

# 400G $\neq$ 4 $\times$ 100G

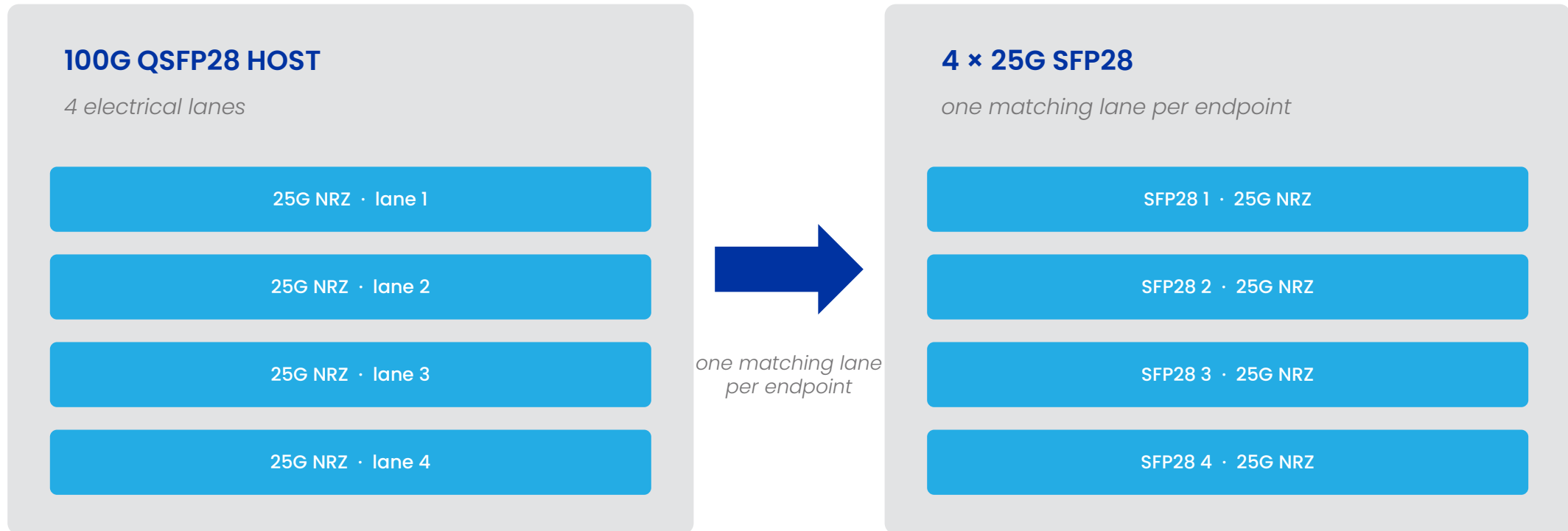
Finding the hidden watts in breakouts, retimers and optics

