TeleGeography Workshop

Brianna, Tim, and Jon

PTC

January 21, 2024

Here’s what you get for the price of admission

1. Global Pricing Trends in a New Era
   - Brianna Boudreau
2. Towards an Interconnection Index: Ranking the World’s Greatest Hubs
   - Tim Stronge
3. The Data Center Market Blazes a New Trail
   - Jon Hjembo

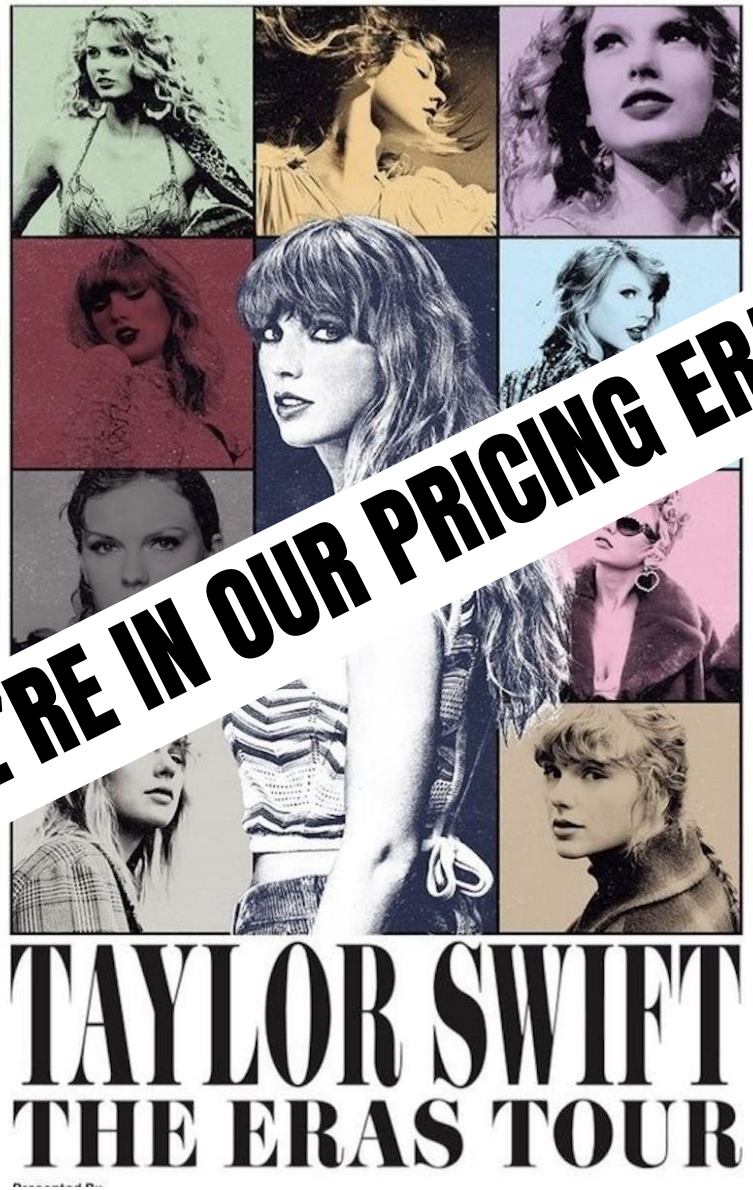
https://www2.telegeography.com/ptc-2024

TeleGeography

Global Pricing Trends in a New Era

Brianna Boudreau

PTC
January 21, 2024



WE'RE IN OUR PRICING ERA

TELEGEOGRAPHY

