GPON evolution: energy-efficient way for Next Generation Access

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SEVENTH FRAMEWORK PROGRAMME

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- Motivation: current access network and its challenges
- Evolution towards NG-PON energy efficiency
- Long-Reach/Large Splitting GPON
- Next Generation PON2

Current access network and its challenges

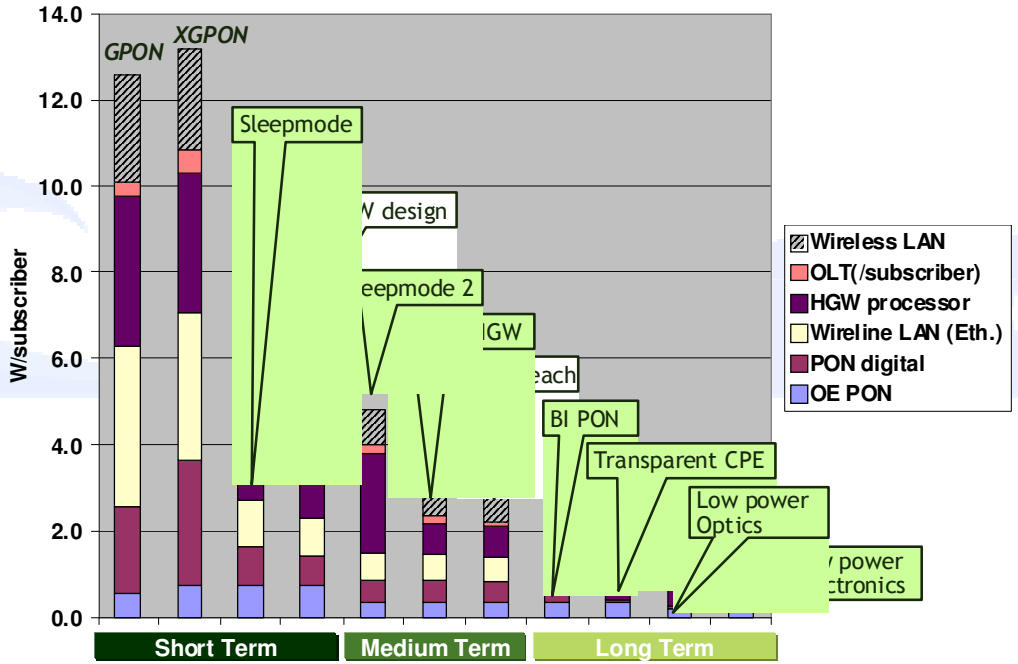
- TREND in downstream access rate is double capacity every 2 years
  - Current drivers: Mobile broadband, multimedia services, social networks, cloud services...
  - This leads to 40 Gb/s aggregate DS rate for PONs in ~2016
- BUT... Revenues vs BW growth link has been broken
  - Operators must address network evolution in a disruptive way, as the tradicional network upgrades do not scale, neither in cost-efficienty nor in power consumption efficiency
- Architectural issues in network evolution is a decisive point for operators
- Fibre technology convergence between metro and access is taking place, overcoming limitations of copper access
- G/E PON standards are mature, NGPON1 is being closed and NGPON2 is expected for ~2014-16

Current PON

- Some experimental results (D1.2)
  - GPON OLT cards (4 PON interfaces) consumption are ~40W for 256 users in GPON (0,16W/customer), VDSL2 card consumption is 25W for 24 ports (around 1W/customer, 6 times more than in optical access) -> **optical is the future, regulation?**
  - Prototype with special functions (RF TV) can increase power consumption 50%
  - Video overlay functionalities have a great impact in overall power consumption due to its >10% ONT consumption increase. **IPTV vs RF video? Strategical-economical issues**
  - Video overlay head-ends power consumptions has been analyzed for 8 relevant providers and a power efficiency between 0,01 W/customer (55k customers) and 0,3 W/customer (10k user) has been found in the literature. **Network dimensioning and the best provider choice can increase power efficiency 30 times (OPEX reduction)**
  - 100Mpbs/user WDM-PON cards power consumption increase 30% for long reach (>20km) and 60% for 1G speed -> Evolution tradeoffs: **impact on CO consolidation?**

Towards energy efficient NG-PON

- Sleep Modes and EE Hardware design are important in the short-term
- Long Reach is an important issue for increasing the energy efficiency of optical access in the medium term, (great impact in network architecture)