**lane rate + modulation + function placement = system watts**

*A framework for comparing DAC, AOC, LPO, CDR and DSP architectures*

## LANE ARITHMETIC

# 100G breakout works because the lanes already agree



**NO LANE-RATE OR MODULATION CONVERSION**

## THE HIDDEN CONVERSION

# 400G and legacy 100G speak different electrical languages

**400G HOST SIDE****8 × 50G PAM4**

*Eight high-speed electrical lanes at the module interface*

50G

50G

50G

50G

50G

50G

50G

50G

**LEGACY 100G ENDPOINT****4 × 25G NRZ**

*Four slower electrical lanes per 100G QSFP28 endpoint*

25G

25G

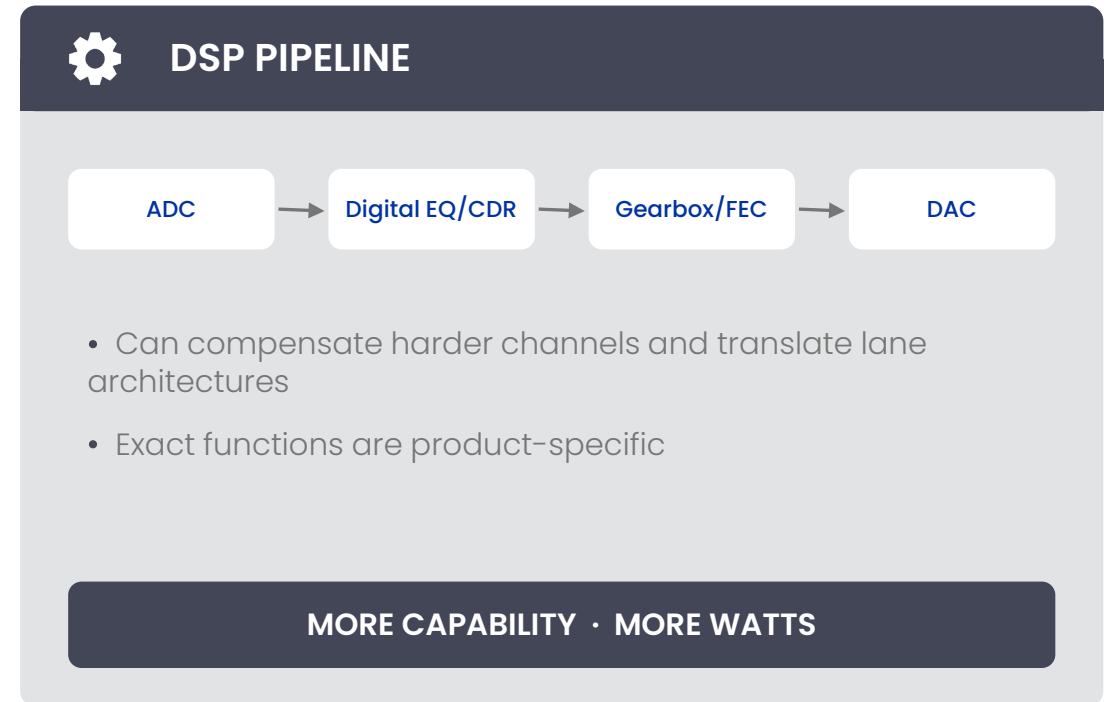
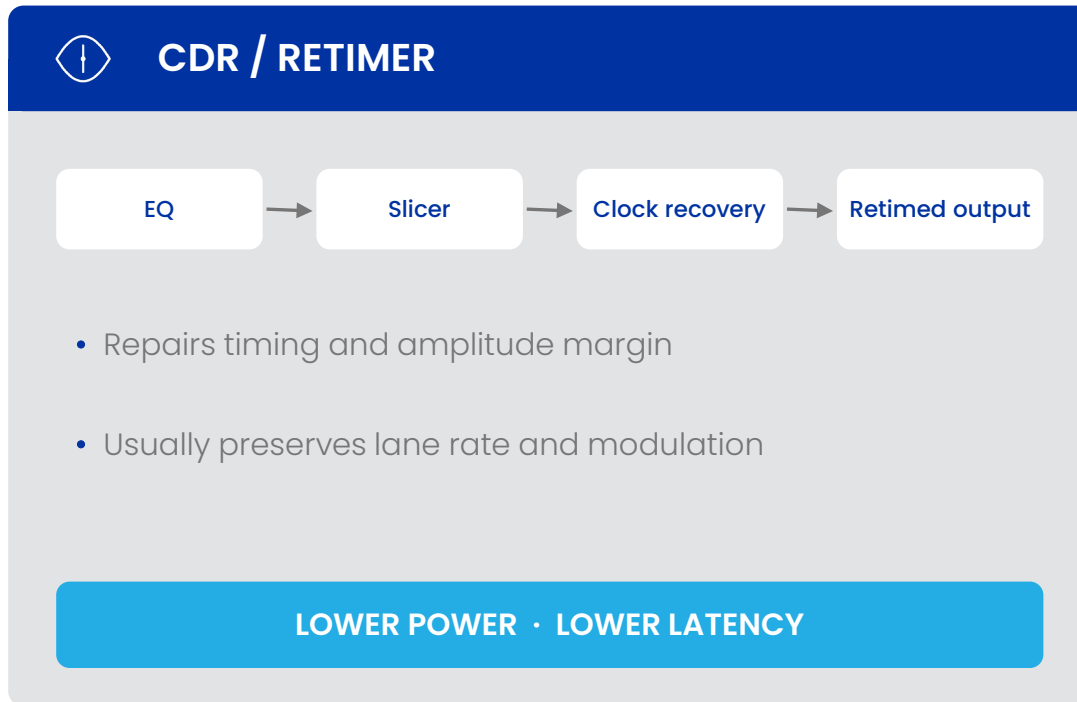
25G

