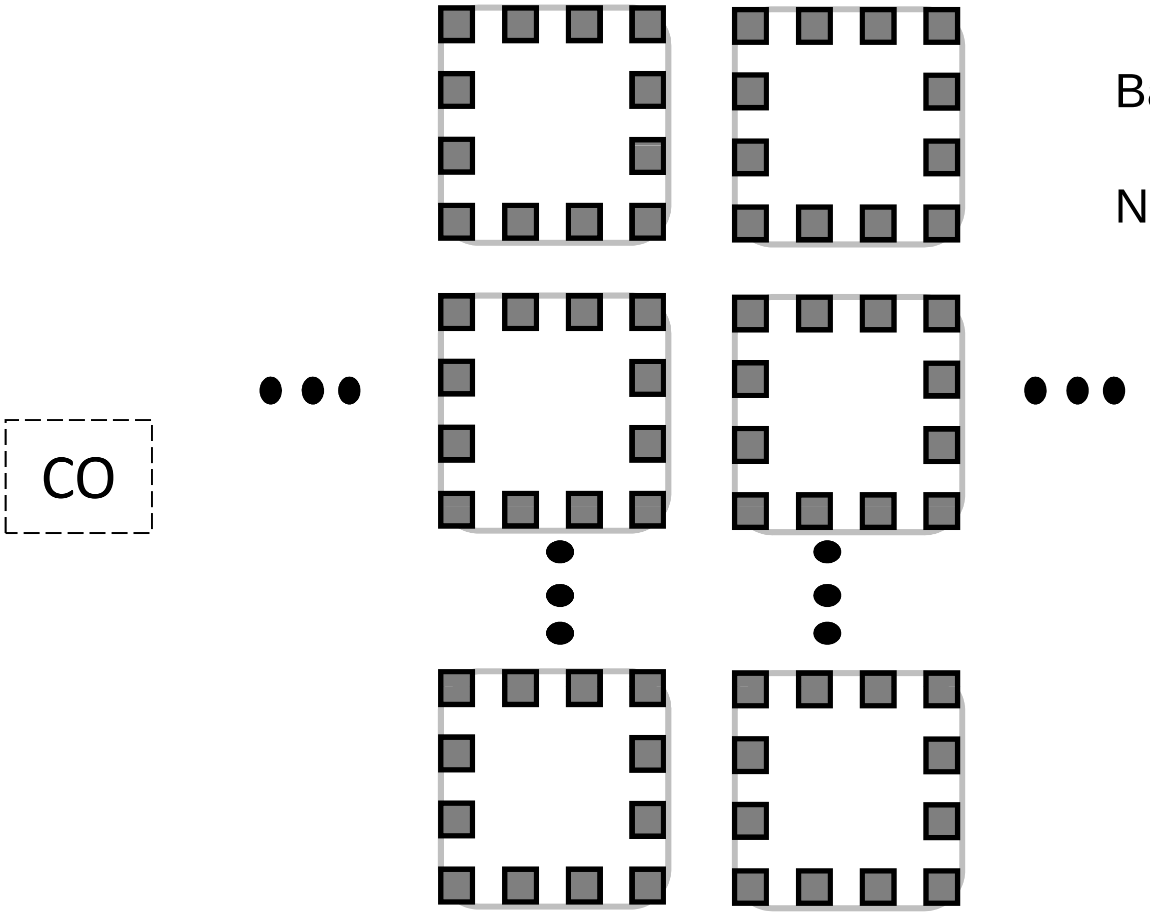
Addressed Problem

- The investments required to offer protection for different planning approaches will be compared for different optical access technologies :
  - Passive Optical Networks (PON): TDM PON and WDM PON
  - Active Optical Networks (AON)
  - Point-to-point (P2P) access networks
- The evaluation is based on costs such as infrastructure, equipment, power consumption and failure reparation associated to each scenario
- The overall cost reduction when investing on infrastructure protection is highlighted.