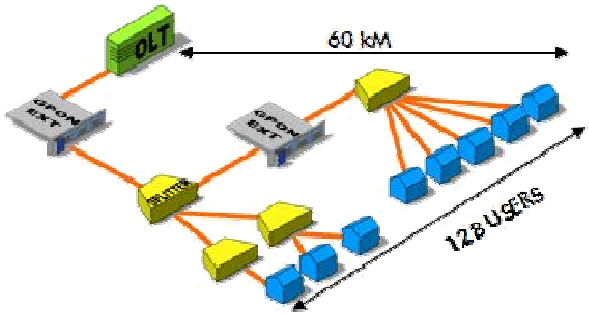
Source: GreenTouch Consortium Wireline Access working group

Towards energy efficient NG-PON

- Long reach has a big impact for POP consolidation and metro-network collapse -> enhanced power budget
- Enhanced power budget addresses two main challenges which can lead to both CAPEX and OPEX reduction (power consumption/maintenance)
  - Physical reach to users (long reach)
  - Efficient use of CO equipment (>cards filling ratio, large splitting)
- GPON standard
  - 28 dB power budget (B+)
  - For 1:64 PON topology, ~21dB are lost just in splitters
  - Other losses give a practical reach around 10km
- Enhanced power budget can increase power efficiency, current commercial approaches:
  - Extender Boxes
  - C+ Optics

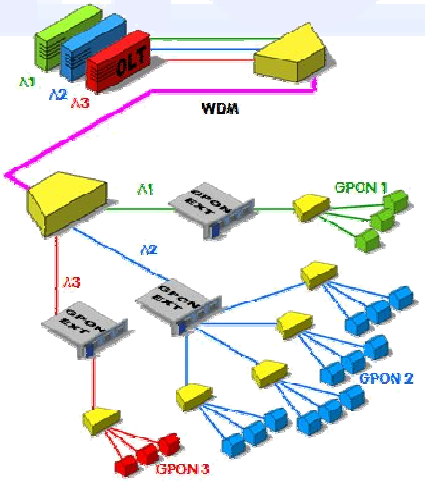
Extender Boxes

- Products available in the market compliant with standard ITU-T G.984.6
- Reach extension up to 60km for 128 users (ideally)
- Two main technological approaches:
  - Semiconductor Optical Amplifiers: transparent to protocol
  - OEO regeneration: may require protocol adjustments due to optoelectrical conversion delay
- 1:1 type and 1:4 types, WDM trunk



1:1 type

WDM Trunk



1:4 type

C+ Optics

- The power budget of the PON can also be increased by using transceivers with improved optical specifications (C+ optics)

Optics	TX power	RX sensitivity	Consumption
B+	1,5/4,5 dBm	-29 dBm	1,5 W
C+	3,0/7,0 dBm	-32 dBm	1,5 W