25G

**CONNECTOR COMPATIBILITY ≠ LANE COMPATIBILITY**

FUNCTION, NOT ACRONYM

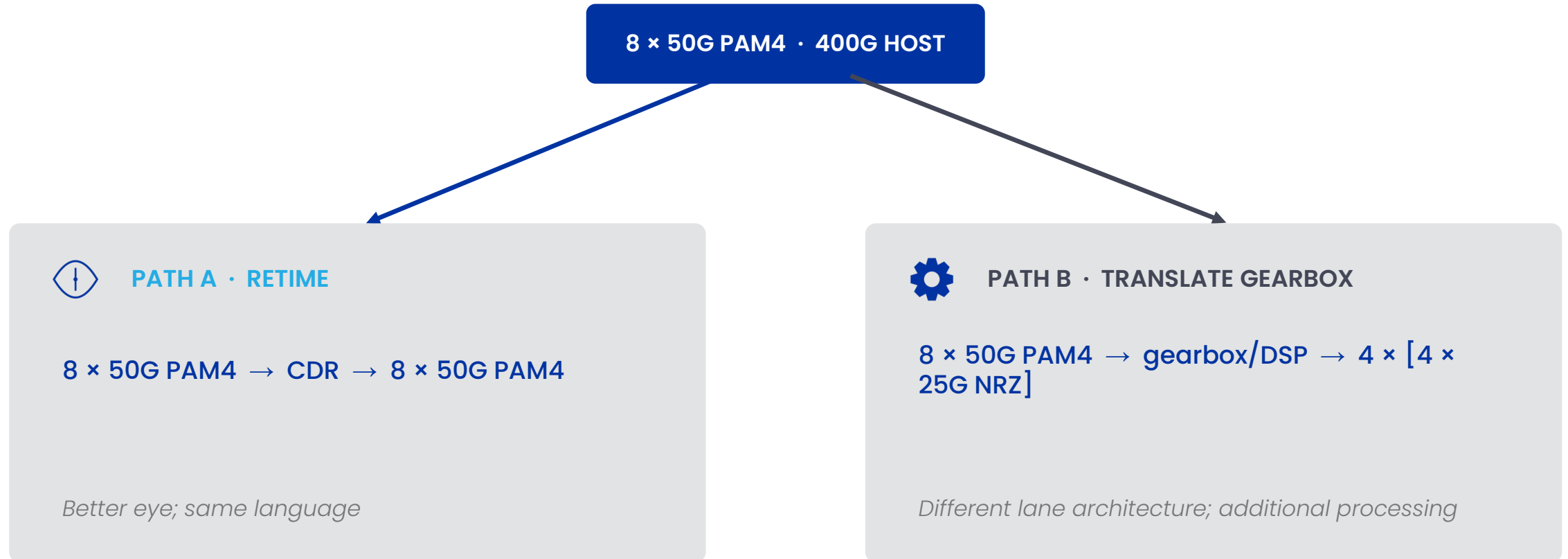
# CDR regenerates the signal; DSP processes it



Typical hierarchy for comparable implementations:  $P_{\text{linear}} < P_{\text{CDR}} < P_{\text{DSP}}$

