



Ecosystem of EPON FTTH Deployment

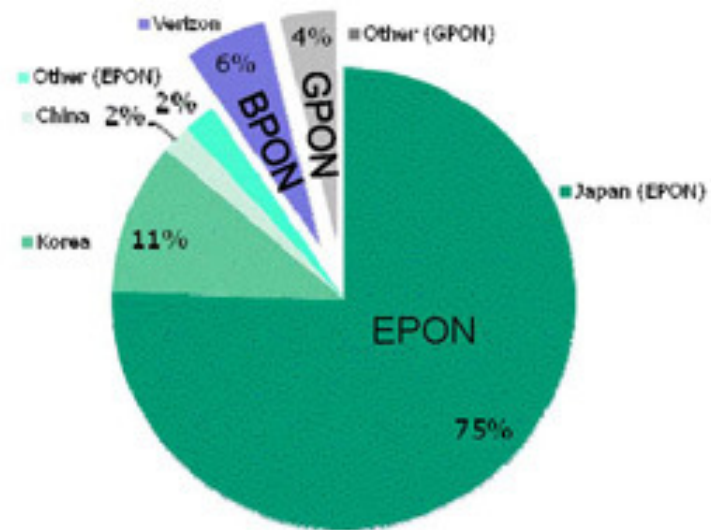
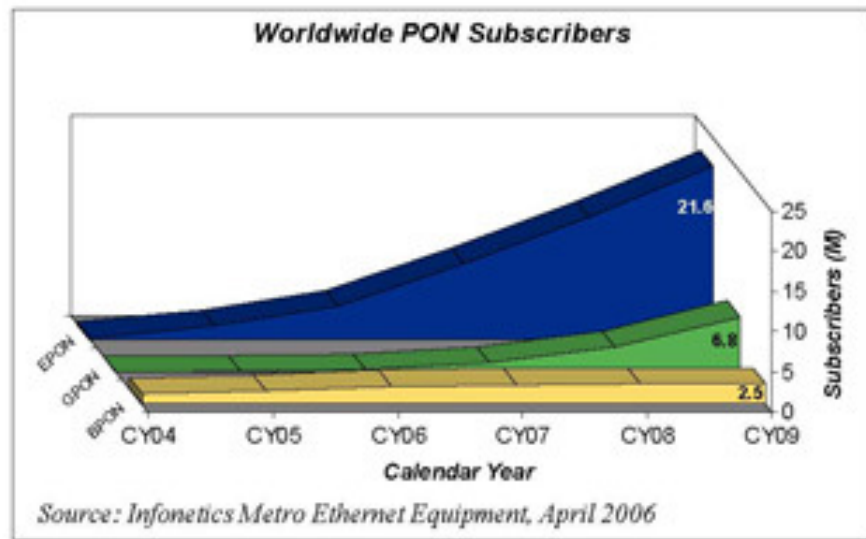
Teknovus Overview

About Teknovus

- Fabless Semiconductor Company for FTTx
- Founding Member
 - IEEE 802.3ah
 - Chair, IEEE 802.3av
- Focus on enabling FTTx and Triple Play
- Offices in Petaluma, San Jose, Tokyo, Seoul, Beijing, Shanghai
- Millions of PON ports sold
- Over 50 vendors world wide with Teknovus design; 14 shipping in large volume
- Over 25 service providers in 5 continents
(Bright House, Chunghwa Telecom, China Telecom, China Netcom, KDDI, Korea Telecom, K-Opticom, ...)



xPON Deployment : where are we today?