Network model for dence area



Based on Manhattan network model

Network Scenario Inputs

- Block side: 113 m
- Street width: 20 m
- 8 buildings/block side

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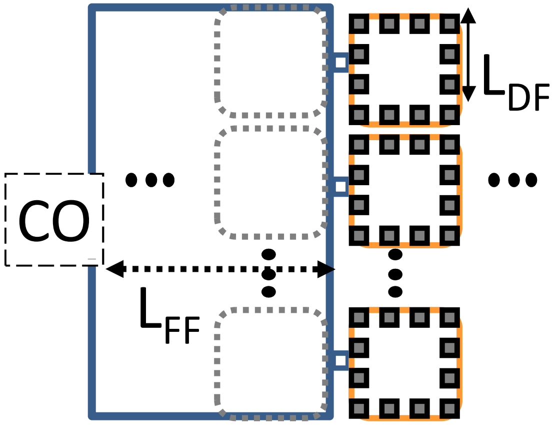
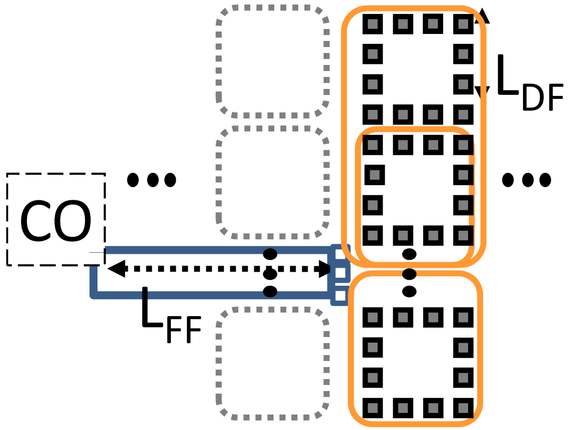
Fiber Layouts



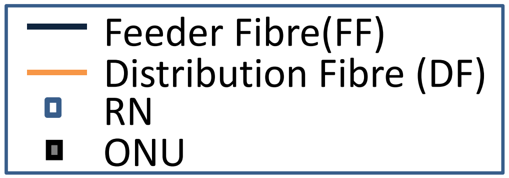
Dense 1 (D1)



Dense 2 (D2)