## THE KEY DISTINCTION

# A cleaner signal is not a compatible signal



**RETIMING REPAIRS THE LANE. GEARBOXING CHANGES THE LANE ARCHITECTURE.**

## ARCHITECTURE MAP

# The module label does not reveal where the watts live

*Every extra watt should buy something: margin, reach, translation or observability.*

| ARCHITECTURE        | WHAT THE MODULE DOES            | MODULE POWER | SYSTEM TRADE-OFF                            |
|---------------------|---------------------------------|--------------|---------------------------------------------|
| Passive DAC         | Copper channel only             | Lowest       | Host SerDes must close the channel          |
| AEC (active copper) | Retimer inside the copper cable | Low-mid      | Longer copper reach (~5–7 m) without optics |
| LPO                 | Linear optical conversion       | Low          | Channel burden moves into host SerDes       |
| LRO                 | DSP on transmit; linear receive | Low-mid      | About half the DSP power; host equalizes Rx |
| CDR AOC / optics    | Equalize + retime               | Low-mid      | Adds margin; preserves lane language        |
| DSP-retimed optics  | Digital compensation            | Mid-high     | More channel tolerance and functions        |
| DSP + gearbox       | Compensate + translate          | Highest here | Buys lane-rate / modulation conversion      |

*Comparable, product-representative ranges; exact power depends on reach, FEC, and vendor implementation.*



NORMAL · LRO · LPO — 400G, 800G, 1.6T

# The DSP-to-linear spectrum repeats at every speed grade

| ARCHITECTURE                                | WHAT CHANGES                               | 400G · TYPICAL | 800G · TYPICAL | 1.6T · TYPICAL |
|---------------------------------------------|--------------------------------------------|----------------|----------------|----------------|
| <b>NORMAL</b><br><i>Fully retimed · DSP</i> | DSP retimes both directions                | ~10 W          | ~15 W          | ~28 W          |
| <b>LRO</b><br><i>Half-retimed</i>           | DSP on transmit only; receive stays linear | ~8 W           | ~11 W          | ~20 W          |
| <b>LPO</b><br><i>Fully linear</i>           | No DSP; host SerDes drives and equalizes   | ~6 W           | ~8 W           | ~12 W          |

## 800G → 2 × 400G

One 800G module at the switch, 400G at each endpoint. DSP mixes freely; LPO expects LPO and LPO-capable NICs at both ends.

## 1.6T → 2 × 800G

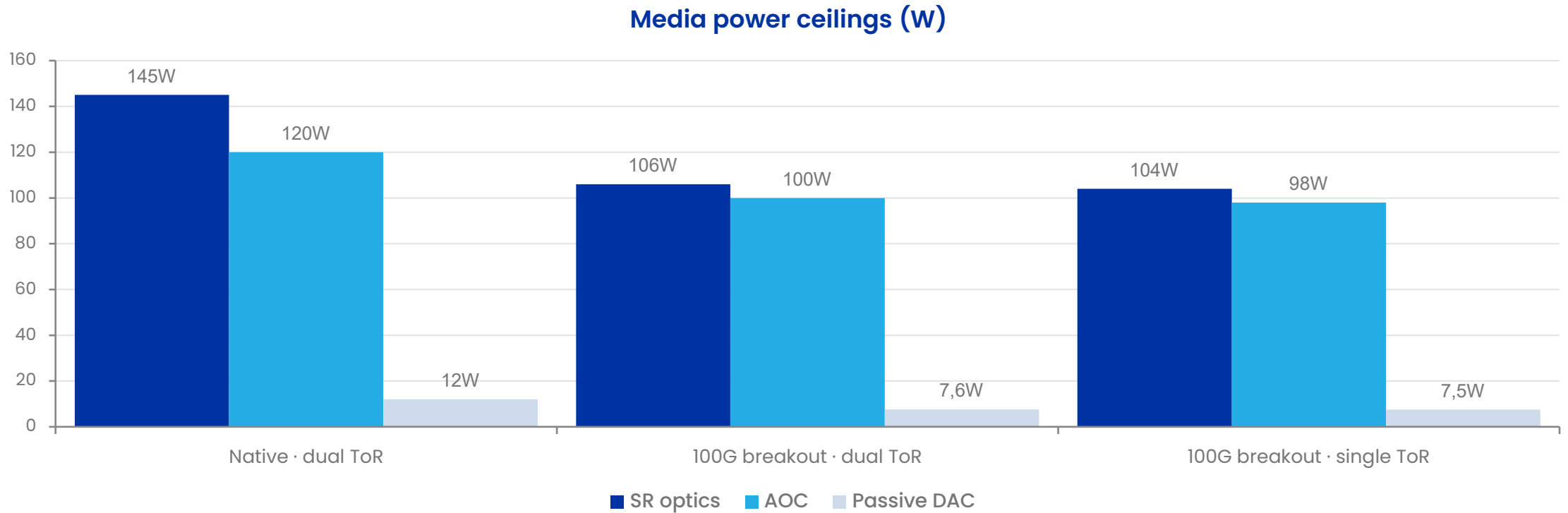
One 1.6T module at the switch, 800G at each endpoint. DSP mixes freely; LPO expects LPO and LPO-capable NICs at both ends.