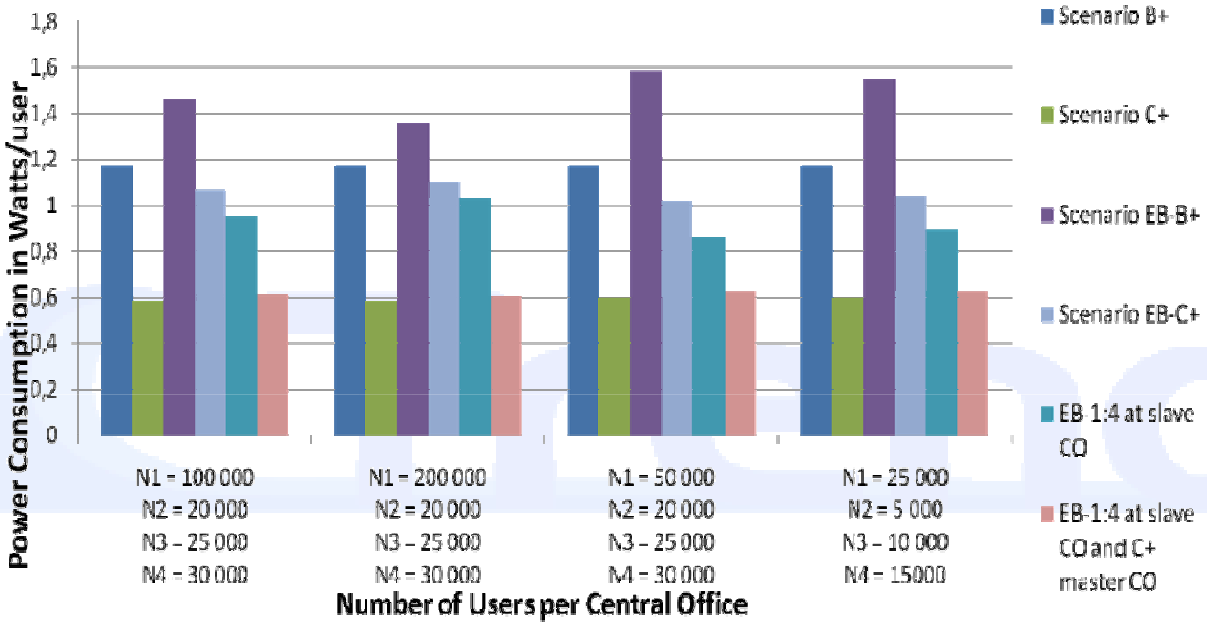
Source: Fujitsu

SFP OLT PON Transceiver

- Transmission power is increased in the OLT TX and the sensitivity of the OLT RX is also enhanced
- ONT/ONU do not require any modification or upgrade
- An average +3dB power budget enhancement can be achieved with regards B+ optics

Active Long Reach/Large Splitting GPON

- Analysis of Power efficiency

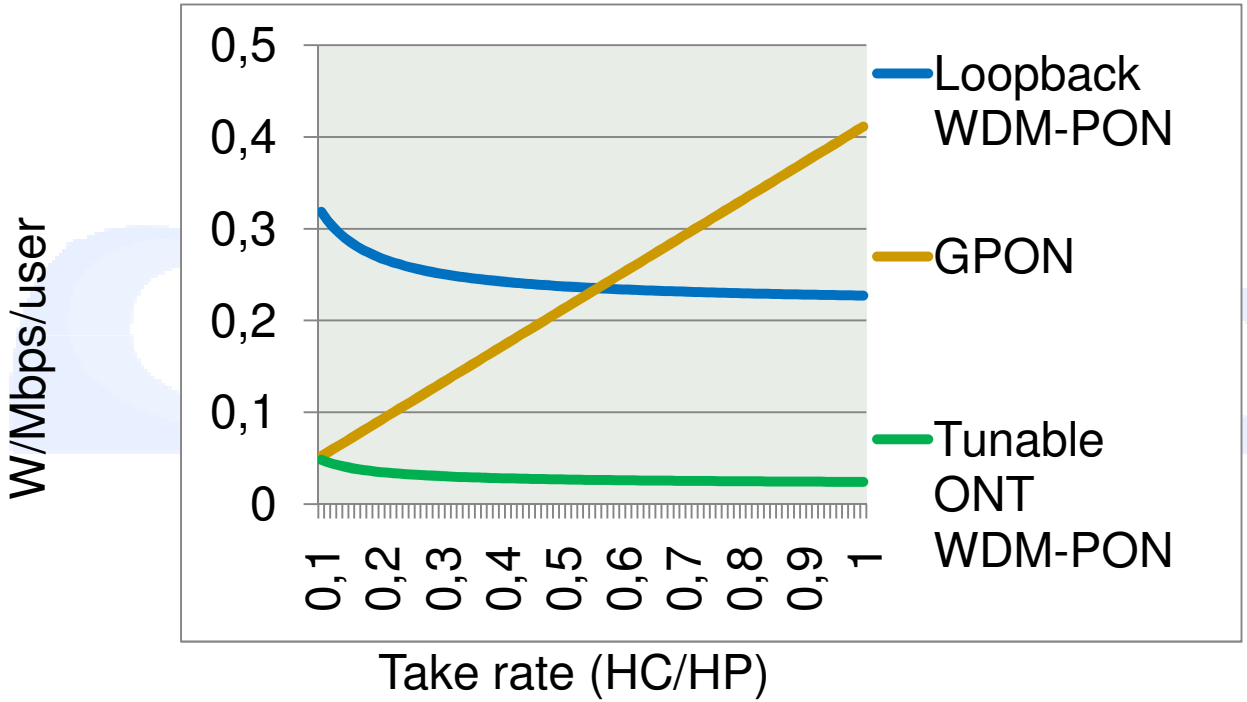


Source: FT, OFC 2011

- EB solutions (1:1 type) with B+ do not improve energy efficiency
- EB solutions (1:4 type) improve energy efficiency, more with C+ optics
- C+ optics deployment keeping all COs as master is more energy efficient than C+ optics at master CO and EB at slaves COs
- C+ master CO and 1:4 EB achieves best filling ratio (less OLT cards)

