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# Power Consumption Considerations in Optical Metro Transport Networks

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# The Importance of Power Consumption in Telecoms

- Steve Harris, **Digital Transformation / Orange Enterprise (**March 2023):

  "The **telecoms** industry is responsible for **2-3% of the total power consumption of humankind**. According to GSMA research, **energy costs today represent between 20% and 40% of a telecoms company's OPEX**" (www.orange-business.com/en/blogs/greening-telecoms-network)

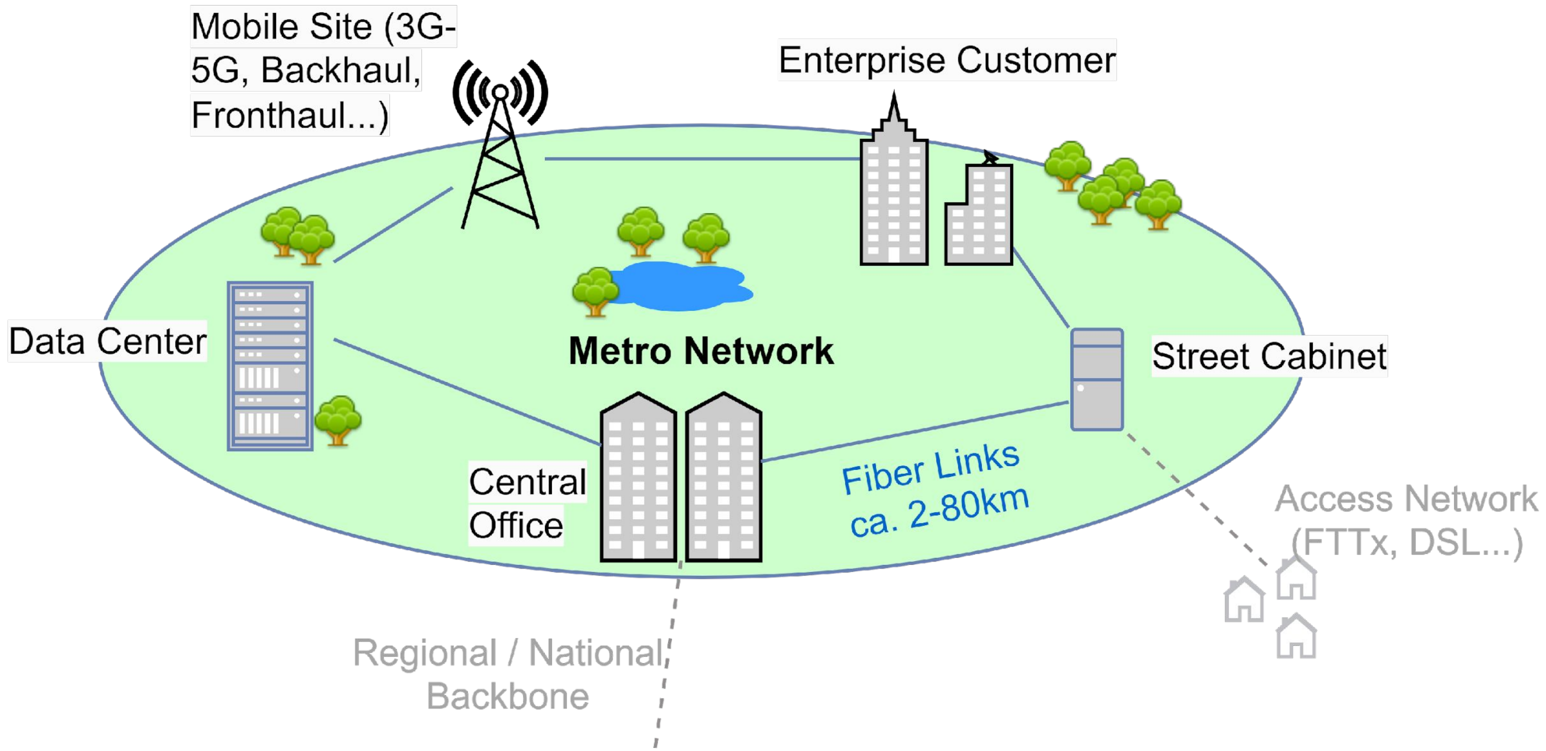
- **McKinsey** Study "The growing imperative of energy optimization for Telco Networks"(Nov 2024):

  - "large operators have seen their energy **cost increases outpace sales growth by more than 50 percent**."

  - "**Pressure** is likely also to come from **regulators** around the world, as they begin to adopt their own decarbonisation goals and factor sustainability considerations into their policies."
    https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-growing-imperative-of-energy-optimization-for-telco-networks

# Focus on Metro Transport Networks

- **Fiber** based link distances **ca. 2 to 80km**
- **Topologies:** Ring, Point-2-Point daisy chain…
- **Protocols**: Ethernet, CPRI, eCPRI, FiberChannel, OTN, SDH etc
- **Data Rates:** 1Gig to multiple 400Gig




- Various **applications** (often on same fiber link): **Backhauling** of Residential Access (DSL, FTTx…), **Mobile** Front/Mid/Backhauling, **DC** Interconnect, **Enterprise** Access, Private Networks etc
- Two Basic Technologies used in Network Nodes to transport data from node to node: **Passive Transport vs. Active Transport**