RN located at each block

All RNs located at same point



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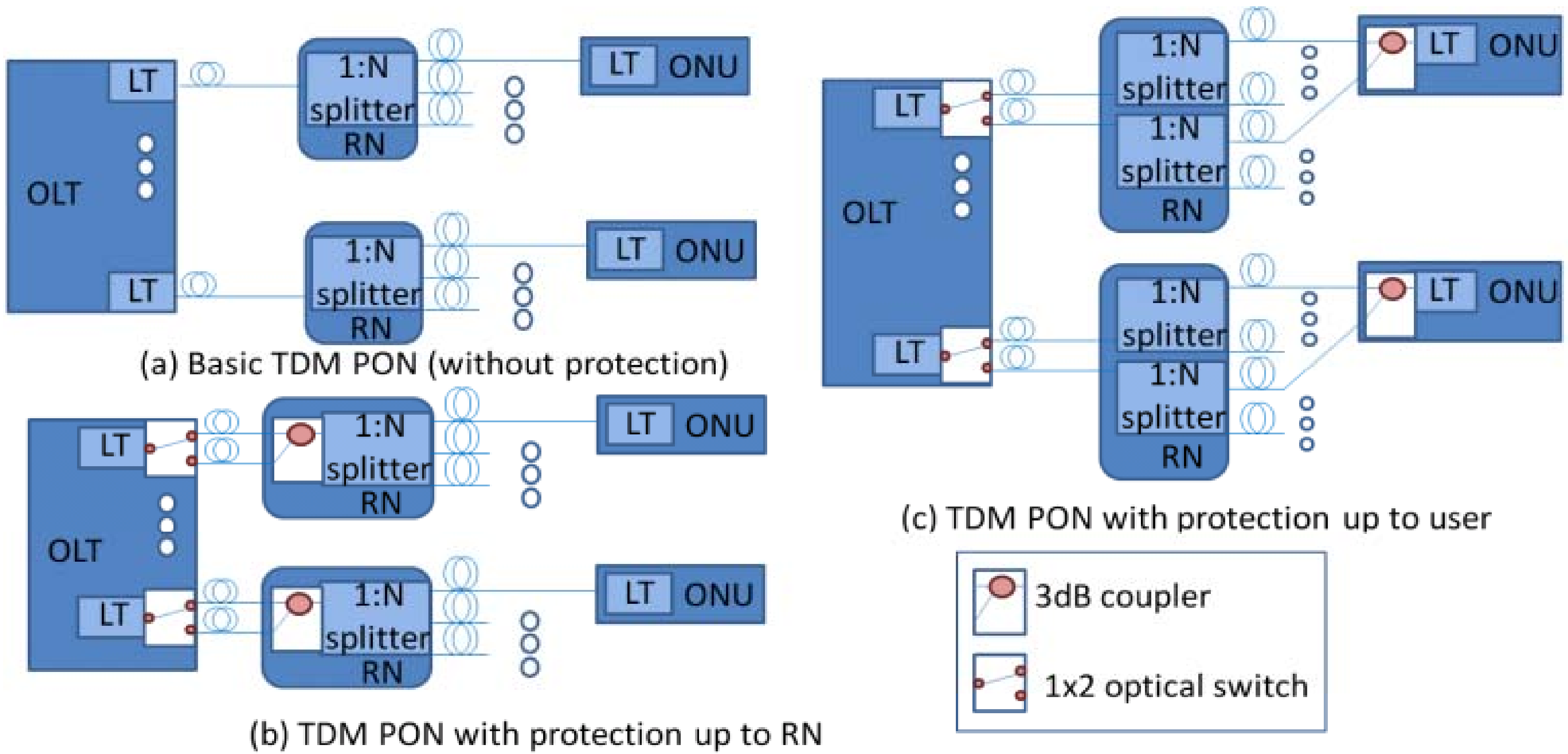
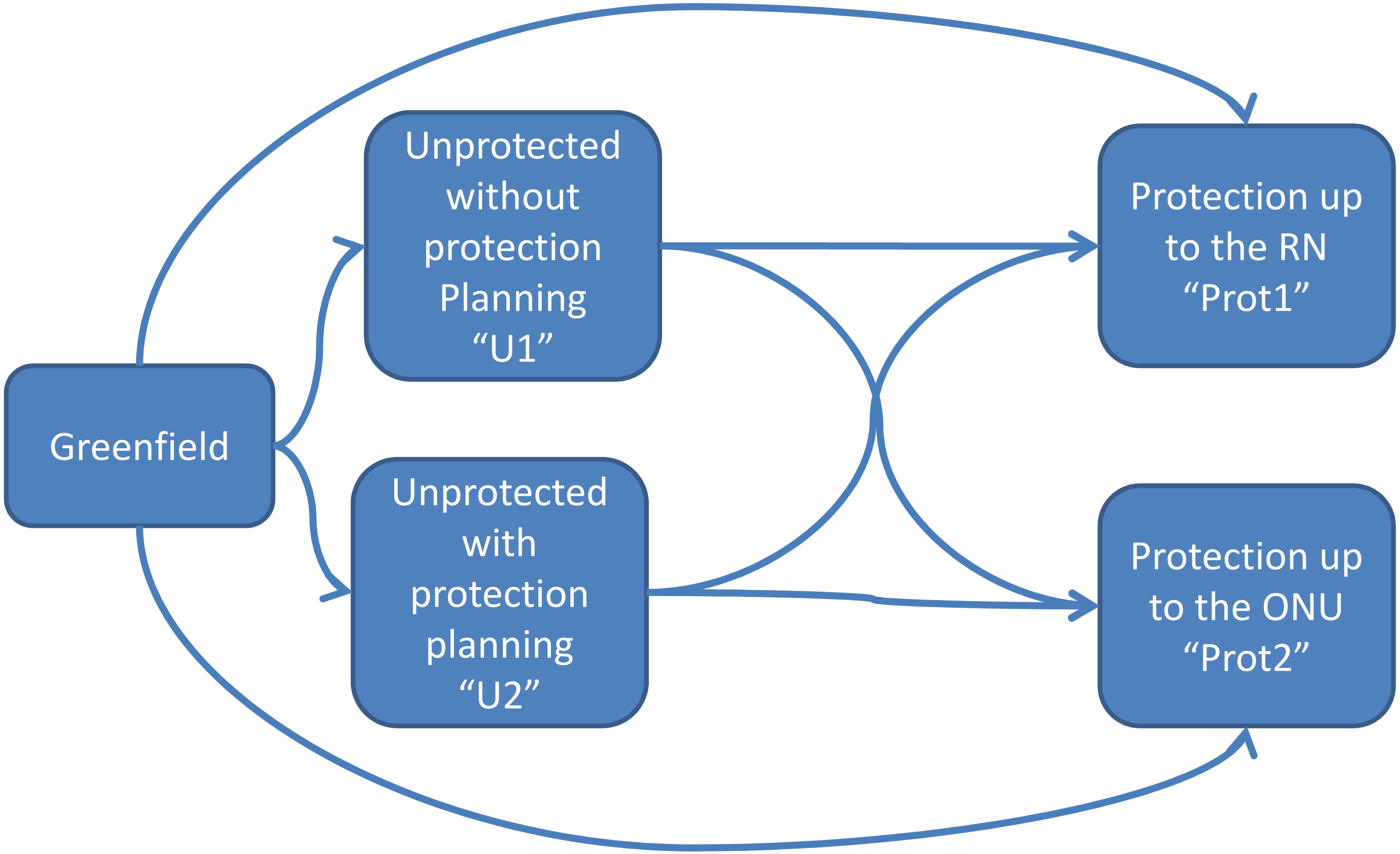
Protection Schemes