NG-PON2 is the answer to Passive Long Reach/Large Splitting

- Preliminary analysis



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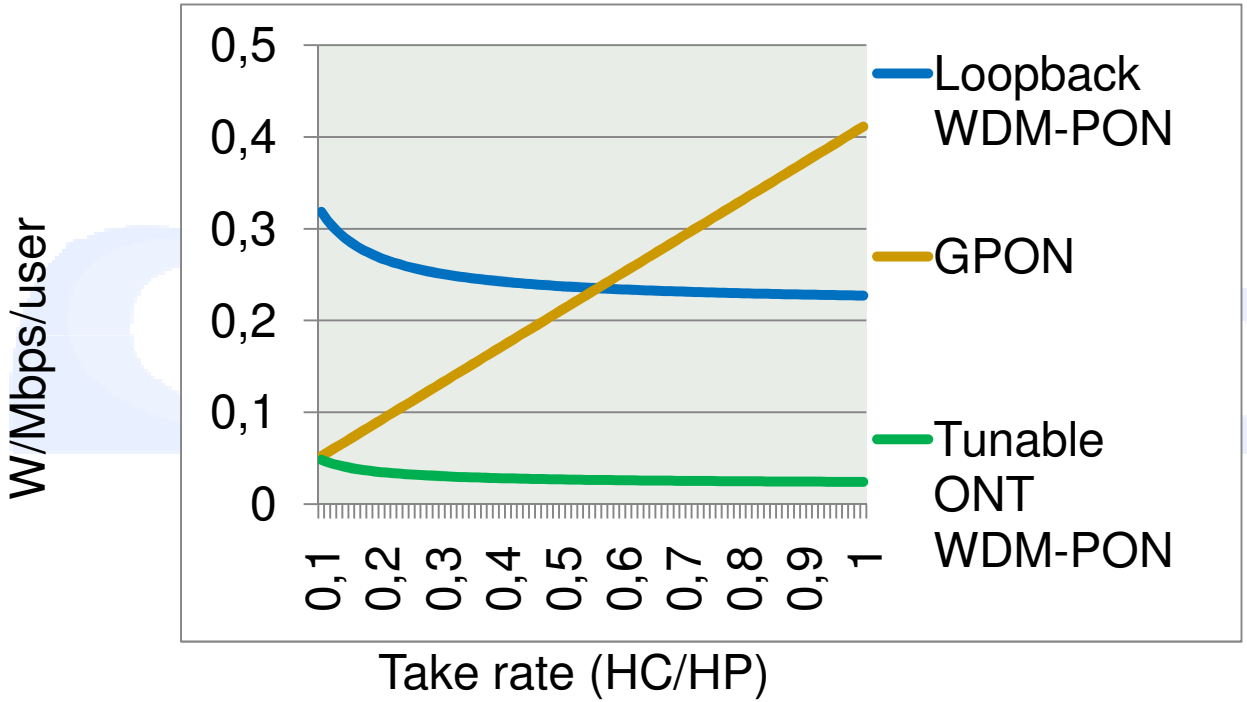

- GPON Energy efficiency per Mbps/user decreases as take rate is higher, due to TDMA

