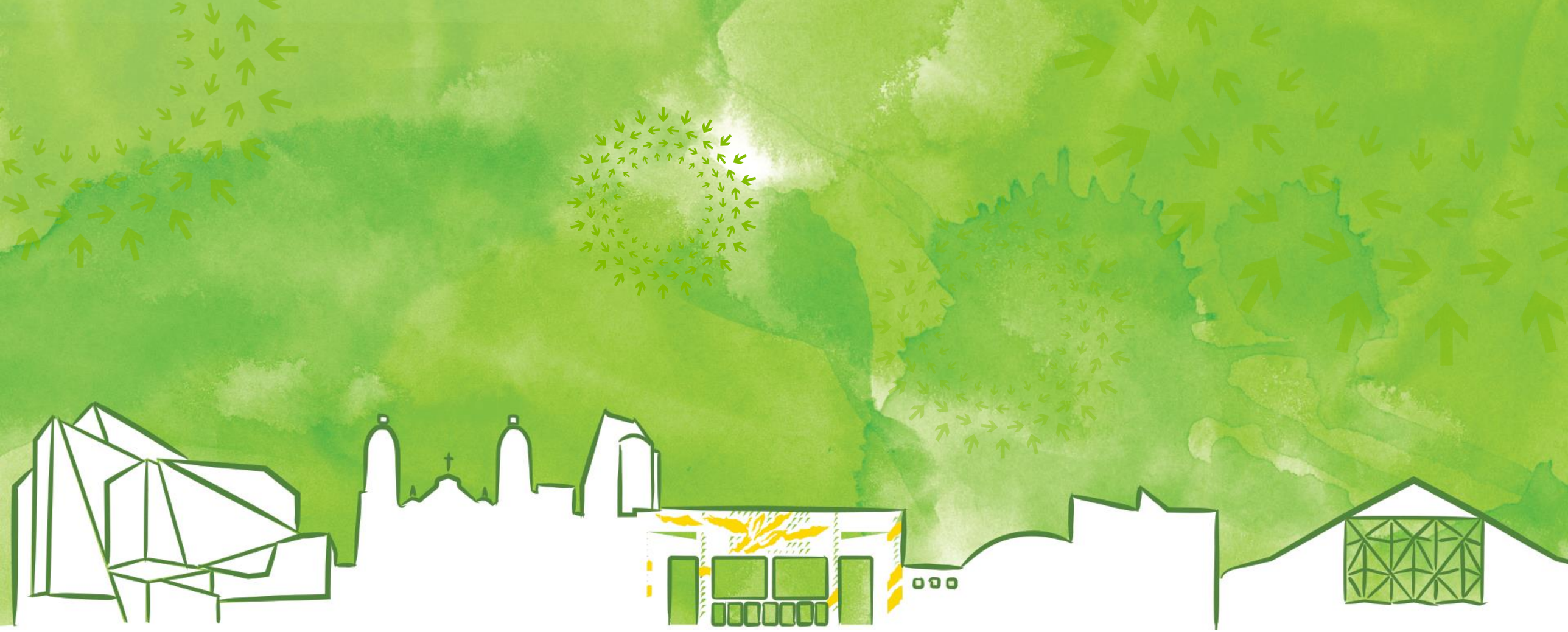

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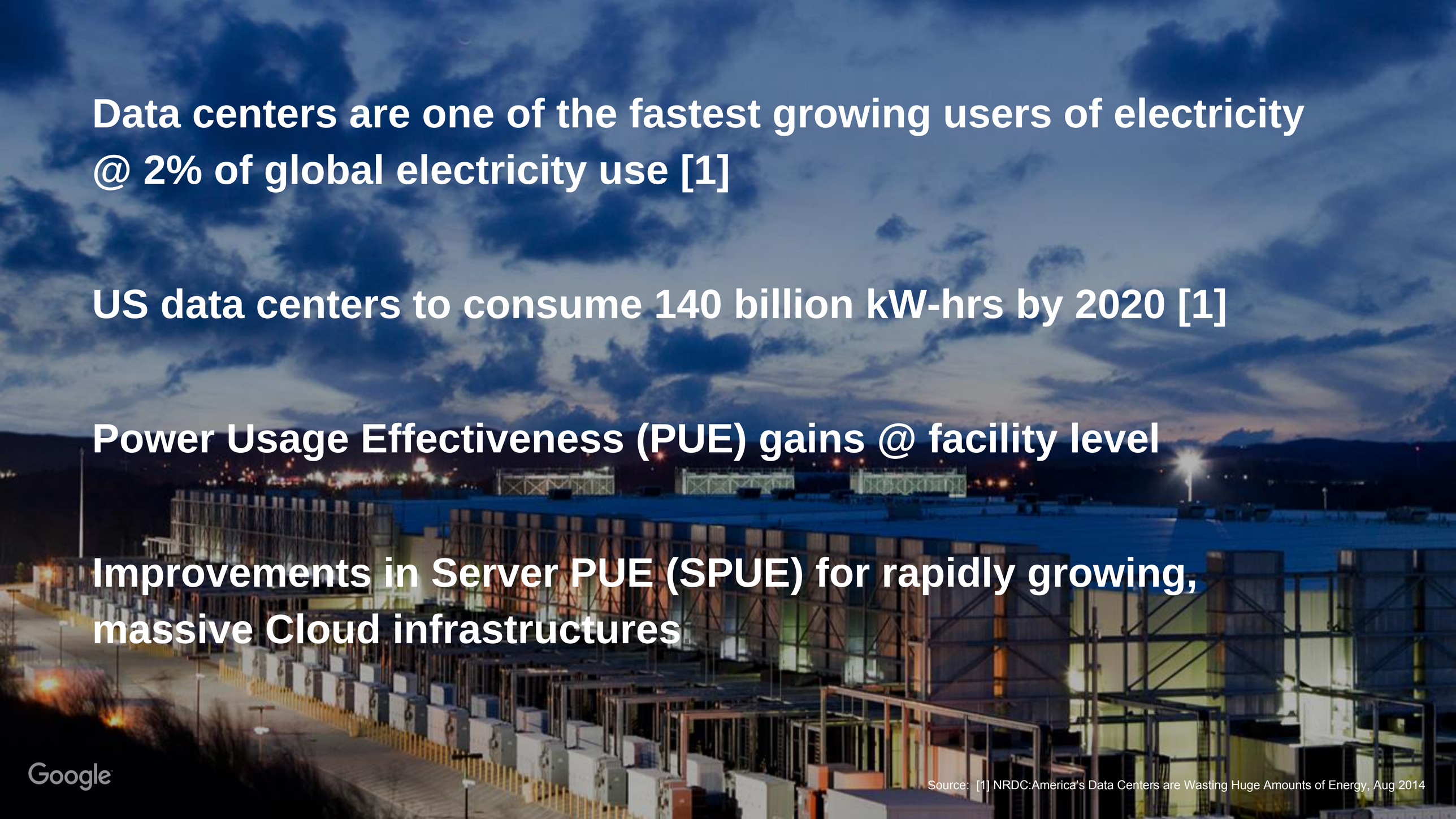
Optimized Power Delivery Architecture for Data Center Scale Server Applications

Neilus O’Sullivan
GOOGLE PLATFORMS POWER TEAM MANAGER



Data centers are one of the fastest growing users of electricity @ 2% of global electricity use [1]

US data centers to consume 140 billion kW-hrs by 2020 [1]

Power Usage Effectiveness (PUE) gains @ facility level

Improvements in Server PUE (SPUE) for rapidly growing, massive Cloud infrastructures