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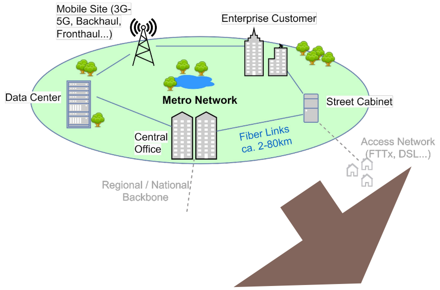
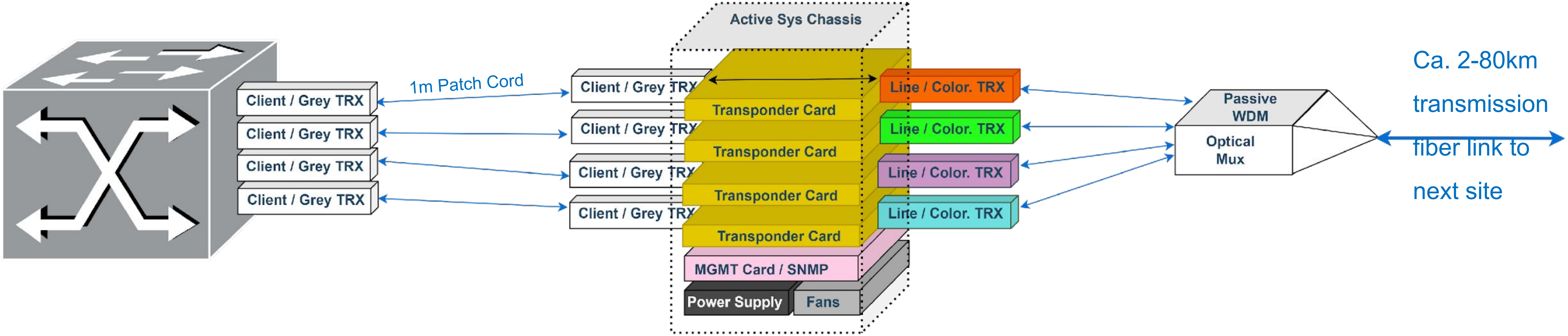
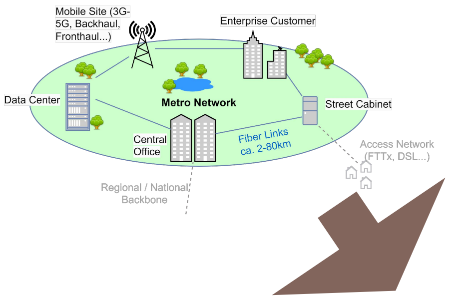
# Traditional Approach: Active (WDM) Transport Systems – Transponding



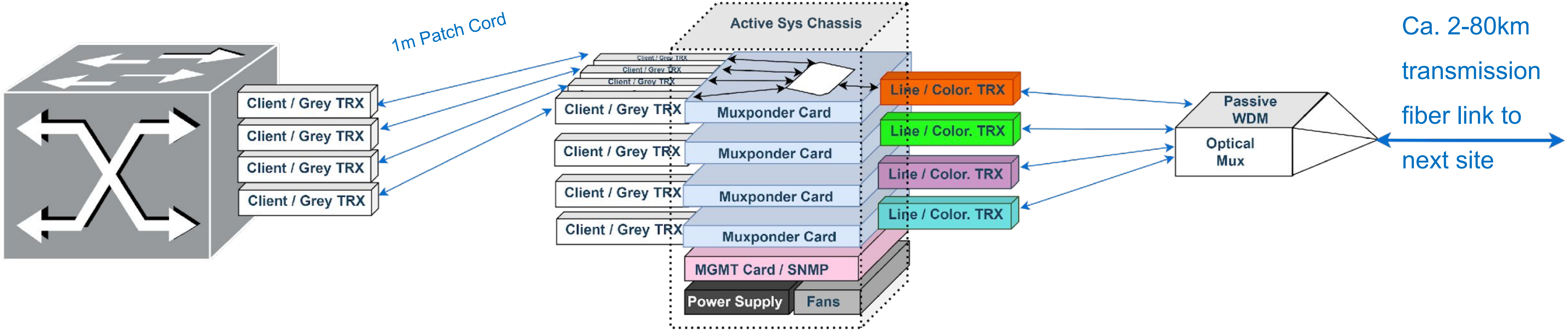

## Metro Network Node / Site



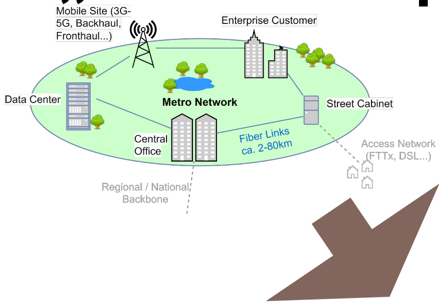
# Traditional Approach: Active (WDM) Transport Systems – Muxponding



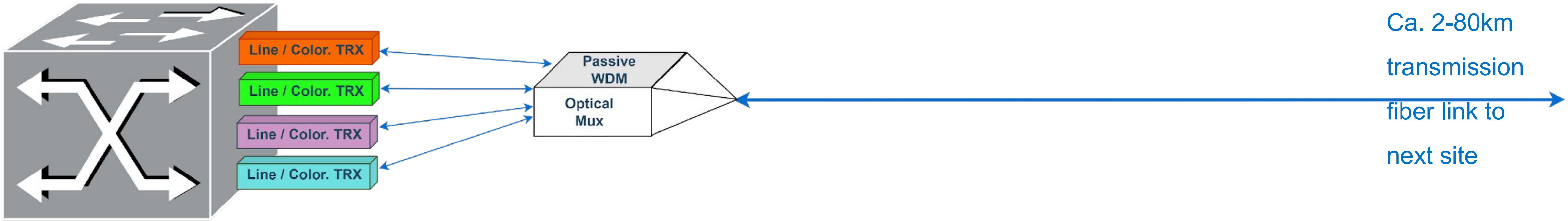

## Metro Network Node / Site



# „Modern“ Approach: Passive (WDM) Transport Systems (aka IPoDWDM)




Metro Network Node / Site



# Methodology

- METRO Links = “typical distances of around 10-80km”
- Only comparing the Transport Technology, **NOT** including the “L2/L3”, i.e. routers, switches, Radios etc…
- Does not include additional items, eg amplifiers.
  - These would come on top in all cases
- Comparing power on per link base (incl. both nodes), looking at data rates of **1G, 10G, 25G, 100G, 400G**
- Power normalised on per link base:
  - the power consumed by the chassis itself, the power supplies themselves etc is broken down for 1 line in said active system and related to 1 coloured TRX at client speed in the host
- Model allows calculation of specific scenarios by multiplying services
- Muxponding based on equivalent Client data rate for comparison with Line TRX (e.g. 100G client aggregation into 400G Line, we need to compare it to the alternative of 100G transport, not 400G Coloured Transceivers in the host)