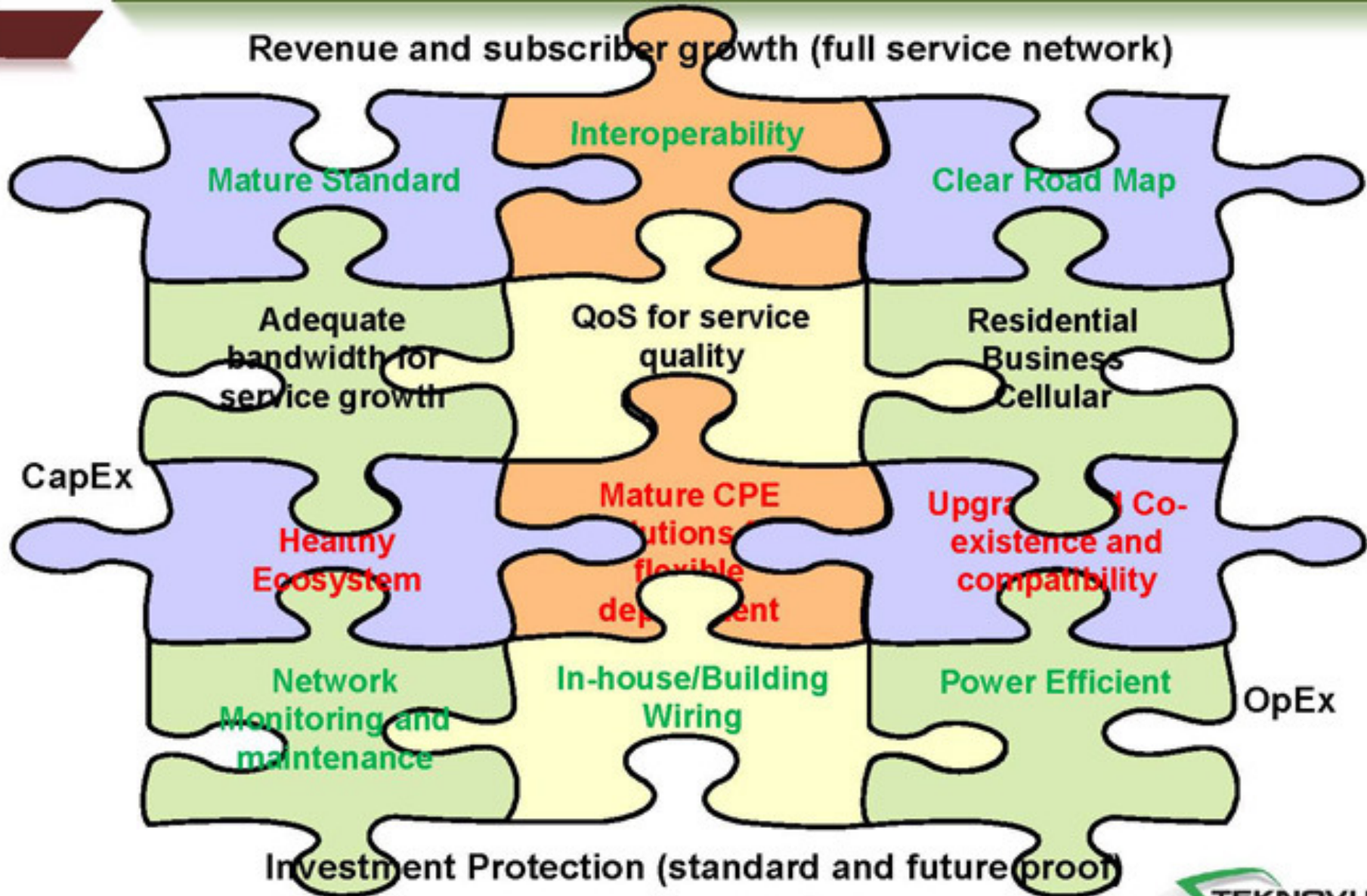
Sources:
EPON: NTT, KDDI, KT, Hanaro, LG Powercomm, CTC, CNC
GPON: Lightwave, Alcatel (public presentation)

> 90% are in Asia (Asia is driving new PON technology). Of those:

- Nearly 100% of those subscribers are EPON
- 10M+ EPON subscribers in Japan
- 1M+ EPON subscribers in Korea
- Mass deployment underway in China

Building Blocks for Mass Deployment

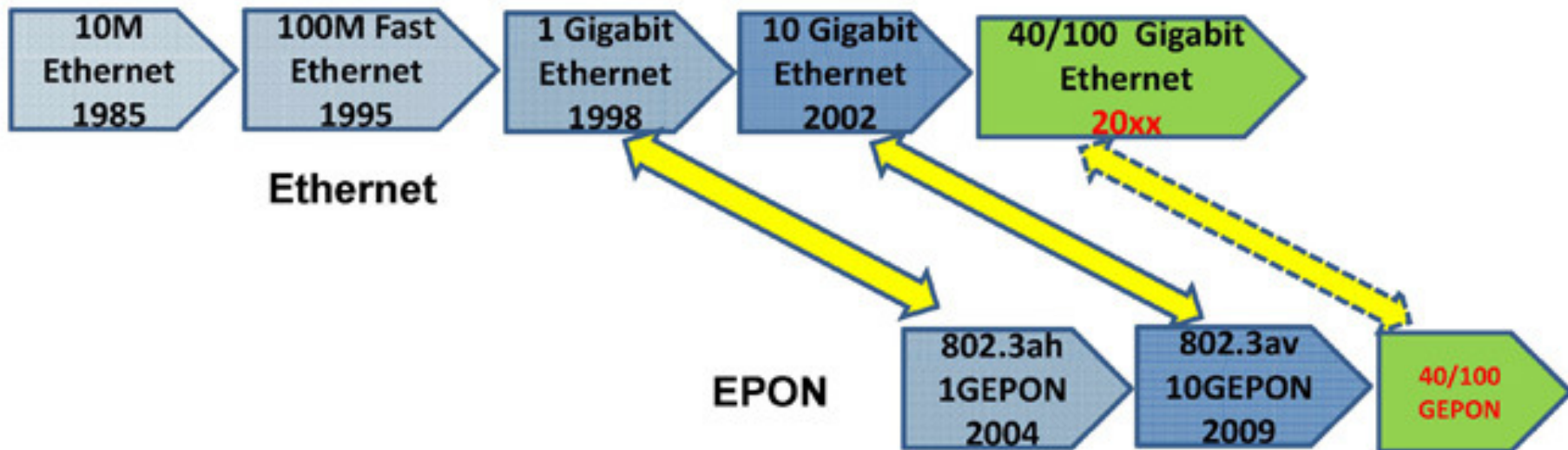
Revenue and subscriber growth (full service network)



Stable Current Standard – 802.3ah

- Virtually no change to the specification since its approval in June 2004
- Jump start and foster key component industry such as optics and ASIC
- Lower system vendor product development risk and shorten the development cycle
- Necessary for service providers to embrace the technology
- Lower service provider deployment risk