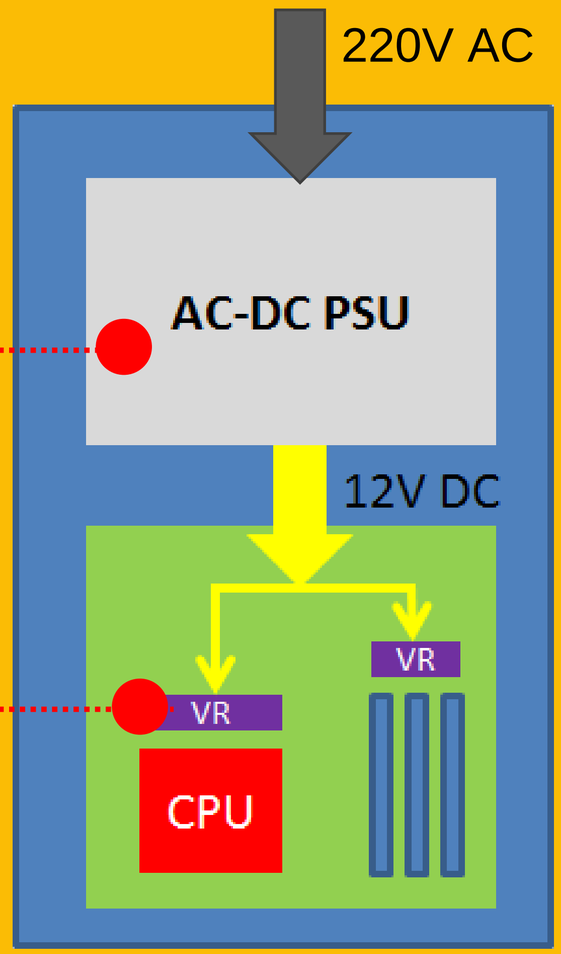
Google

Source: [1] NRDC:America's Data Centers are Wasting Huge Amounts of Energy, Aug 2014

Traditional Server Power Architecture

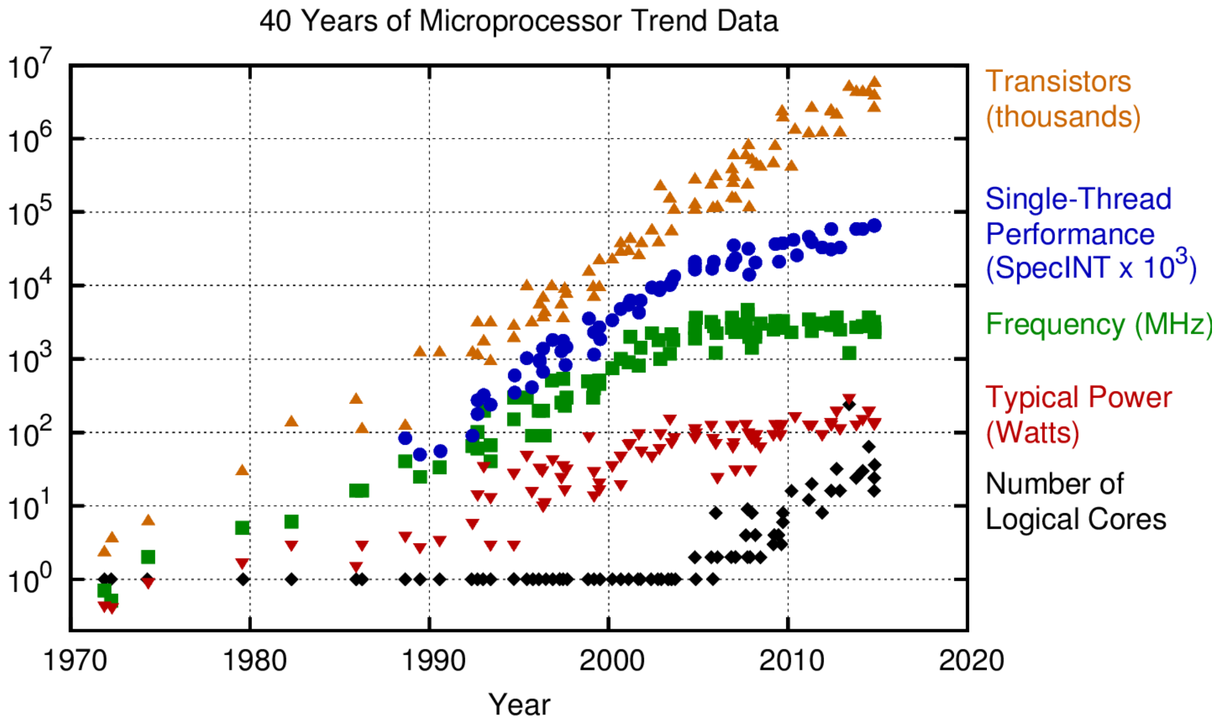
AC-to-12V PSU benefits from 80PLUS efficiency standard