# Power Consumption PER LINK for 4 Transport Scenarios

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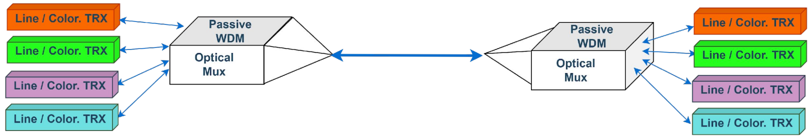
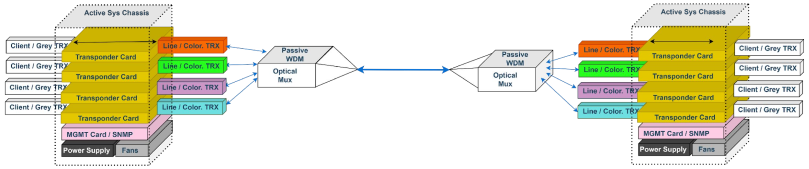
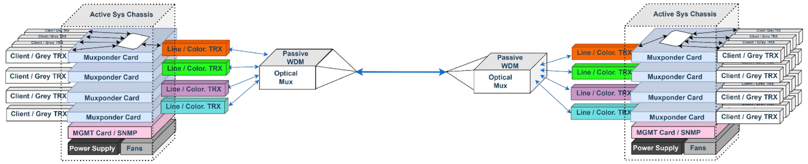
***assume 10G***

| | Scenario | Fully included Equipment | Proportionately included Equipment |
|---|---|---|---|
| Passive Transport | Grey TRX | 2pcs Grey (long reach) TRX | |
| | pWDM | 2pcs Coloured WDM Line TRX | |
| Active Transport | Trans-ponding | 4pcs Grey (shortest reach) TRX<br>2pcs Coloured WDM Line TRX | 2pcs Transponder Card<br>2pcs Chassis, each incl. 2 Fan<br>2pcs *redundant* Power Supply<br>2pcs Management Cards |
| | Mux-ponding[1] | 4pcs Grey (shortest reach) TRX | 2pcs Muxponder Card<br>2pcs Line TRX (colored or not)<br>2pcs Chassis, each incl. 2 Fans<br>2pcs *redundant* Power Supply<br>2pcs Management Card |

# Device Power Consumption per Data Sheet – Transceivers (1-25Gig)

| Transceiver Type | Power Consumption (max) [W] |
|---|---|
| 1G SFP SX (500m, MMF) | 1 |
| 1G SFP ZX (80km, Industrial Temperature Range) | 1 |
| 1G SFP CWDM ZX (80km) | 1 |
| 1G SFP DWDM EZX (120km) | 1,2 |
| | |
| 10G SFP+ SR (500m, MMF) | 1 |
| 10G SFP+ SR (500m, MMF, Ind. Temp) | 1 |
| 10G SFP+ LR (10km, Ind. Temp.) | 1 |
| 10G SFP+ ZR+ (100km, Ind. Temp.) | 1,8 |
| 10G SFP+ CWDM ZR (80km) | 1,5 |
| 10G SFP+ CWDM ZR (80km, Ind. Temp) | 1,6 |
| 10G SFP+ DWDM ER (40km) | 1,3 |
| 10G SFP+ DWDM ER (40km, Ind. Temp) | 1,6 |
| 10G SFP+ DWDM ZR (80km, Ind. Temp.) | 1,6 |
| | |
| 25G SFP28 SR (500m, MMF) | 1 |
| 25G SFP28 LR (10km) | 1,2 |
| 25G SFP28 ER (40km) | 1,8 |
| 25G SFP28 CWDM LR ("40km") | 1,2 |
| 25G SFP28 DWDM LR ("40km", Ind. Temp.) | 2 |

| |
|---|
| Short Reach Client Grey TRX |
| Long Reach Client / Line Grey TRX |
| Line WDM Colored TRX |

- (almost) independent of data rate (at 1-25G)!
- Maximum reach has / has no significant influence on power usage.
- Specified operating **case** (!) temperature range (Standard 0 to 70°C vs. Ind. Temp. -40° to 85° C) makes a difference
- *Coloured WDMs (often) use Temperature Controllers*

*Note: example TRX is Huber+Suhner CUBO TRX. However, underlying data used in this model originates from ca. 10 manufacturers. Shown values are average values over multiple makers, however, are mostly anyway identical*

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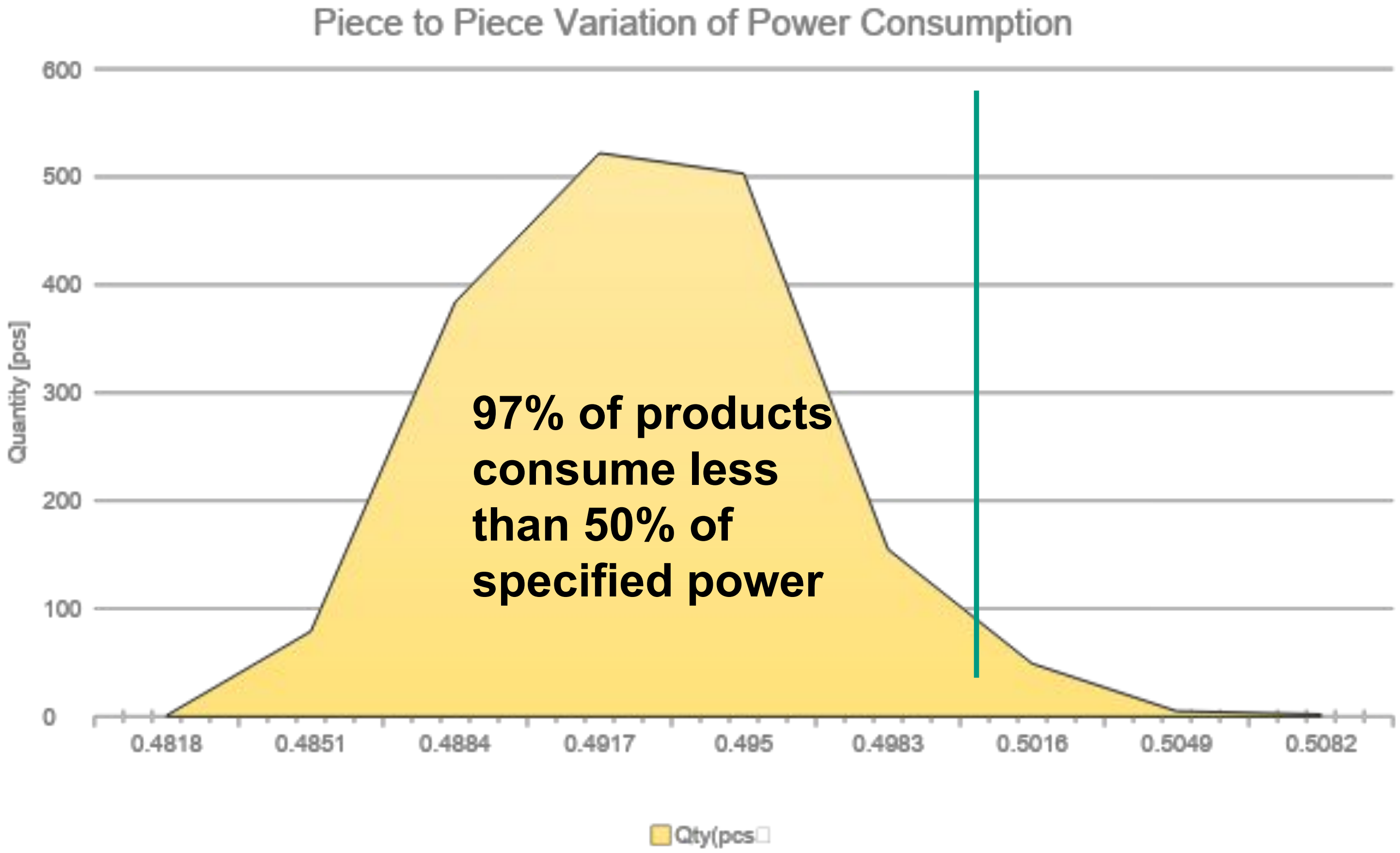
# TRX Power Consumption: Data Sheet vs Part to Part Variation