Protection planning



Power consumption

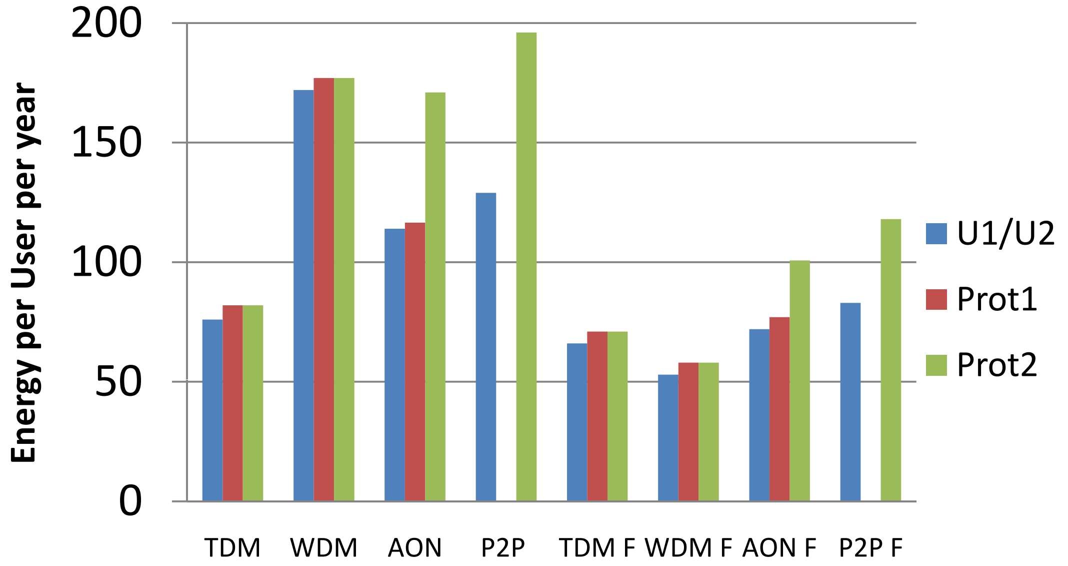
- The power consumption per user in the access network is calculated by dividing the total power consumption of all the equipment in the network (both optical and electrical parts) by the number of users.

$$P_{user} = P_{ONU} + \frac{\alpha P_{OLT}}{N.M} + \frac{\alpha P_{RN}}{M}$$

α: factor to include consumption of the housing and cooling systems (2 in this study)
N: number of RNs
M: number of ONUs/RN

Power consumption

Yearly power consumption per user based on the today and the future (F) component energy consumption data for the unprotected and protected scenarios.



-The P2P technology has the highest power consumption per end user, and is even higher for networks with protection, since in P2P the equipment is not shared with other end users.