12V-to-PoL DC-DC multi-phase buck Voltage Regulator



Challenges @ 12V

- High Power CPUs @ ~150A and ~500A/uS
- New high power devices like GPUs

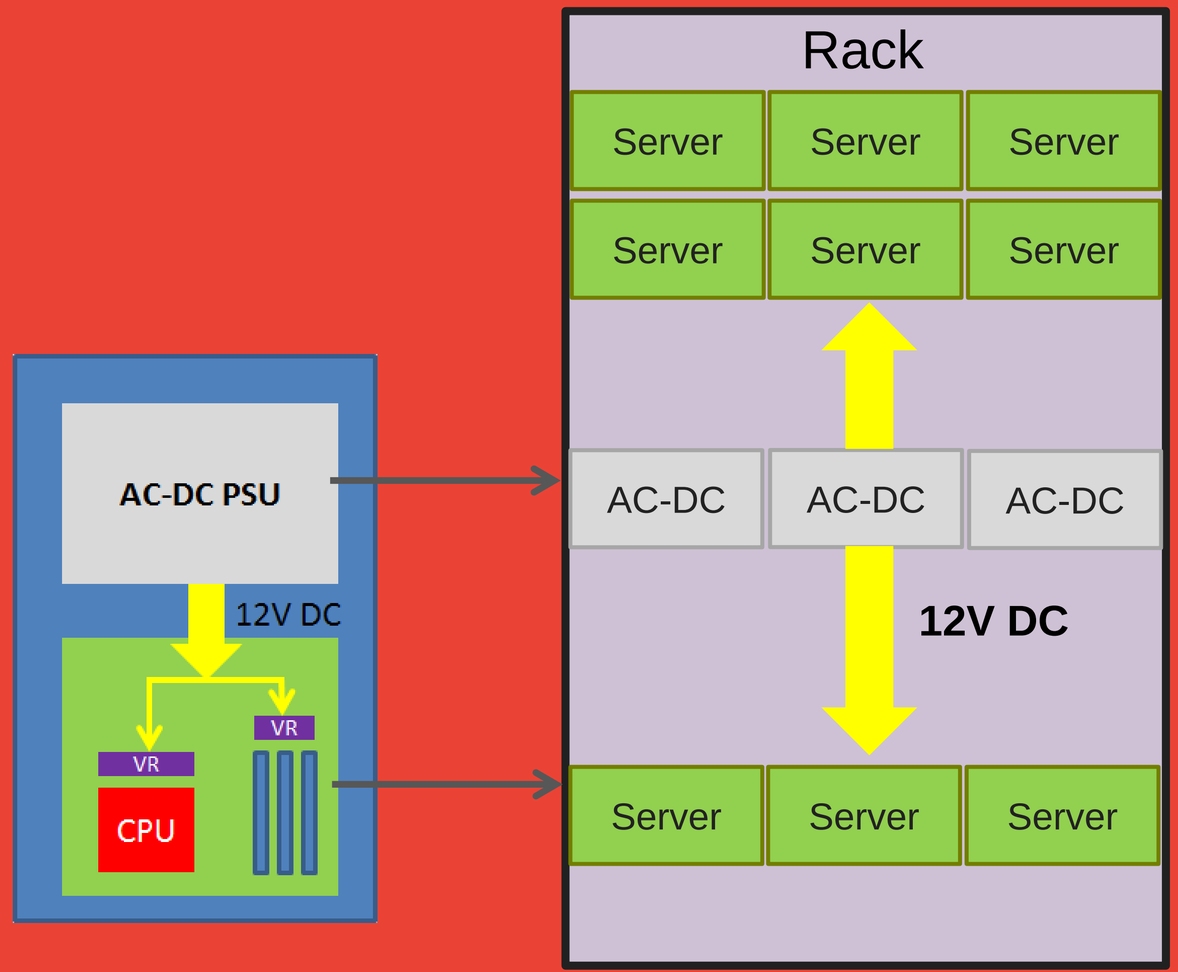


Source: [2] Original data up to 2010 by M.Horowitz et al, 2010 to 2015 by K.Rupp

Challenges @ 12V

System Integration

Distribution Losses



Enabling Higher Voltage

- Suitable PoL Topologies
- Component Ecosystem
- Supplier Expertise
- Reliability
- Availability
- EMI, Safety etc