Clear Future Standard Roadmap – 802.3av



- EPON leverages and follows P2P Ethernet standard progress
- EPON inherits a clear standard roadmap from P2P Ethernet
- A clear standard roadmap is key for service provider network growth and expansion

1G/2G/10G Compatible Standard Family



- Wavelength, protocol, and service compatibility
- Gradual upgrade - once ONU/ONT at a time
- 1/2/10G ONU/ONT co-existence on same fiber – OLT one end upgrade only
- No forklift upgrade required – investment protection

[†]2.5G λ can use frequencies other than 1550 nm

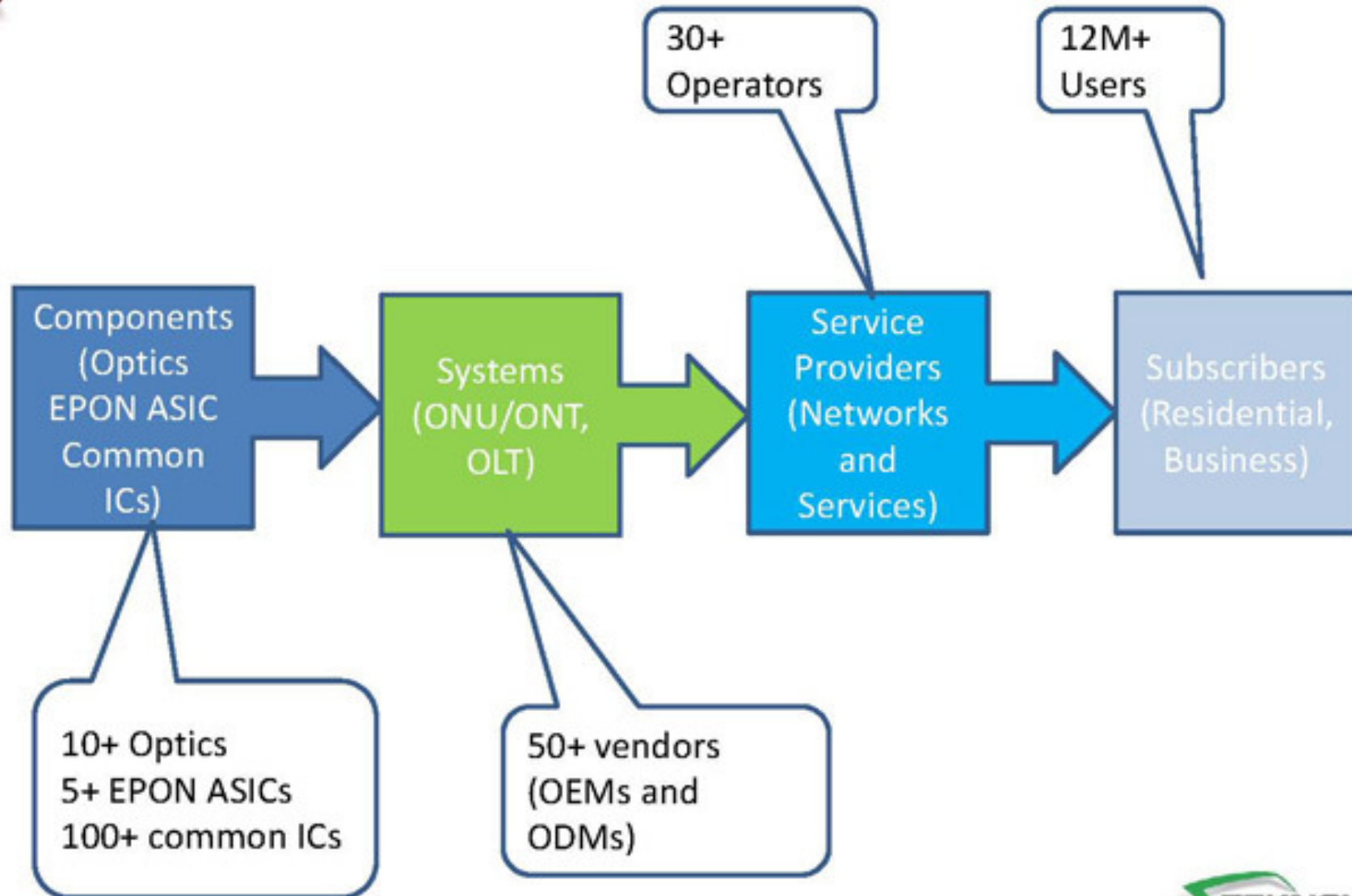
Interoperability – Chip/System/Service Levels

Interoperability must cover chip level, system level and service level

	Chip Vendors	System Vendors	Services
KDDI	Teknovus	Multiple	Multi-play
NTT	Multiple	Multiple	Multi-play
Korea Telecom	Multiple	Multiple	Multi-play
China Telecom (CTC)	Multiple	Multiple	Multi-play

Major service providers have been deploying full service EPON networks in the past 2-3 years