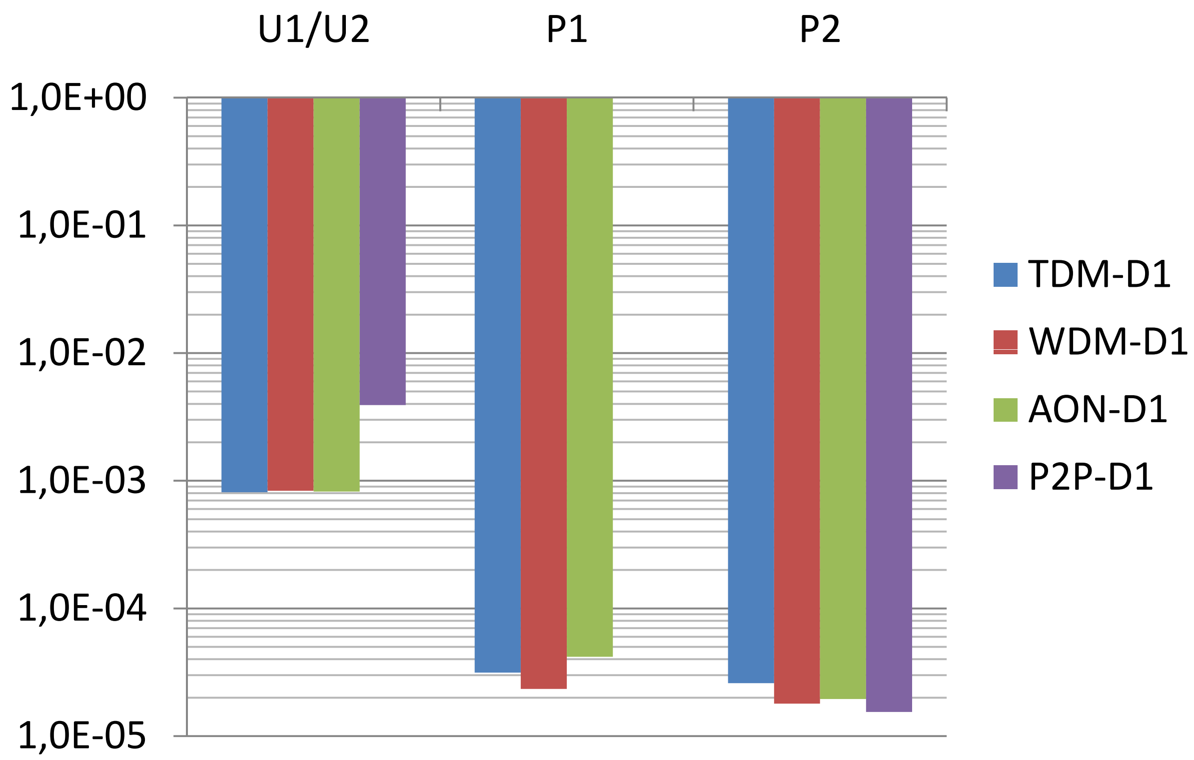
- The biggest gap between the power consumption of today and tomorrow belongs to the WDM technology. WDM seems to be the most energy-efficient access solution in the future, subject to components advances (PICs).

Reliability

- Network failures affect the TCO in mainly two ways:
  - Cost associated to the reparation of failures:
    - Location of the failure
    - MTTR
    - Technicians required to repair failure
    - Salary of technician
  - Cost related to connection interruptions:
    - How may users are affected by the failure
    - How long the connection interruption lasts
    - Penalty agreed at SLA to each particular user

Reliability

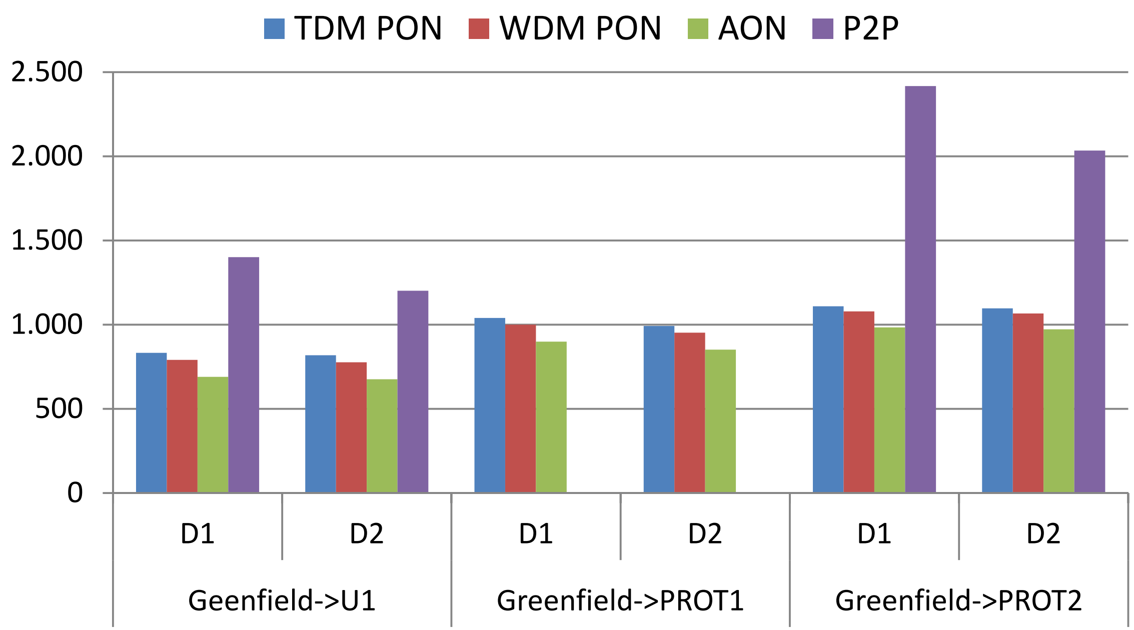
- *Connection unavailability for the different technologies*