NG-PON2 is the answer to Passive Long Reach/Large Splitting

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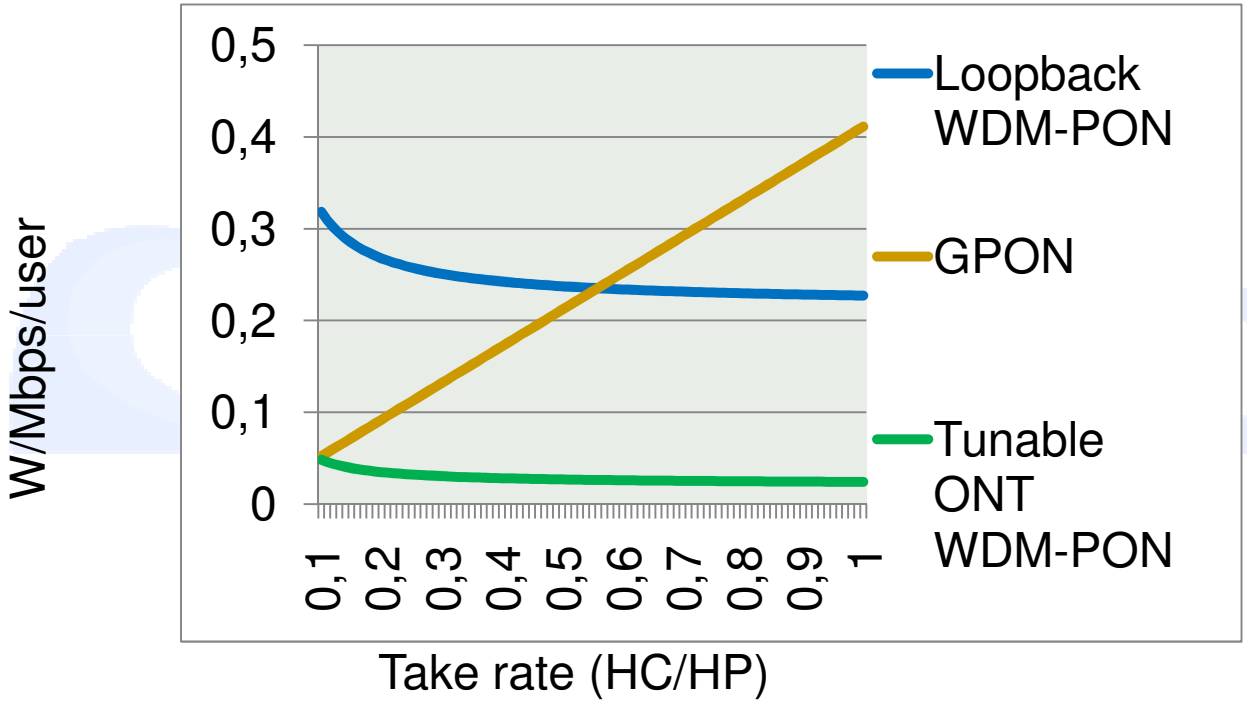

- Tunable ONT 1G WDM-PON is the most energy efficient system per Mbps/user (due to 1G), (1G Loopback WDM PON?)

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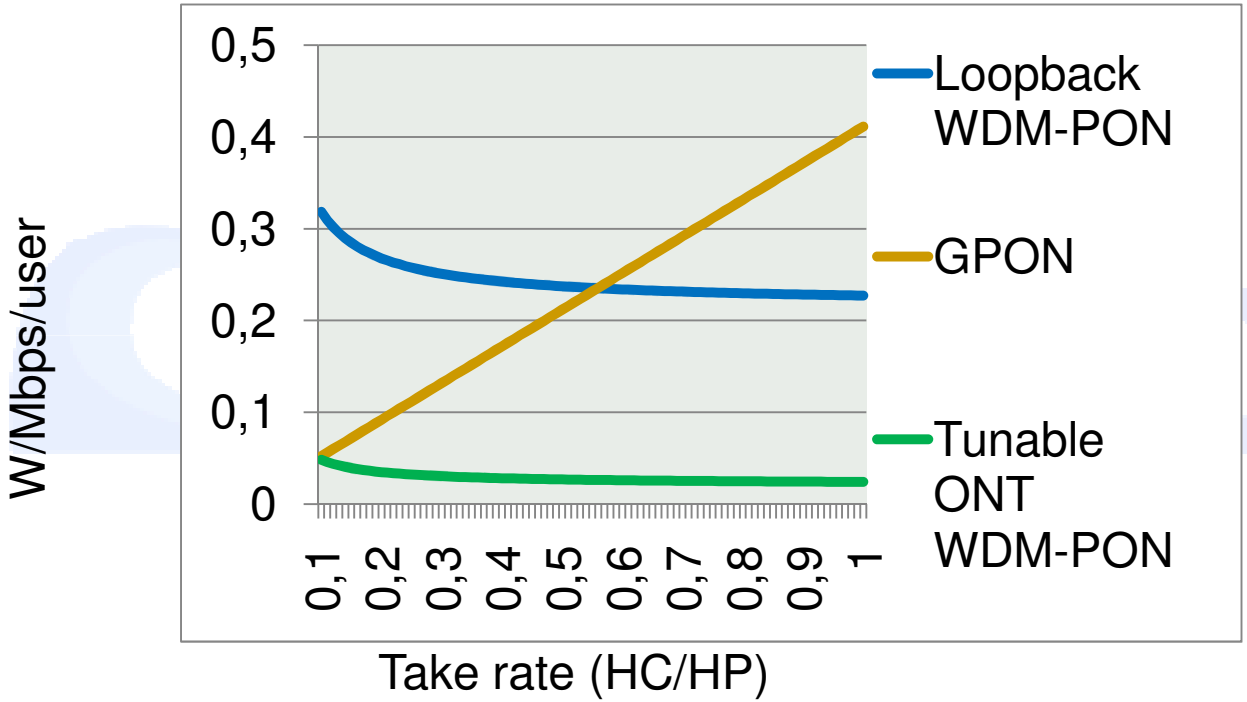