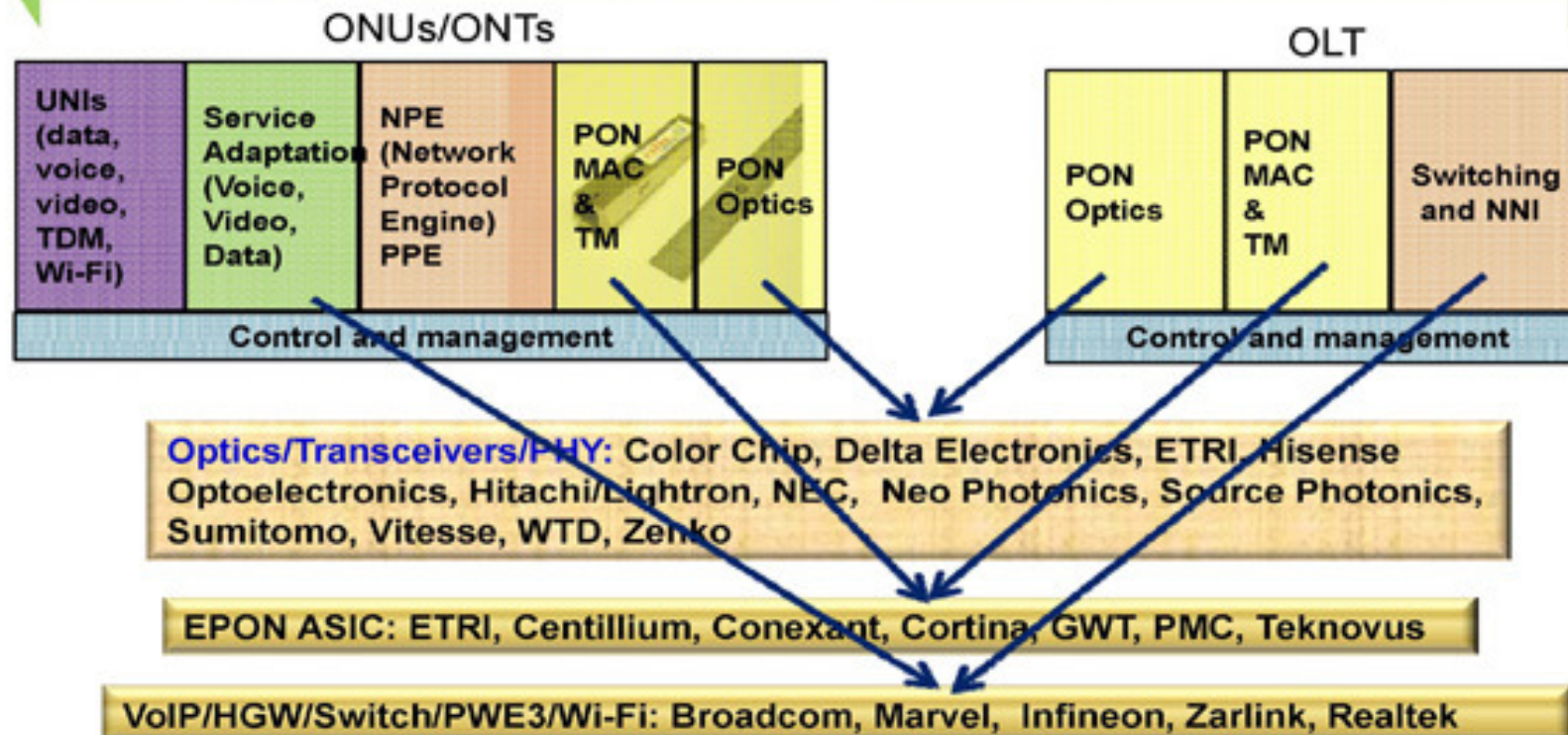
Established and Growing Ecosystem



Established and Growing Ecosystem

System: Allied Telesyn, Alloptic, Corecess, Dasan/ Siemens, Entrisphere, Fiberhome, Fujitsu, Furukawa, H3C, Hitachi, Huawei, Hyundai, Mitsubishi, NEC, Ocean Broadband, OKI-Fujikura, Salira, Samsung, Sumitomo, Ubiquoss, UTStarcom, ZTE, ...

Test Equipment: Agilent, Anritsu, EXFO, Fujitsu



Bandwidth Capacity for Service Growth and Expansion

- 1GEPON supports SMB biz data service up to 100Mbps
- 10GEPON (symmetrical) will support full spectrum of business customer needs from T1/E1 replacement to Multi-GE data service for disaster back up.

of possible customers per EPON port

6000+

1000

100

10

802.3ah 1G/1G

802.3ah Turbo 2G/1G

802.3av 10G/1G, 10G/10G

	Min Rate	Max rate	# of possible customers per EPON port
T1 replacement	1.5Mbps	1.5Mbps	600+
Guaranteed 10Mbps Ethernet Data Service	10Mbps	10Mbps	100
Guaranteed 100Mbps Ethernet Data Service	100Mbps	100Mbps	10
Fixed GE data service	1000Mbps	1000Mbps	1

Business Services

Bandwidth Capacity for Service Growth and Expansion

- 2X More IPTV channels
- 5X Higher HDTV channels

Per PON Bandwidth Need
$250 * 3.8Mbps = 950Mbps$
$50 * 12Mbps = 600Mbps$
$64 * 4Mbps * 10\% \approx 25Mbps$
$64 * 0.1Mbps * 10\% \approx 1Mbps$
$64 * 10Mbps * 60\% = 384Mbps$
1960Mbps