Cost Study

- Each CO supports 1024 users.
- Maximum fiber length from any user to the CO is 20 kms.
- Traveling speed in dense urban areas: 20kms/h.
- The transceivers at the ONUs for P2P, AON and WDM PON support 1Gbps bit rate while TDM PON runs at 10Gbps both upstream and downstream
- Considered CAPEX:
  - Infrastructure (fiber cable and installation cost (i.e. trenching, blowing and splicing).
  - Equipment
  - Installation
- Considered OPEX:
  - failure reparation cost
  - penalty cost associated to connection interruption
  - power consumption cost

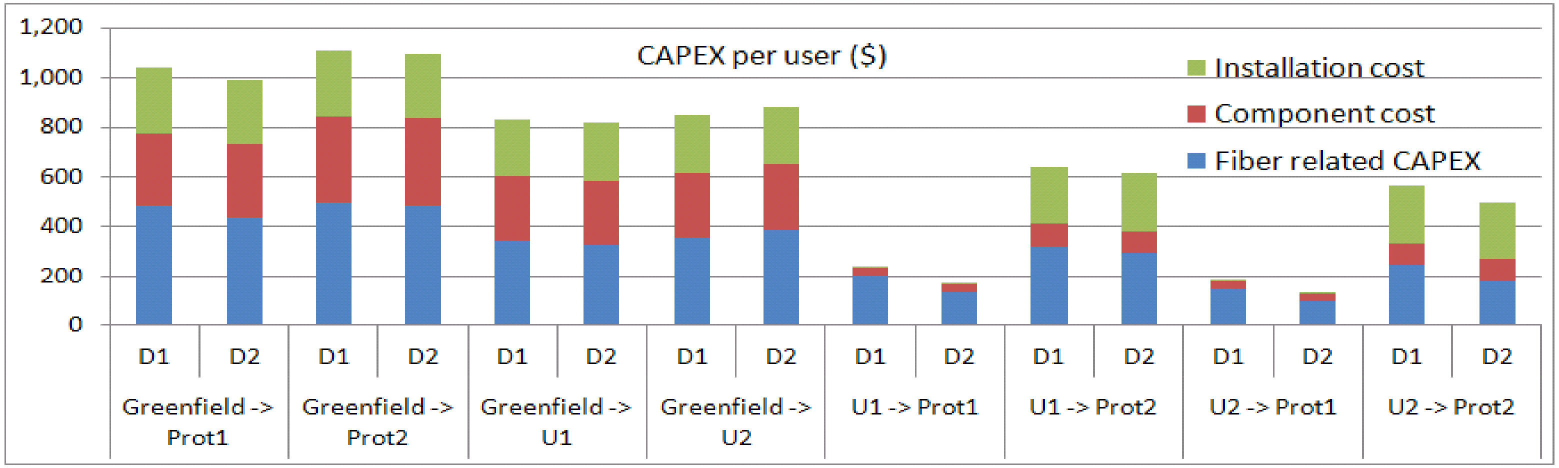
Capex ($) per User



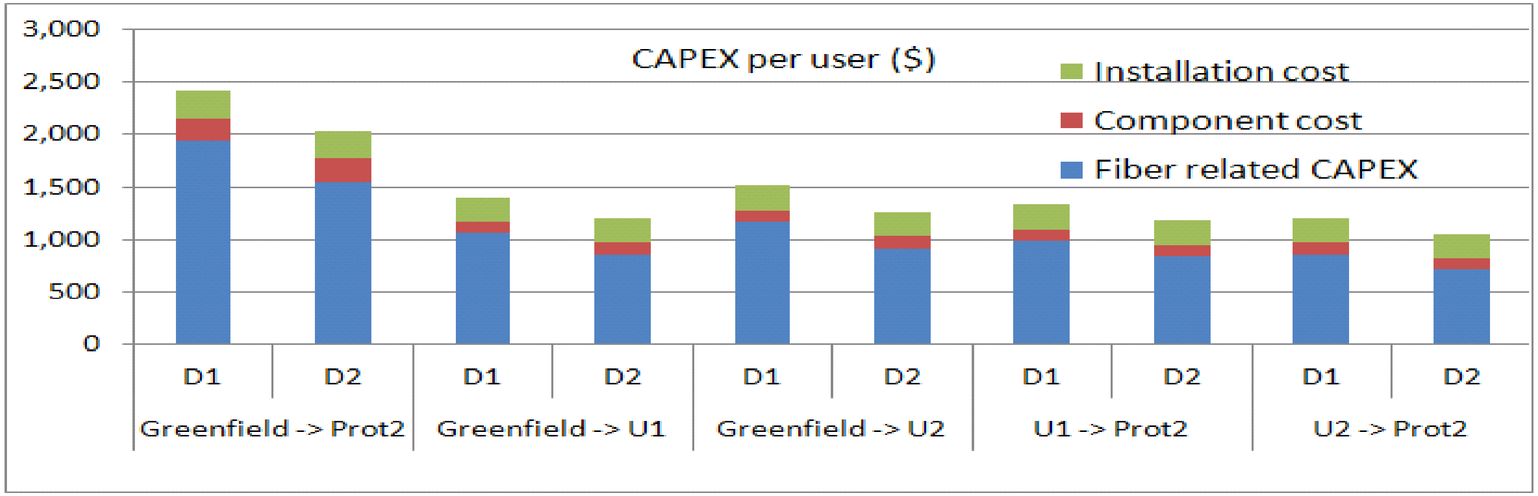
- The CAPEX for P2P scheme is significantly higher than all the other schemes due to the dedicated feeder fiber required by each end user.