## Example 1G LX SFP

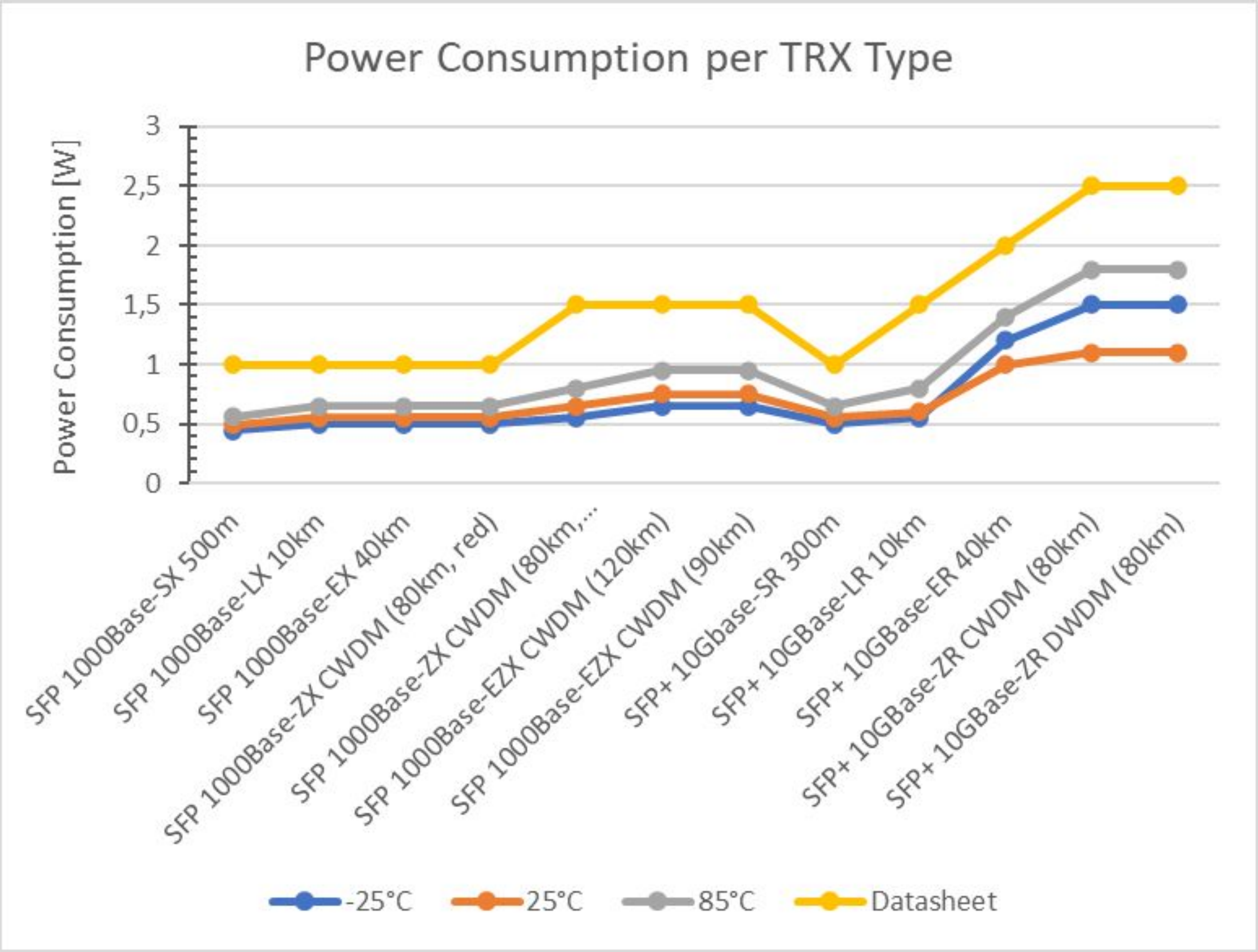



**1G SFP LX**
**Product number 85210507**
**Identifier CSS-303A11**
Variation: 10km, 1310nm, LC/PC duplex, Singlemode
Type 1G SFP LX
Media Reach Type10km, 1310nm, Singlemode fiber
Protocol 1G Ethernet, 1G Fiber Channel, CPRI 2

https://www.hubersuhner.com/en/shop/product/transceivers/pluggable-transceivers/1g-2-5g-6g-8g-10g/85210507/1g-sfp-lx