- 10X more IPTV channels
- 10X Higher HDTV channels
- MDU deployment



Per User	Per PON Bandwidth Need
4 SDTV multicast IPTV (MPEG2)	$100 * 3.8Mbps = 380Mbps$
2 HDTV multicast IPTV (MPEG4)	$10 * 12Mbps = 120Mbps$
1 VOD session	$64 * 4Mbps * 10\% \approx 25Mbps$
2 VoIP sessions	$64 * 0.1Mbps * 10\% \approx 1Mbps$
High speed Internet data	$64 * 10Mbps * 60\% = 384Mbps$
Total	910Mbps

Residential Services

Per PON Bandwidth Need
$1000 * 3.8Mbps = 3.8Gbps$
$100 * 12Mbps = 1.2Gbps$
$512 * 4Mbps * 10\% \approx 200Mbps$
$512 * 0.1Mbps * 10\% \approx 8Mbps$
$512 * 10Mbps * 60\% = 3Gbps$
9.5Gbps

QoS for Service Quality and SLA

- EPON solution widely deployed with QoS support for triple play residential and business services
- Teknovus unique features allow per subscriber SLA protection and meet TDM jitter and latency requirement for business and cellular backhaul

Correlation between Key QoS Features and Service provider services offerings

Service provider services	High Speed Internet tiered data service	IPTV	VoIP	TDM/Cellular backhaul	Business VPN and TLS
Buffering and queuing	yes	yes	yes	yes	yes
Scalable DBA	yes	yes	yes	yes	yes
Multiple LUID	yes	yes	yes	yes	yes
High split ratio (1:64)	yes	yes			yes
Multicast management	yes	yes			
VLAN and Layer 2 Ethernet	yes	yes	yes		yes
Deep Packet Classification	yes	yes	yes	yes	yes
Layer 3 security	yes	yes	yes		yes

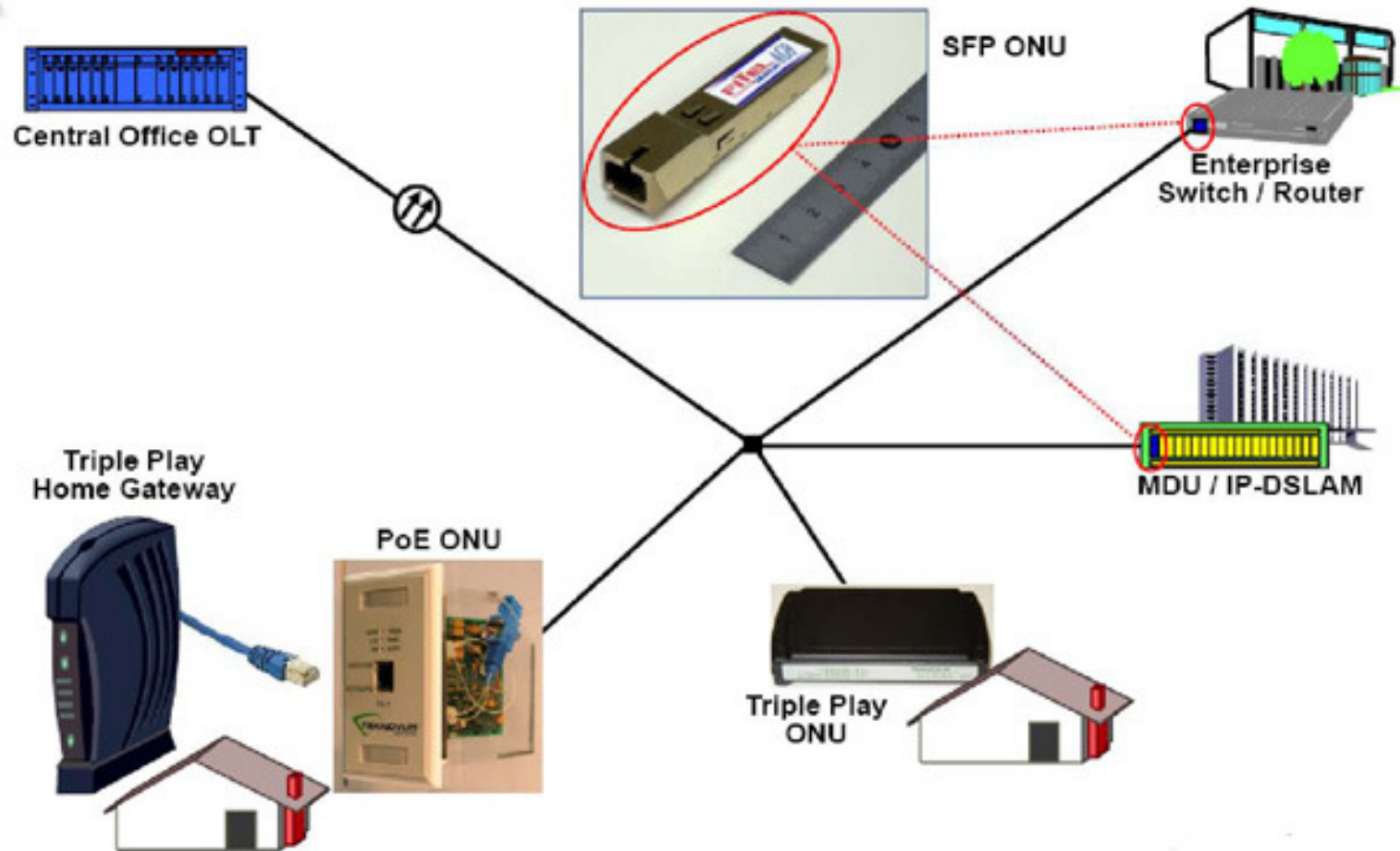
Mature CPE Solutions for Flexible Deployment