- Offering protection all the way up to the user in green field only requires trivial additional cost compared with the unprotected scheme for PON and AON.
- AON requires slightly lower investment cost than TDM PON and WDM PON

Additional cost for protection migration per user ($)

TDM PON



P2P



OpEx Modelling

- Failure reparation:
  - The number of failures of a given component or cable is given by the FIT.
  - The reparation cost associated to each failure is proportional to the required number of technicians to repair the failure ($team_i$), the traveling time to and from the failure location ($t_{travel\ i}$), the time to repair the failure ($MTTR_i$) and the salary of the technician.

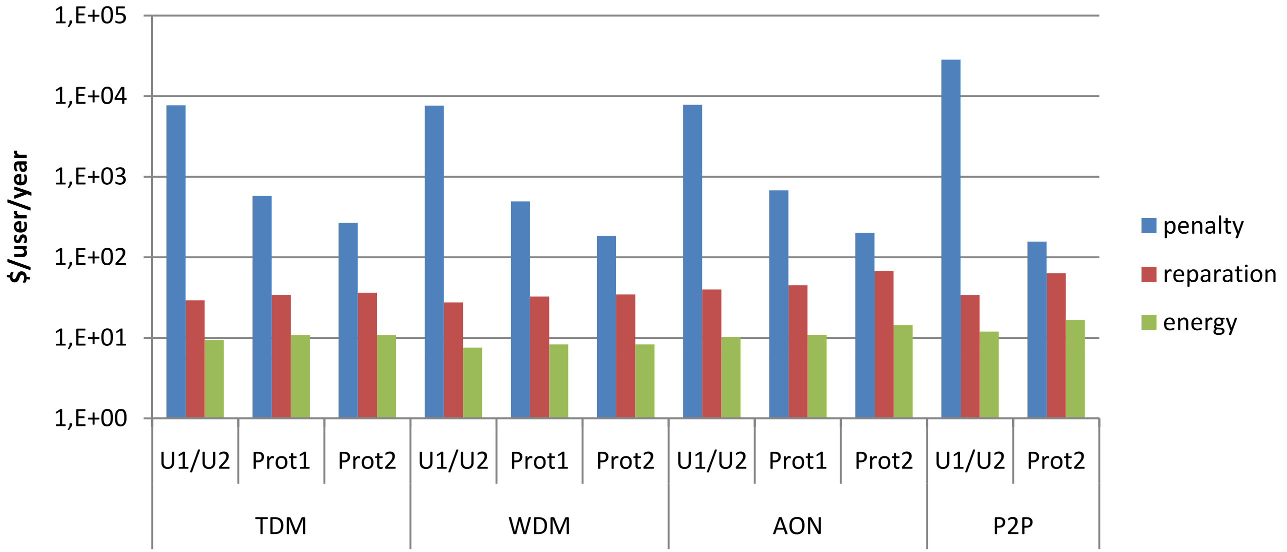
$$T_{rep\ i} = team_i \,.(MTTR_i + 2.t_{travel\ i})$$