**Key features**
Multi-protocol support
Data rate 125 Mbps and 1.0625...1.25 Gbps
Reach up to 10km
Wavelength 1310nm
LC/PC duplex connector
Singlemode fiber
Temp. range 0 ... 70°C
Link budget at least 11 dB
**Power consumption < 1 W**

# TRX Power Consumption: Influence of Case Temperature




- Power Consumption of Client & Line TRX at 1 & 10Gig **highly depending on case temperature**
- But always only a fraction of data sheet values

*Note: example TRX is Huber+Suhner CUBO TRX. However, underlying data used in this model originates from ca. 10 manufacturers. Shown values are average values over multiple makers, however, are mostly anyway identical*

# Device Power Consumption per Data Sheet – Transceivers (100-400Gig)

| Transceiver Type | Power Consumption (max) [W] |
|---|---|
| 100G QSFP28 SWDM4 (100m, MMF) | 3,5 |
| 100G/40G QSFP28 SR1.2 (100m, MMF) | 3,5 |
| 100G QSFP28 SR4 (150m, MMF) | 2 |
| 100G QSFP28 LR4 (10km) | 4 |
| 100G QSFP28 LR4 (10km, Ind. Temp.) | 5 |
| 100G QSFP28 LR4 (10km, Hermetic) | 3,5 |
| 100G QSFP28 ER4 lite (30km) | 4,5 |
| 100G QSFP28 ER4 (40km, Ind. Temp) | 5,5 |
| 100G QSFP28 ZR4 (80km) | 6,5 |
| 100G QSFP28 ZR4 (80km, Ind. Temp.) | 7,5 |
| 100G QSFP28 DWDM ZR (100km) | 5,5 |
| 100G **QSFP28 Coherent** (limited DSP, 80km Ind. Temp.) | 6 |
| 100G **QSFPDD Coherent** (full DSP, 800km) | 23,6 |
| | |
| 400G QSFP56-DD SR8 (100m, MMF) | 10 |
| 400G QSFP56-DD DR4 (500m SMF) | 10 |
| 400G QSFP56-DD LR4 (10km) | 12 |
| 400G QSFP56-DD ER8 (40km) | 15,4 |
| 400G **QSFP56-DD Coherent** DWDM ZR+ (full DSP, 800km) | 23,6 |

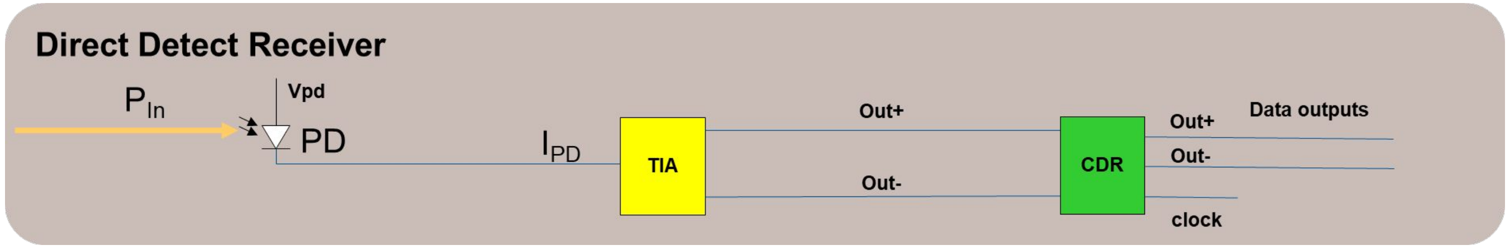
| |
|---|
| Short Reach Client Grey TRX |
| Long Reach Client / Line Grey TRX |
| Line WDM Colored TRX |

Power Consumption:

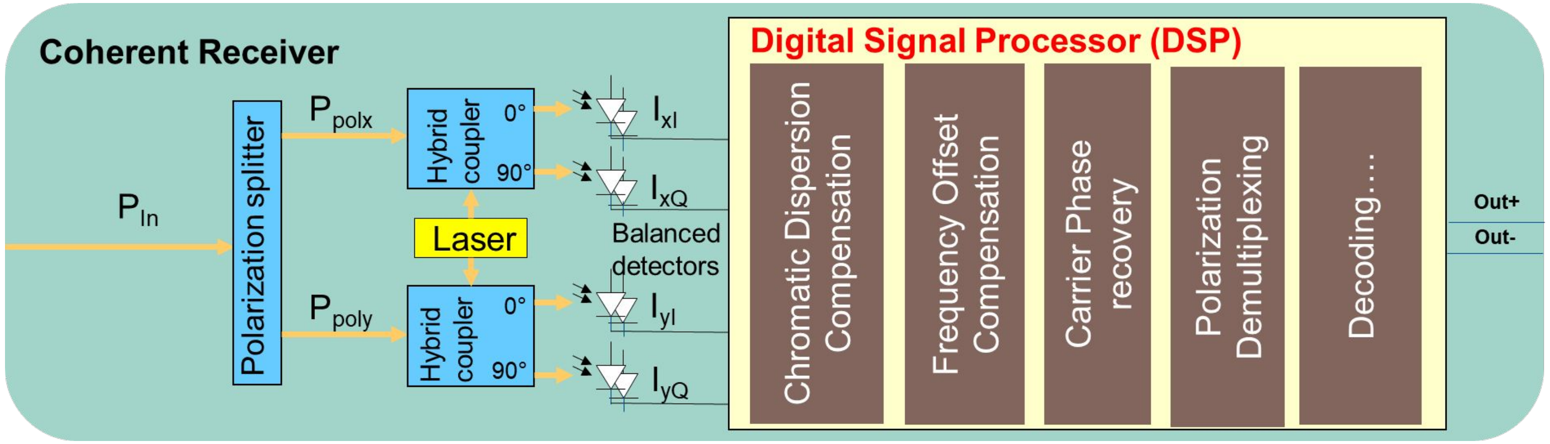
- Very dependent on data rate!
- Different product designs can make a difference
- Main driver is **modulation** technology, i.e. “**Direct Detect” vs. “Coherent**”
- Importance of CAUI for ≥100G