ONU Type	Data PORTS	1550 Overlay	Voice	Additional Variations and Requirements
FTTH – Data only	1xFE, 2xFE, 4xFE, 2xFE / 2xGE 1xGE, 2xGE	--	--	TR-069, Interoperability [IOP], Optical Monitoring [OM], multiple VLAN with multiple classification criteria [m-VLAN], low power ($\leq 2W$)
– Home Gateway	4xFE 2xGE	optional (China, Japan, Korea, Taiwan)	1 w/ RJ-45 (w/ internal IAD) 2 w/ RJ-45 (IAD)	WiFi 802.11g, USB, IPv6, TR-069, IOP, OM, m-VLAN, low power
– 1550 Overlay	<i>(see others)</i>	<i>(see others)</i>	<i>(see others)</i>	integrated filter/splitter
– PoE	1xFE, 1xGE	--	--	IOP, OM, m-VLAN, low power ($\leq 2W$)
FTTO – Small business	$\geq 8x$ FE	--	0, 4, 8 (IAD)	TDM (1, 2, or 4 E1), IPv6, IOP, OM, m-VLAN

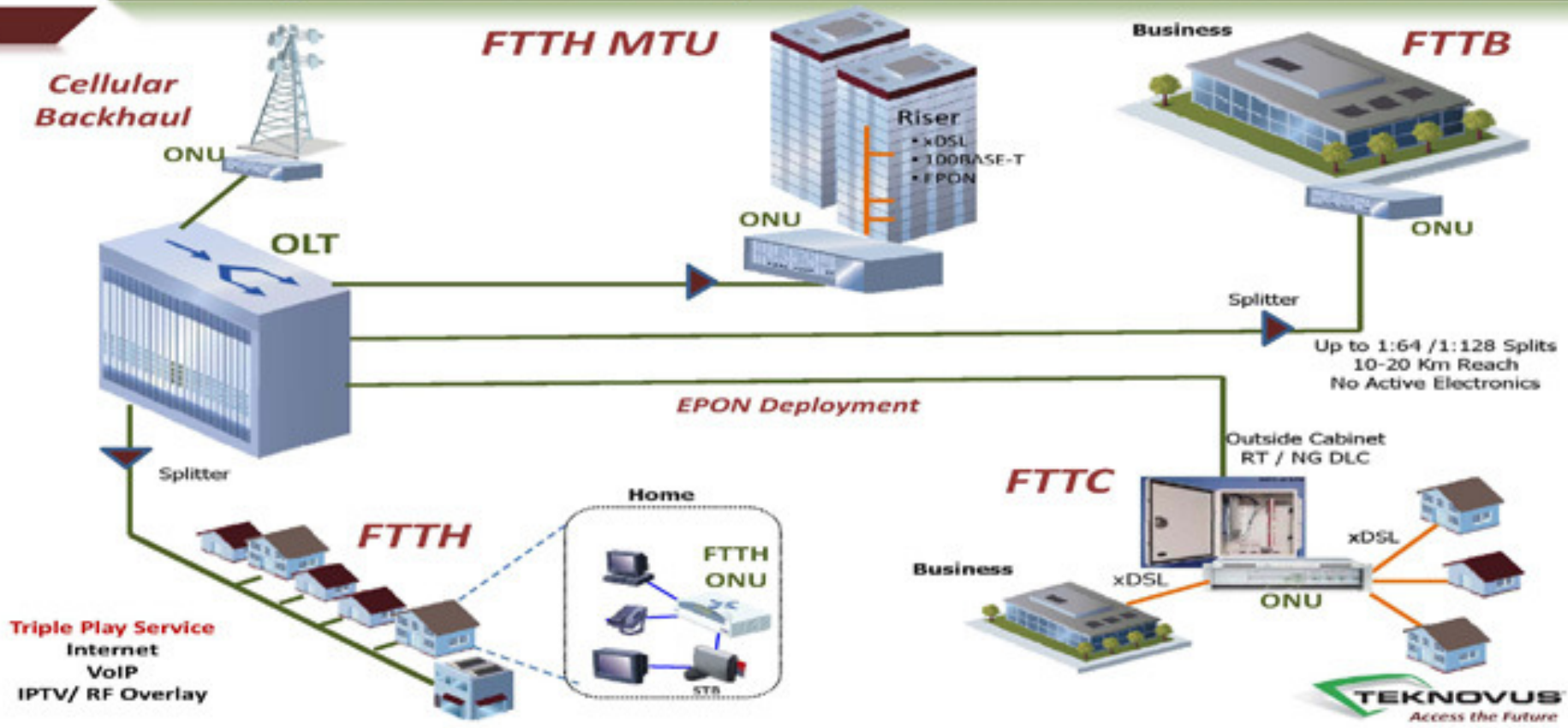
Mature CPE Solutions for Flexible Deployment