- Penalty:
  - The penalty associated to one failure is proportional to the number of interrupted connections, the % of business users, and the time $T_{pen\ i}$

$$T_{pen\ i} = MTTR_i + t_{travel\ i}$$

OpEx per User

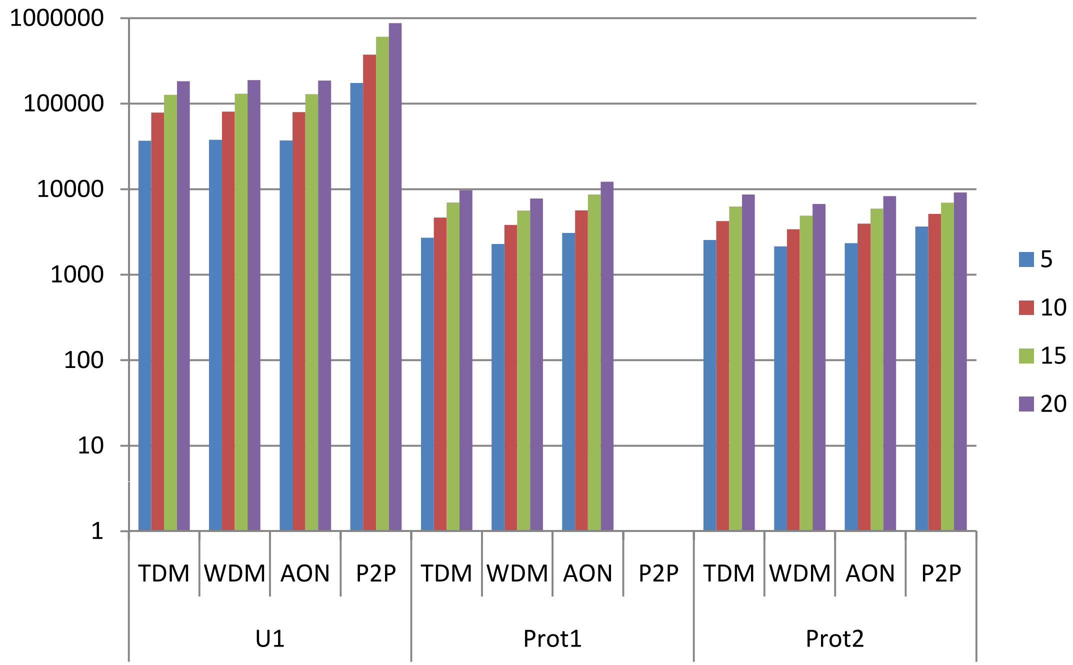
- Considered values:
- salary of a field technician is 255$/hour including all the material and transport means required for the reparation
- 80% of BU in dense urban areas, and a penalty of 1200$/hour
- 0.142$ (Price of 1 kWh electricity power in Belgium for 2010)



Penalty, failure reparation and energy cost per user per year for the D1 scenario

Overall cost comparison

- 5, 10, 15 and 20 years
- The cost of salaries, energy and penalties are assumed to increase 5%, 5% and 3% per year respectively.



- the longer the network timeframe, the higher cost per user since more reparation and penalties would have to be paid.
- The “small” savings of Prot. 2 with respect Prot.1 may justify the decision of most of operators to offer protection up to the remote node

Conclusions

- The availability and energy consumption of different access network technologies (TDM PON, WDM PON, AON and P2P) used in two different dense urban scenario layouts have been studied.
- It has been shown that P2P technology has the highest power consumption
- The best candidates for next generation access networks are passive technologies such as TDM (it has lowest power consumption nowadays) or WDM PONs (based on the expected low power consumption of new WDM components).
- In the studied fiber layout cases, offering protection all the way up to the user in the greenfield only requires trivial additional cost compared with the unprotected scheme for PON and AON.
- It has been shown that the most cost efficient technology is WDM PON with protection up to the user, which is the compromise of required investments with the reduction of costs (more infrastructure needed for protection, more failures are expected but lower penalties should be paid.)