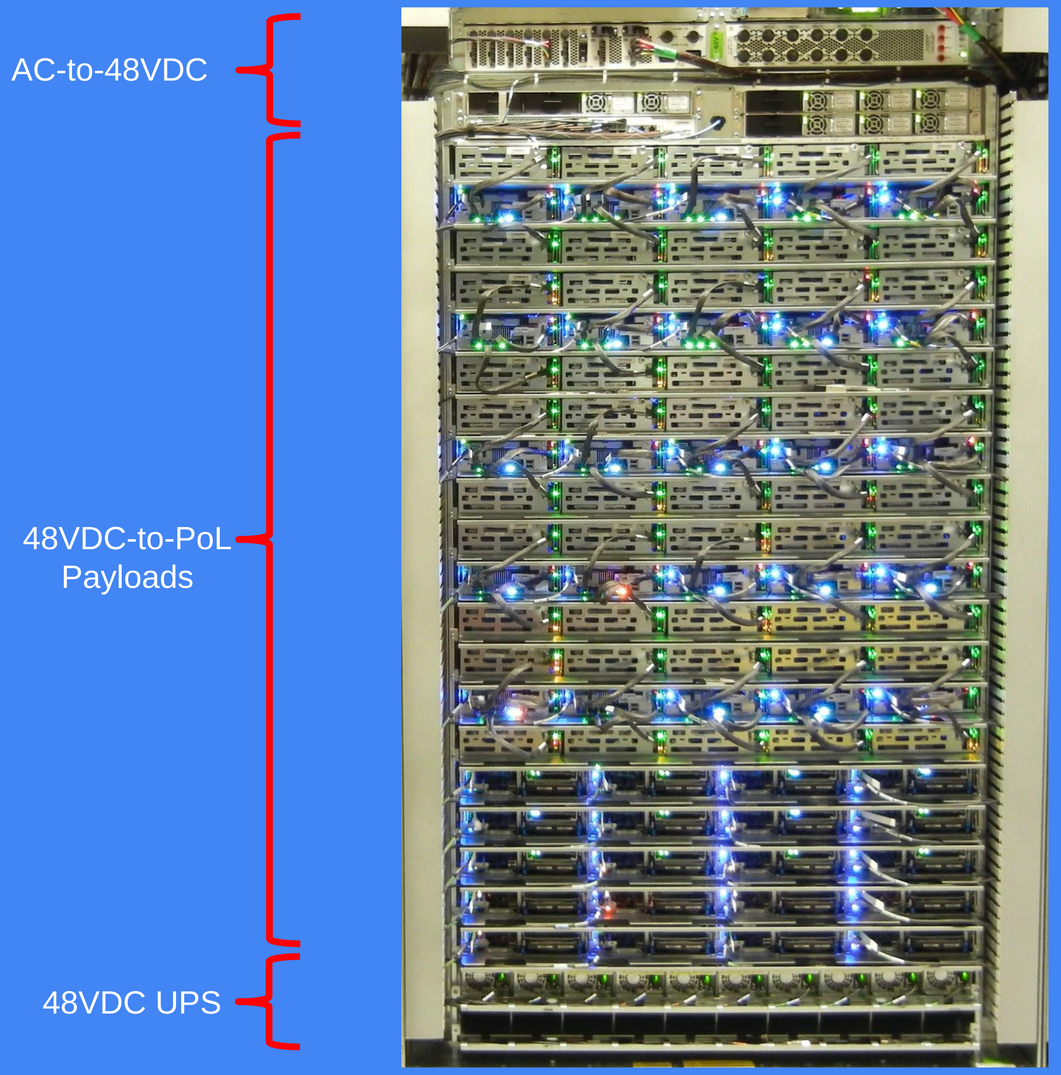
Why 48V Power Architecture ?