Typical industry-reported values, not datasheet maximums — hence 400G here sits below the 12.61 W DR4 ceiling in the case studies.

LPO MSA: an LPO-to-retimed link is possible but counts as an engineered link, outside the MSA spec. LRO keeps a transmit DSP, which eases pairing.

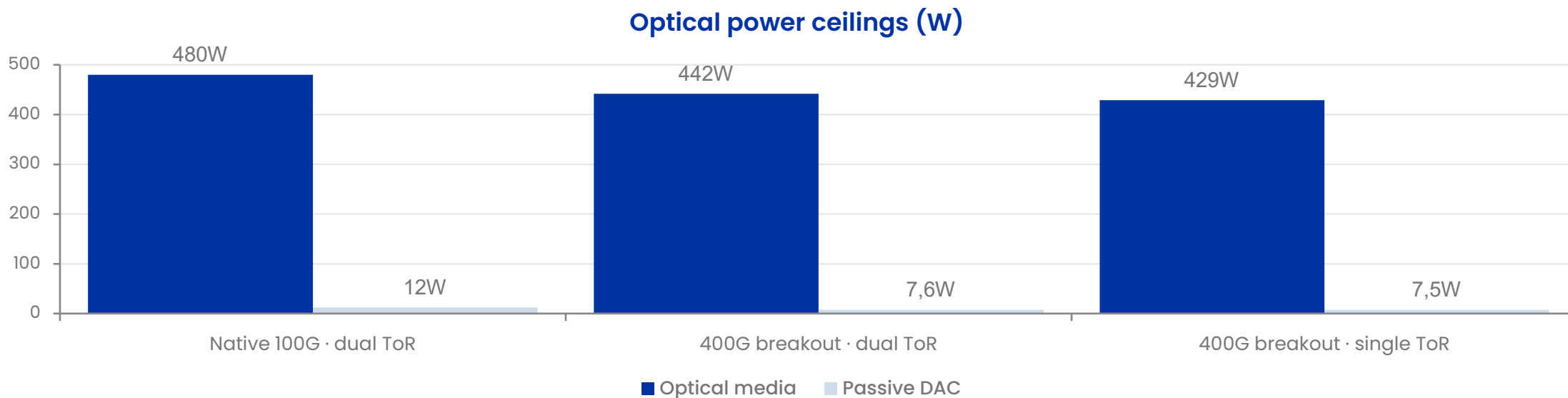
30 SERVERS · 2 × 25G EACH · MEDIA POWER CEILINGS