ONU Type	Data PORTS	1550 Overlay	Voice	Additional Variations and Requirements
MDU (Residential) – xDSL	24/32/48/64/ 72/96	--	--	ADSL2 and VDSL2, IOP, OM, m-VLAN
– switch	≥8xFE	optional	--	IOP, OM, m-VLAN
– EoC	8-50	required (China)	--	many variants being used and evaluated
– SFP	--	--	--	IOP, OM, m-VLAN, 2.5 (see below), ≤1.5W
MTU (Business) – switch	≥8xFE	--	optional	TDM transport capability (4 or 8E1), IOP, OM
– SFP	--	--	--	TDM, IOP, OM, 2.5 (see below)
2.5Gbps	(various, see above)	optional	(various, see above)	<ul style="list-style-type: none"> • WDM IOP (Japan) • 1G<->10G bwd/fwd compatibility • SFP

Mature CPE Solutions for Flexible Deployment



Integrated Residential, Business and Cellular Network



EPON Cost Advantage

- EPON Technology inherently provides cost advantage compare other PON technology
 - Optics – EPON optics cost is less than half of other PON optics.
 - MAC Layer – EPON MAC doesn't require SAR function
- EPON technology leverages massively cost efficient Ethernet industry, therefore virtually every single part in the BOM, EPON part is same or lower priced due to the use of commodity part
- EPON chip solution provides more efficient hardware implementation option
 - Assuming same ONU configuration, (Teknovus)EPON BOM has less or same chip count than other PON
 - EPON ONU chip (Teknovus) allows 2 layer PCB design vs 8 layer PCB design for other PON ONUs
- EPON's leading volume provides 10% to 15% component cost advantage and manufacture cost advantages
- Ease of provisioning and operation further reduces the OpEx cost for service providers