Less distribution losses

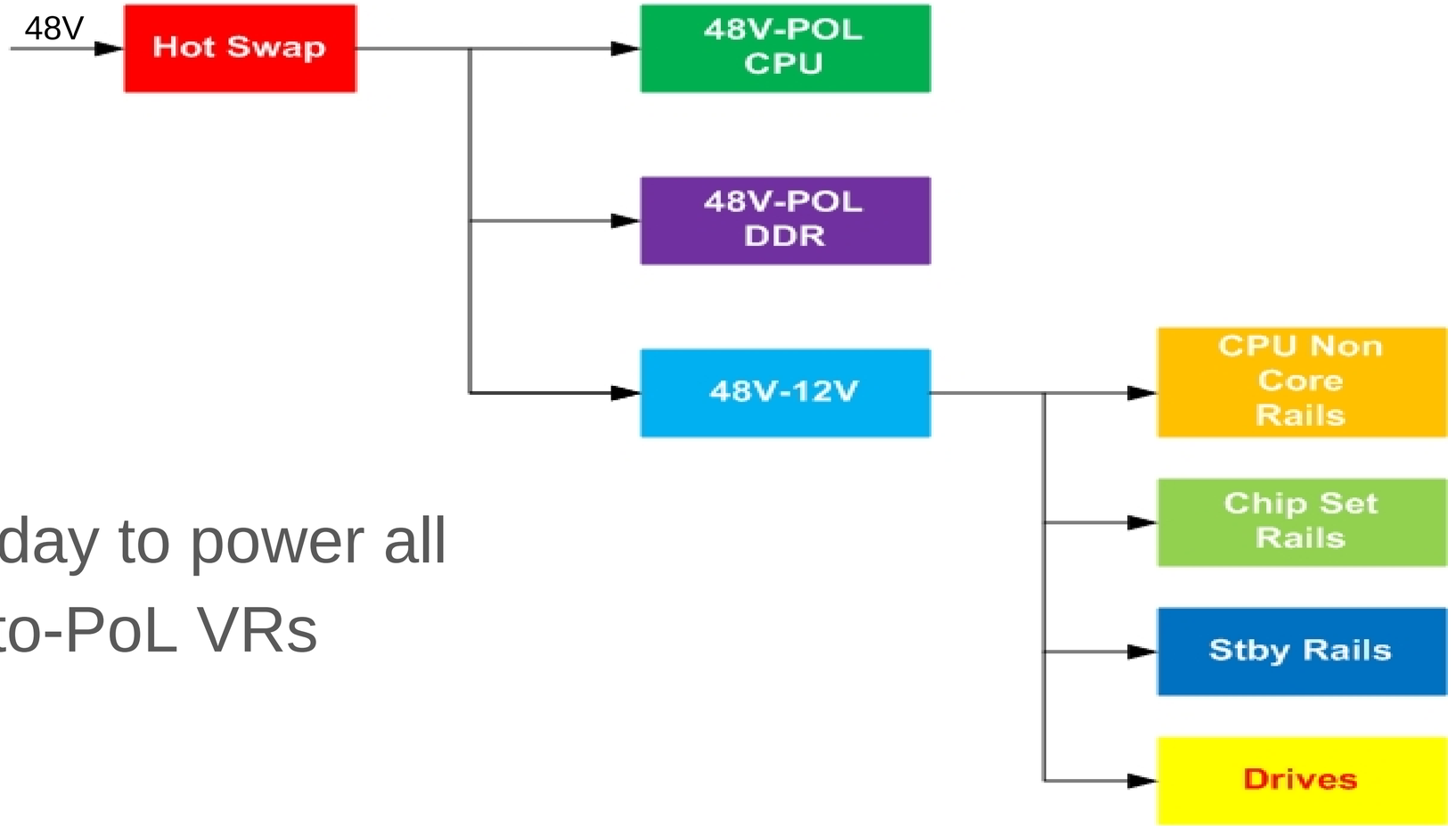
48V Telecom ecosystem

Efficient and cost effective UPS

48V-to-PoL VR technologies deployed and proven at scale



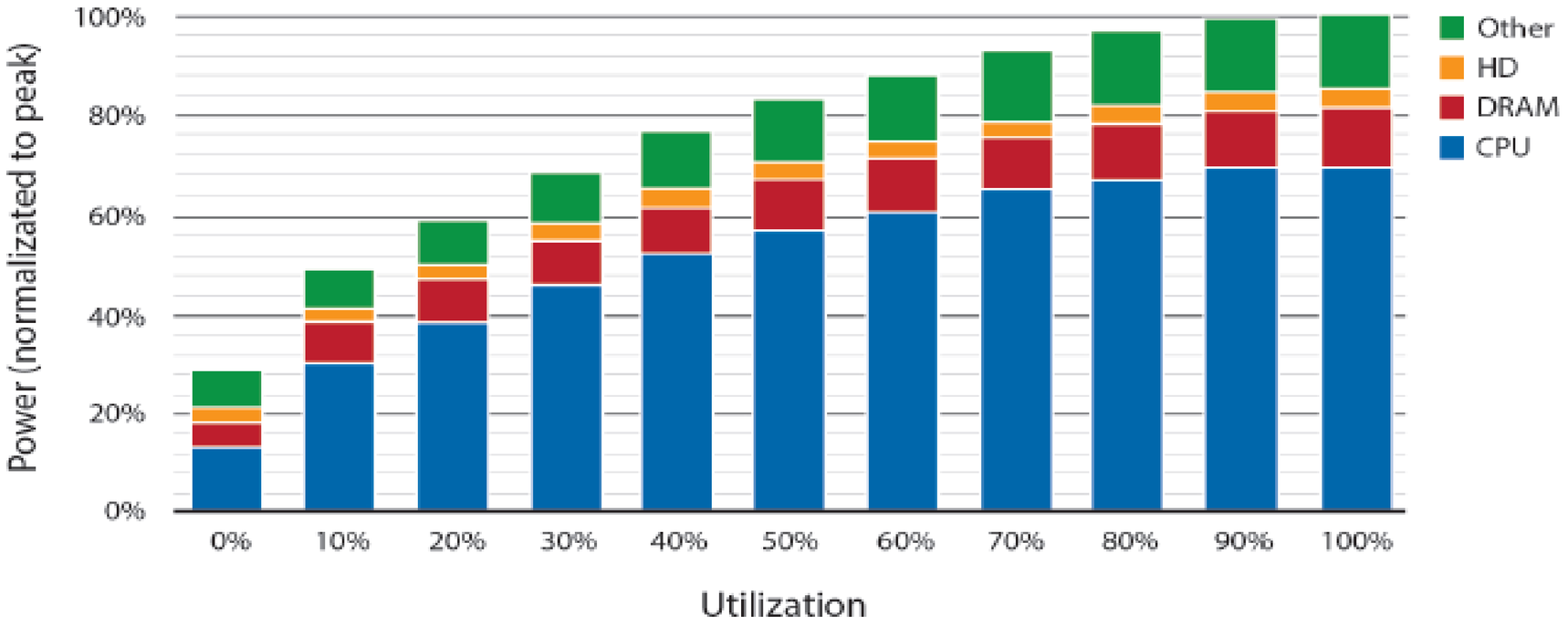
Server Power Architecture Overview



Technology exists today to power all rails with direct 48V-to-PoL VRs

+48V to PoL Focus

CPU and memory rails consume over 80%
of server power at peak load [3]



Source: [3] The Datacenter as a Computer – Luiz Andre Barroso, Jimmy Clidaras, Urs Holzle

Typical Efficiency Gains

Power Architecture	Conversion Stages	Stage Efficiency (%)	System Efficiency (%)