*Note: example TRX is Huber+Suhner CUBO TRX. However, underlying data used in this model originates from ca. 10 manufacturers. Shown values are average values over multiple makers, however, are mostly anyway identical*

# Direct Detect vs. Coherent TRX: Main Difference are the Receivers




**Direct Detect TRX**:
few & simple optoelectronics




**Coherent TRX**
- Much more (opto-)electronics
- Extremely power-hungry **DSP** processor chip
- Which also contains **Muxponder** and **data processing** functionalities

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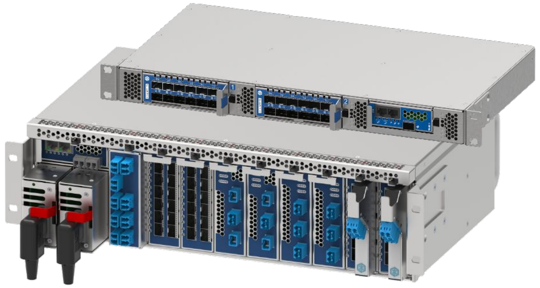
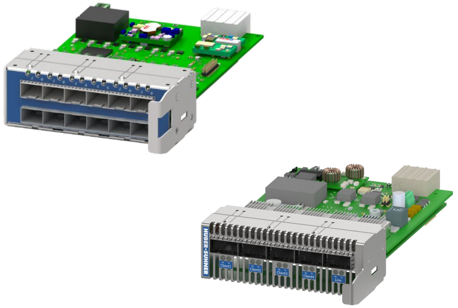
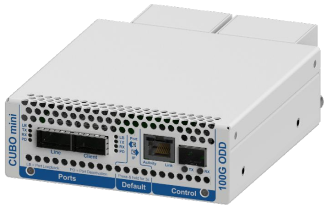
# Summary on Transceiver Power Consumption

- Data Sheets state the **maximum power** consumption. Can differ hugely from **actual power** consumption.
- Model is based on **typical power** consumption. i.e. average of **part-to-part variation** and **25°C** as case temperature (& ambient temperature for Active Systems)
- **Direct Detect** TRX 1G, 10G, 25G (100G) typically consume **40-60%** of their given maximum
  - 57% used in model
- **Coherent** TRX (≥ 100G) depending on specific **DSP** designs, typical power is around **75-90%** of data sheet (max) value
  - 87% used in model

# Notes on Active Transport System Power Consumption

- The power consumption (actual, typical, max.) greatly **varies from vendor to vendor,** caused by differing **design** (used electronics and chips…) and **additional features**
- Biggest variation is on **muxponding** variants.
- A not “**fully loaded”** / utilised chassis, line card etc consumes much more power per service.
- Power consumption of electronics rises with **ambient temperature** (here “typical” assumed as 25°C!)
- “Typical” power consumption values represent a best-case scenario based on
  - A) **lowest power system**
  - B) **fully loaded smallest possible set-up** (i.e. no 3HU Chassis with 2 line cards for 1 service)
- **Active Transport solutions tend to use much more power than our “Typical Model”!**




Note: Depicted example Active System products originate from Huber+Suhner. However, underlying data used in this model originates from various vendors.

# Notes on Cooling / Air Conditioning

- All scenarios are calculated **with and without external (AC) cooling,** reflecting only additional cooling for the transport, <u>not</u> the routers etc.
- Again, how much energy is needed for cooling e.g. 1W?
  - depends on too many varied factors to be precisely reflected in this presentation.
- Is “**over cooling**” an issue?
  - cooling capacity can be over dimensioned (data sheet based calculations!), which can lead to **additional** (significant) power consumption.
- As an approximation of **power for cooling we used a factor of 2**, i.e. every Watt that you have on transport requires (at very least) another Watt for cooling.
  - **external cooling will at least double the power used of power needed to transport data.**

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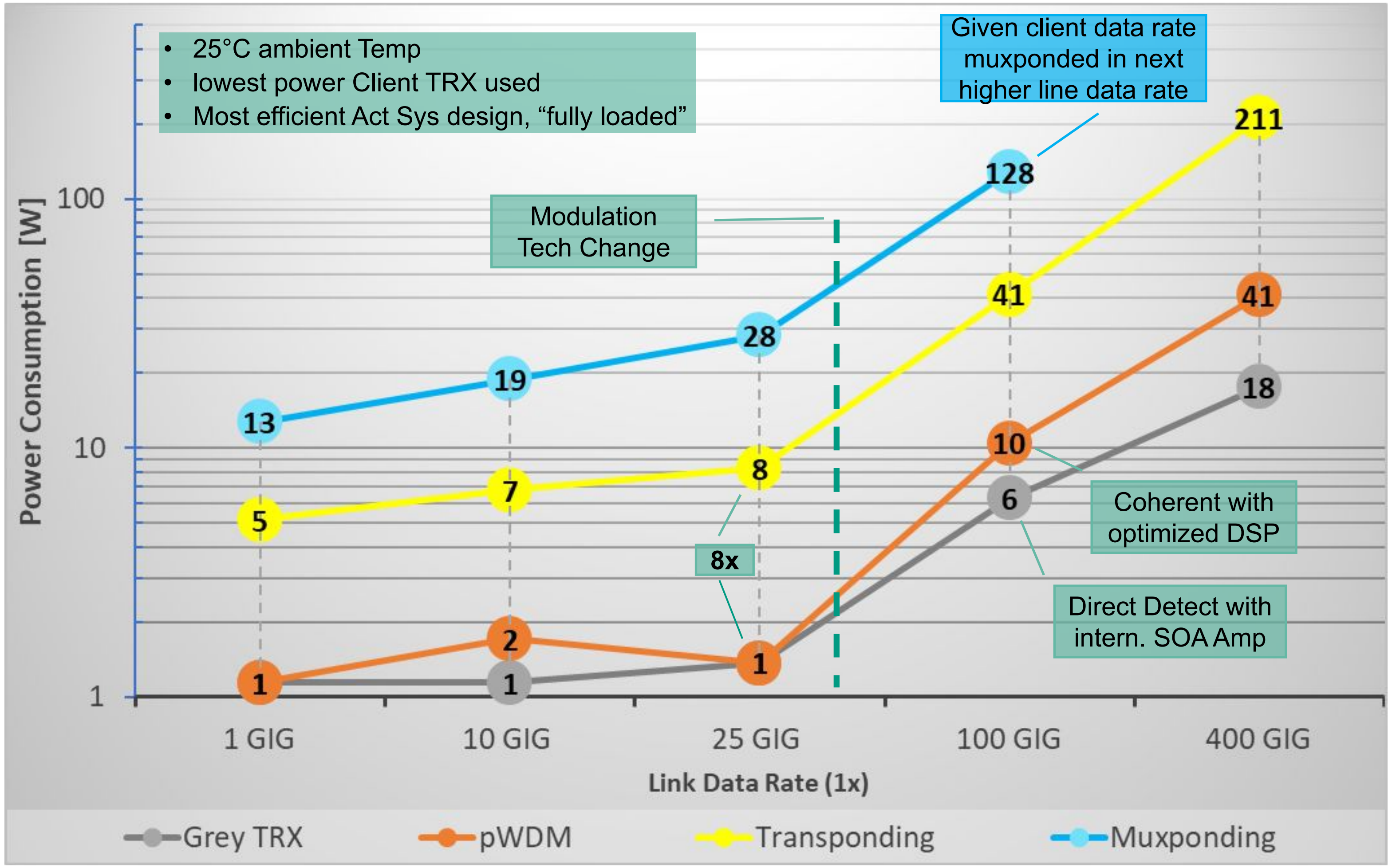
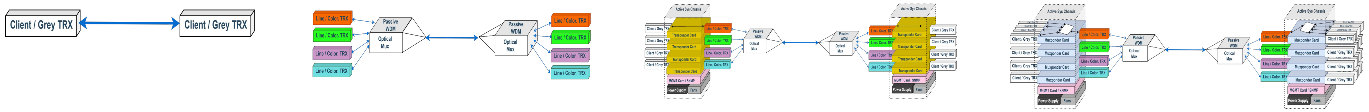
# Typical Power Consumption per Link [W] – **Excl**. external Cooling