- WDM-PON energy efficiency per Mbps/user increases with take rate as OLT card consumption is shared between connected homes

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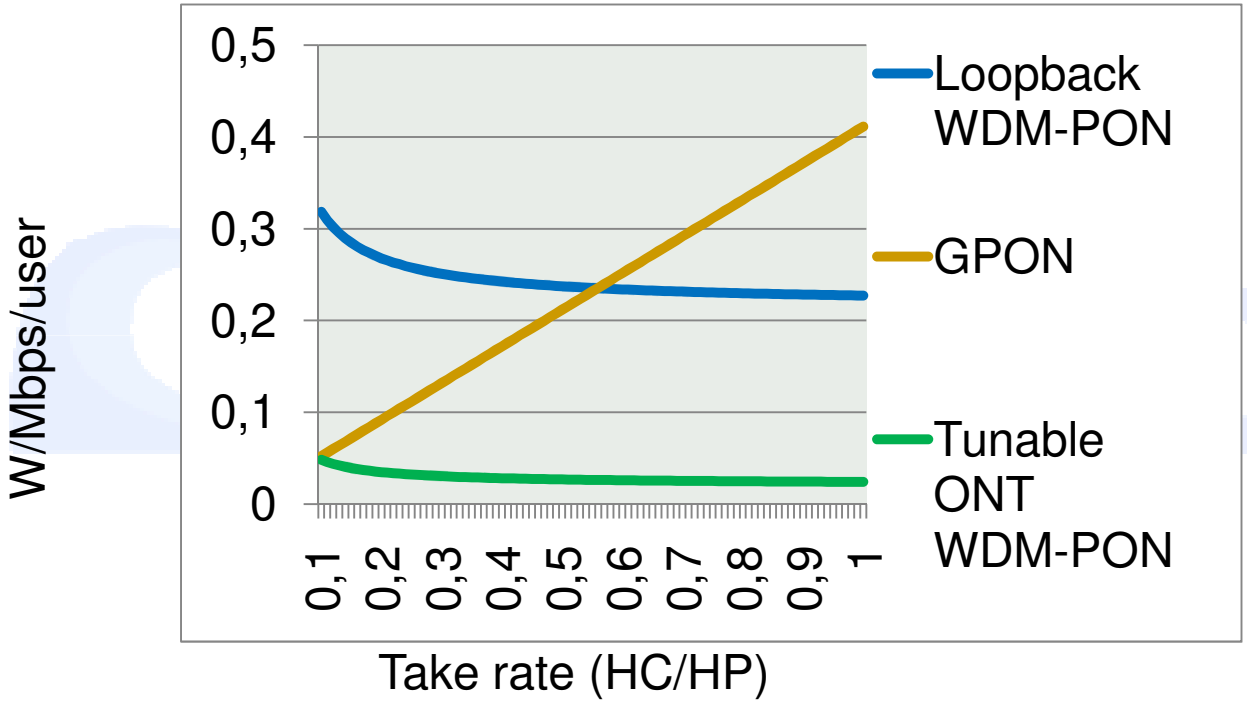

- Loopback 100M WDM-PON is more energy efficient than GPON for take rate>0.56 (1G Loopback WDM PON?)

NG-PON2 is the answer to Passive Long Reach/Large Splitting

- **Deployment scenarios with a comparative technology framework must be studied for overall energy efficiency**

NG-PON2 is the answer to Passive Long Reach/Large Splitting

- Joint activity between Telefónica Research and France Telecom ongoing (more partners accepted)

  - Topic: Electro-optical power consumption comparative of NG-PON2 systems
  - Objective: Comparative evaluation of NGPON2 technologies energy efficiency at component (WP1) and deployment levels (WP2).
  - Deployment model and study of NG-PON2 can be the foundation of another Joint Activity in WP2.


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