## At 25G, breakout removes endpoints without translation



30 SERVERS · 2 × 100G EACH · OPTICAL POWER CEILINGS

## At 100G, one fewer DR4 saves only 13 W of media



### NATIVE

120 × 100G DR1

### DUAL BREAKOUT

16 × 400G DR4 + 60 × DR1

### SINGLE BREAKOUT

15 × 400G DR4 + 60 × DR1

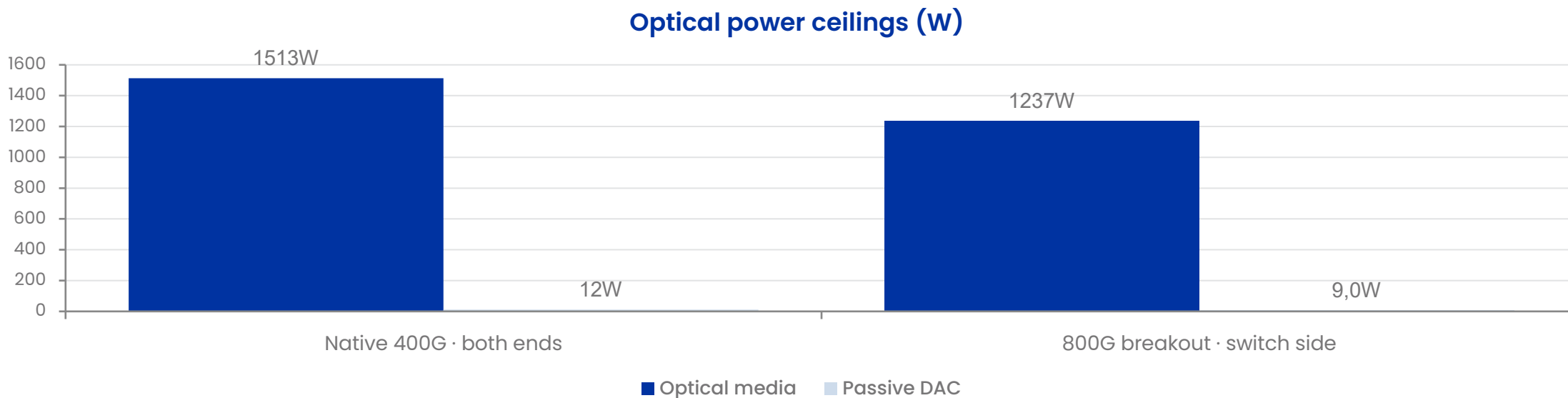
THE 13 W GAP IS EXACTLY ONE 400G DR4 CEILING

The translation watts hide in each 100G DR1: it gearboxes 4 × 25G NRZ into 1 × 100G PAM4. DR1 = 4.00 W, DR4 = 12.61 W

A passive breakout DAC only works with 100G-PAM4 (2 × 50G) server NICs — copper cannot gearbox to 4 × 25G NRZ.

30 SERVERS · 2 × 400G EACH · OPTICAL POWER CEILINGS

## At 400G, breakout saves twice the share it did at 100G



### NATIVE

120 × 400G DR4 (60 links × both ends)

### 800G BREAKOUT

30 × 800G + 60 × 400G DR4 (switch consolidates; server end unchanged)

**~276 W SAVED (≈18%) VS ≈9% AT 100G — FROM FEWER MODULES, NOT A FASTER CAGE**

400G DR4 = 12.61 W (Solid Optics). 800G = 16 W, typical DR8 max-power class.

A passive 800G → 2 × 400G DAC needs 400G NICs on 100G lanes (4 × 100G). DAC: 120 vs 90 cable ends × 0.1 W.

## OPERATOR CHECKLIST

# Count functions and powered silicon—not cages

01

Do lane rate and modulation already match?

02

Is there a CDR, a DSP, or a gearbox?

03

How many optical / AOC endpoints are powered?

04

Where do equalization and FEC live?

05

Can unused SerDes or ASIC blocks actually power down?

06

Are failure domains still independent?

**ONE 400G PORT CAN BE BETTER. THE PORT SPEED IS NOT THE REASON.**



## RONOG · HIDDEN WATTS

*Thank you — questions?*

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Source data: Solid Optics datasheets and published vendor specifications