**EPON currently enjoys a 30%+ cost advantage over other
Competitive PON**

Teknovus Proprietary and Confidential

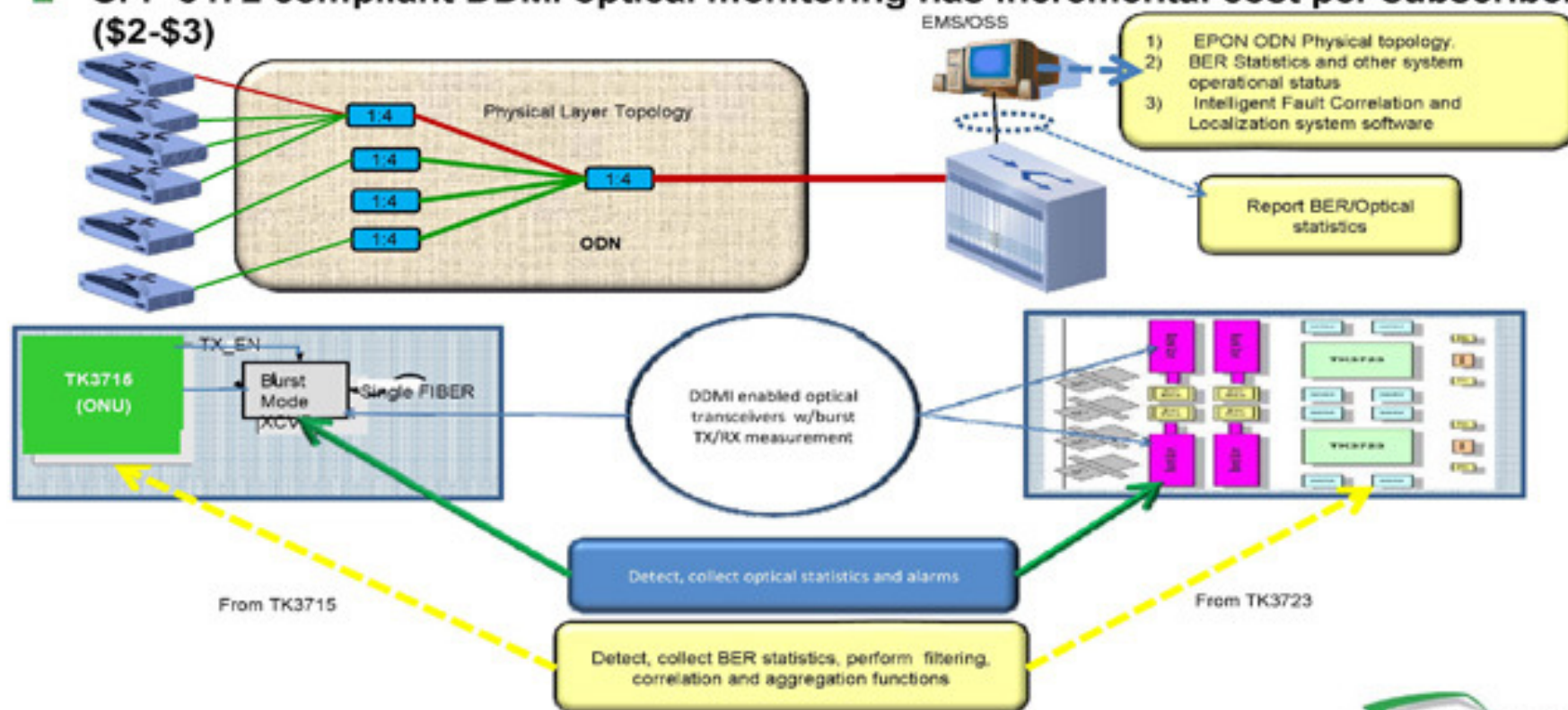


Network Health Monitoring, Fault Diagnosis, and Troubleshooting

- Crucial for reducing overall network operation and maintenance cost (OpEx)
- Crucial for customer satisfaction and Subscriber SLA
- Must cover and able to separate ODN failures and optical transceiver failures
 - ODN failures typical require repair as follow up
 - Transceiver failures will likely require the order of a replacement unit as follow up
 - Two separate organizations and processes are invoked as a result
- Failure coverage
 - Continuous monitoring of optical link status, transceiver status (temperature, Tx Bias, supply voltage, Tx power, Rx power)
 - Continuous monitoring of BER
 - Detection of ODN failures such as fiber cut, macro bend, loose connector
 - Detection of gradual transceiver failures such as out of spec due to aging, laser stuck-on, laser signal leak

Network Health Monitoring, Fault Diagnosis, and Troubleshooting

- Teknovus supports both BER (8B/10B decoding and FEC stats on per LLID basis) based and SFF-8472 compliant DDMI (Digital Diagnostic Monitoring Interface) based solution
- BER based solution has no additional cost
- SFF-8472 compliant DDMI optical monitoring has incremental cost per subscriber (\$2-\$3)

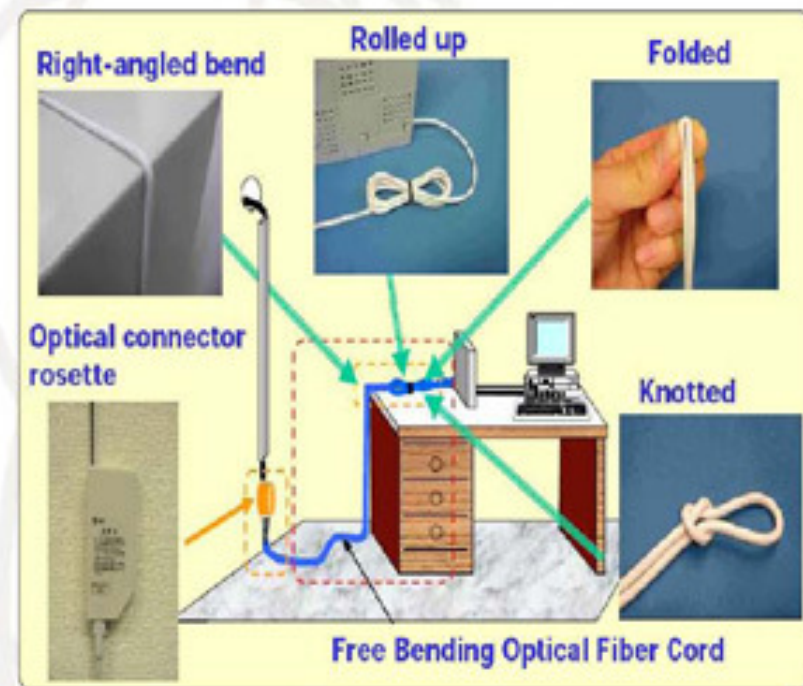


In-house and In-building Wiring Technology

- Many 90 degree bends for MDU wiring (for example, average 12* right-angle bends to each apartment)
- Bendable fiber (such as Corning Clearcurve) allows various harsh fiber handling (see NTT diagram below*)
- Splice-less fiber installation (pre-connectorized fiber segments)
- Re-use existing wirings
 - Ethernet Over Coax (EOC)
 - EPON + VDSL/ADSL (copper)
 - EPON + Ethernet (Cat5)

* For a typical apartment building in US

Significant improvement in wiring to the ONU.



* From NTT presentation to joint ITU/IEEE session

Power Efficiency for a Green FTTx Network

Per Residence	Average Power Consumption
Teknovus enabled GREEN ONU	< 2.2W
Less Power efficient xPON ONU	>5W
Power Consumption Power Penalty for single residence	2.8W
Annual Power saving per single residence	2kWh

Annually	Long term impact for any Nation wide – 10M FTTH Homes
Power Consumption penalty	28MW (continuous load on China national power grid)
Coal Consumption penalty	112 Kilotons coal burned
CO2 emission Penalty	~0.5 Metric tons of CO2 generated
Fly Ash (U & Th) penalty	~0.5 Metric tons released



Based on energy efficiency only, any PON system that consumes more than 3-4W per subscriber is obsolete and is not suitable for mass deployment.

Summary

Must all be adequately addressed for mass deployment	Ether net	xDSL	GPON	EPON	Note
Meeting today and future bandwidth and service demand	✓	✗	✓	✓	Top line growth
Enable competitive service pricing	✓	✓	✓	✓	Subscriber growth
Availability of mature product and technology	✓	✓	🍷	✓	Low CapEx
Availability of stable standard and interoperability	✓	✓	🍷	✓	Low CapEx; Investment protection
Clear future technology roadmap	✓	✗	🍷	✓	Investment protection
Simple and plug-play installation and service turn-up	✓	✓	🍷	✓	Low OpEx
Efficient network operation and maintenance	✓	✓	🍷	✓	Low OpEx