+48VDC Architecture (Google)	AC to +48V	98	92.1
	+48 to PoL (1.8V)	94	
-48VDC Architecture	AC to -48V	98	88.9
	-48V to +12V	96.5	
	+12V to PoL(1.8V)	94	
12VDC Architecture	AC to +12V	95	89.3
	+12V to PoL(1.8V)	94	

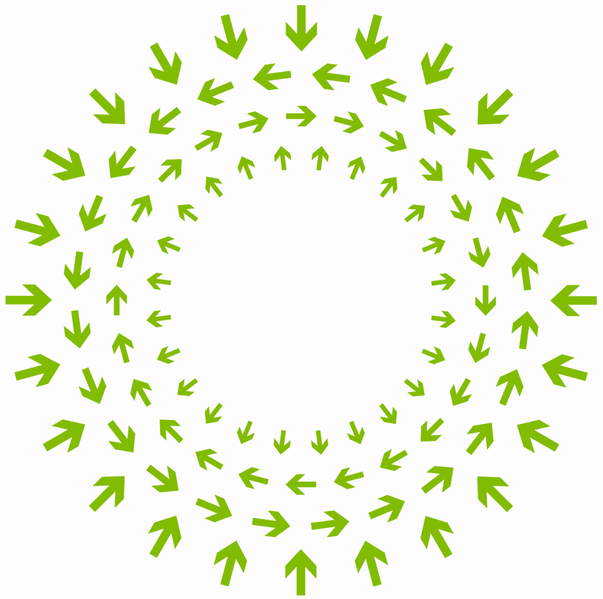
Note: Distribution Loss reductions give additional gains @ 48V

Summary

Save	+48v Architechure reduces losses by over 30% compared to 12V
Enable	48V-to-PoL -- key enabler for high power loads
SPUE	Improved SPUE saves Billions of Dollars and Kilowatt Hours

THANK YOU

Google



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