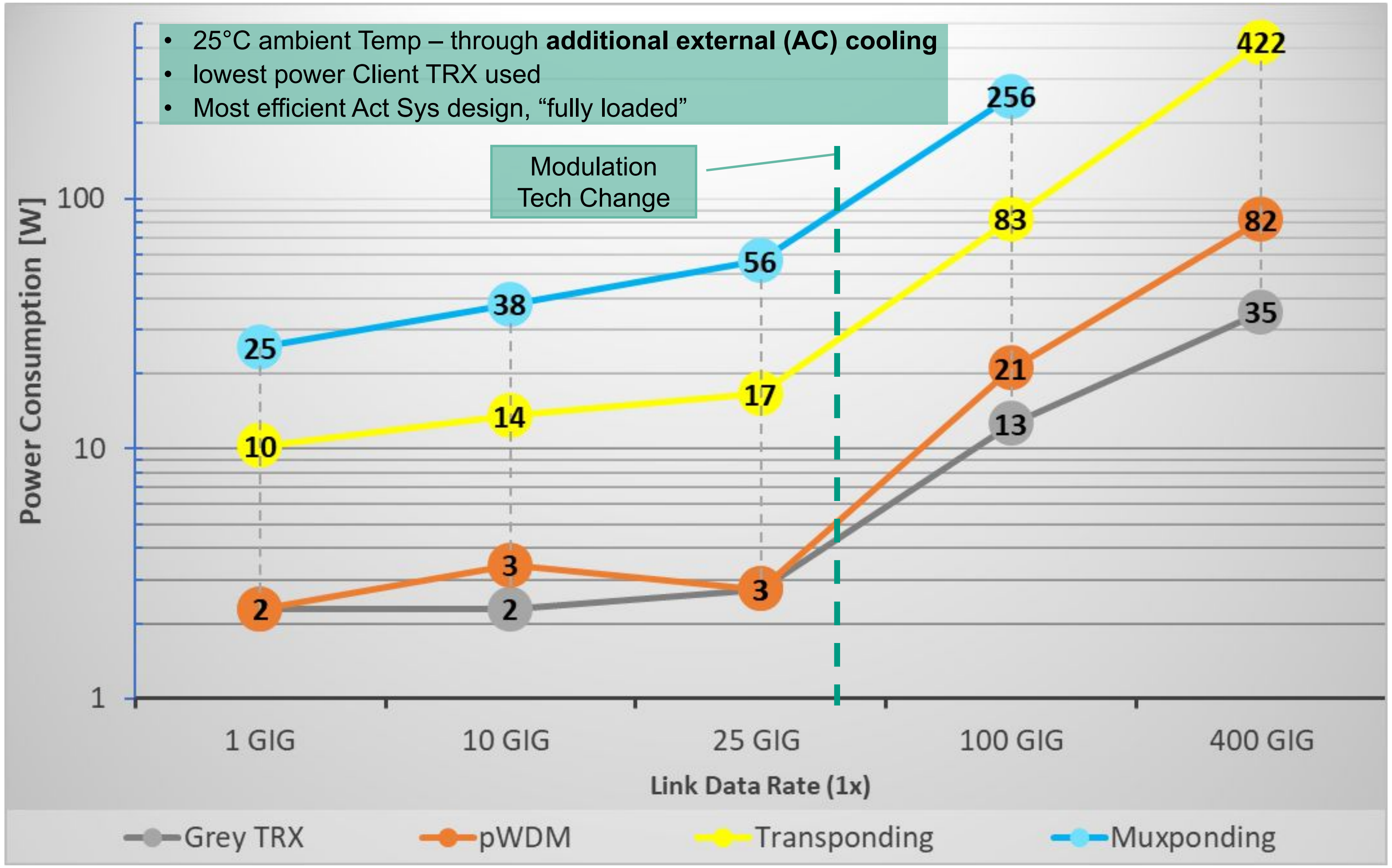



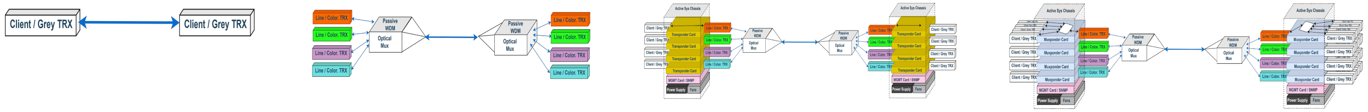

Acknowledgement that cost (power) per bit carried is lower at higher speeds

**Transponding** uses approx. 4-5 times higher power consumption vs pWDM

**Muxponding** uses approx. 10-20 times higher power consumption vs pWDM

# Typical Power Consumption per Link [W] – Incl. external Cooling




Based on model assumptions

all **power consumption,** including Cooling, **will simply double.**

However, it makes a huge difference if you double e.g 2W vs. 38W (especially if you operate more than 1 link)

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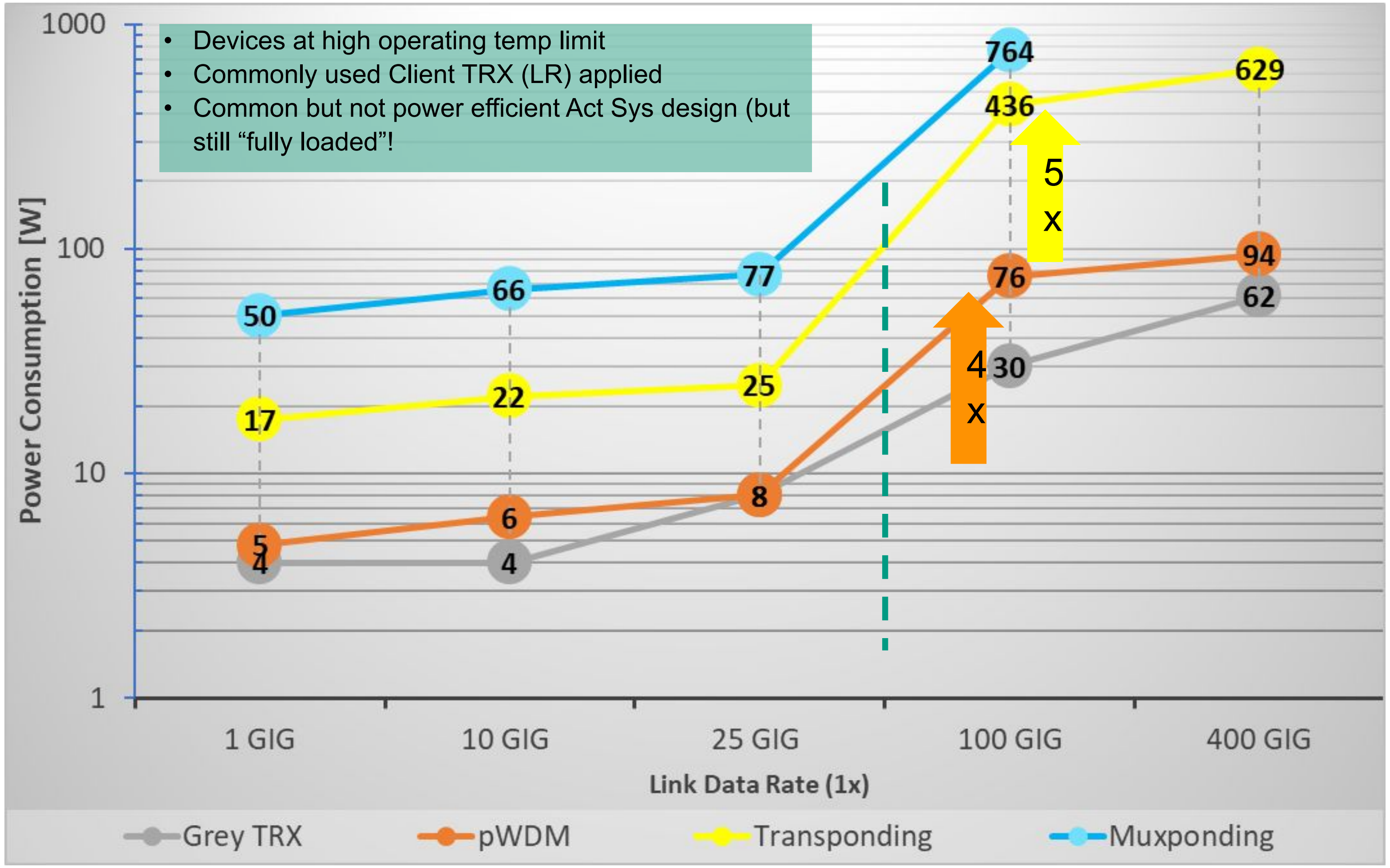
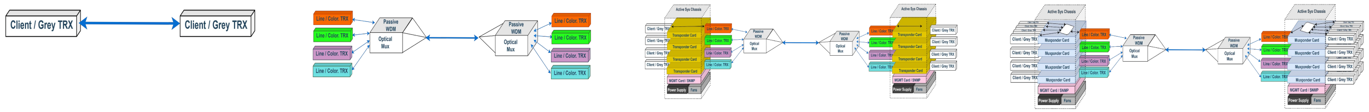
# Comparing “Max.” Power Consumption per Link [W] – Excl. external Cooling




- Notes:
  - Operating devices at high operating temperature can impact performance over time
  - Use of “Industrial Temp” TRX and common LR TRX as Client
- Active System use power – even when not fully populated ,ie not power optimized designs
  - Results in ~2-3 times of power consumption for pWDM compared to “Typical (incl. cooling”) scenarios
  - Increase ~4-5 times for Active Transport
- Can increase necessary power consumption by a factor >100 times!

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# Summary

- With the continued trend of **increasing data rates** in transport networks, the power usage will increase further.
- Some scenarios can result in consuming up to **>100 times more electrical power** than technologically necessary for transporting services
- This energy inefficiency combined with the growing data rate is becoming an **OPEX threat** for carriers.
- **Passive Transport is cutting down** those (direct energy and $CO_2$) **costs by at least a factor of 5 to 20**!
- We **do not** suggest using only Passive WDM.
  - Many operators mix passive & active systems on same Metro Optical network

*Note, **less power used by** the network means a significant reduction of $CO_2$ **Scope 3***

*(Scope 3 = $CO_2$ generated at production of devices at suppliers)*

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