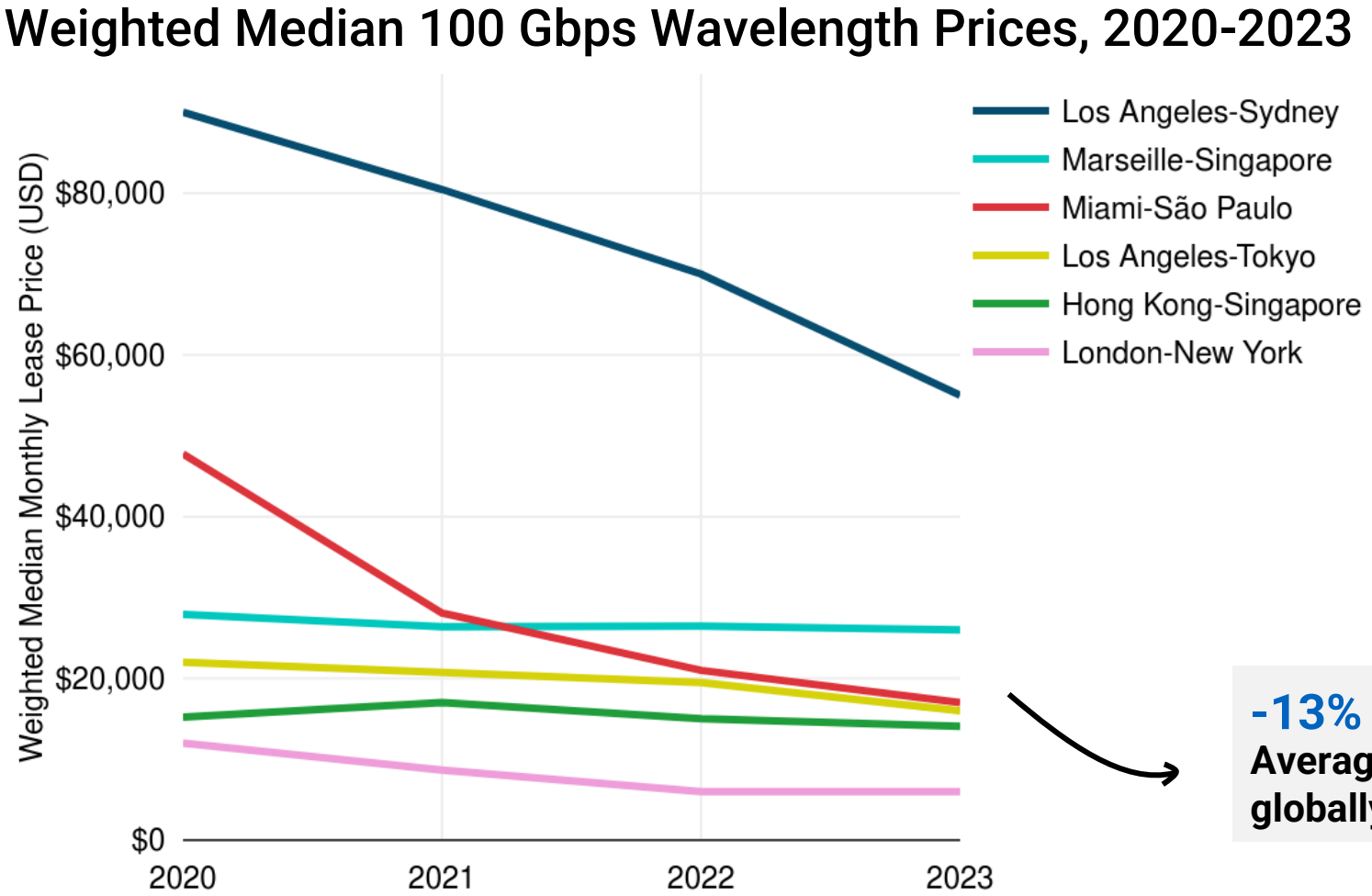
The Set List

- Transport Pricing
  - Are we out of the woods yet? Has price erosion returned to “normal?”
  - How do trends compare across regions?
- 400 Gbps
  - How have 400 Gbps pricing models rolled out?
  - Lessons learned from 100 Gbps
- IP Transit Pricing
  - Impact of transport on transit pricing
  - Impact of network investments on existing hubs & secondary markets
- Our Next Era
  - Where are we headed in 2024?
  - Potential changes in customer purchasing patterns

Transport Pricing

Are we *out of the woods* yet?

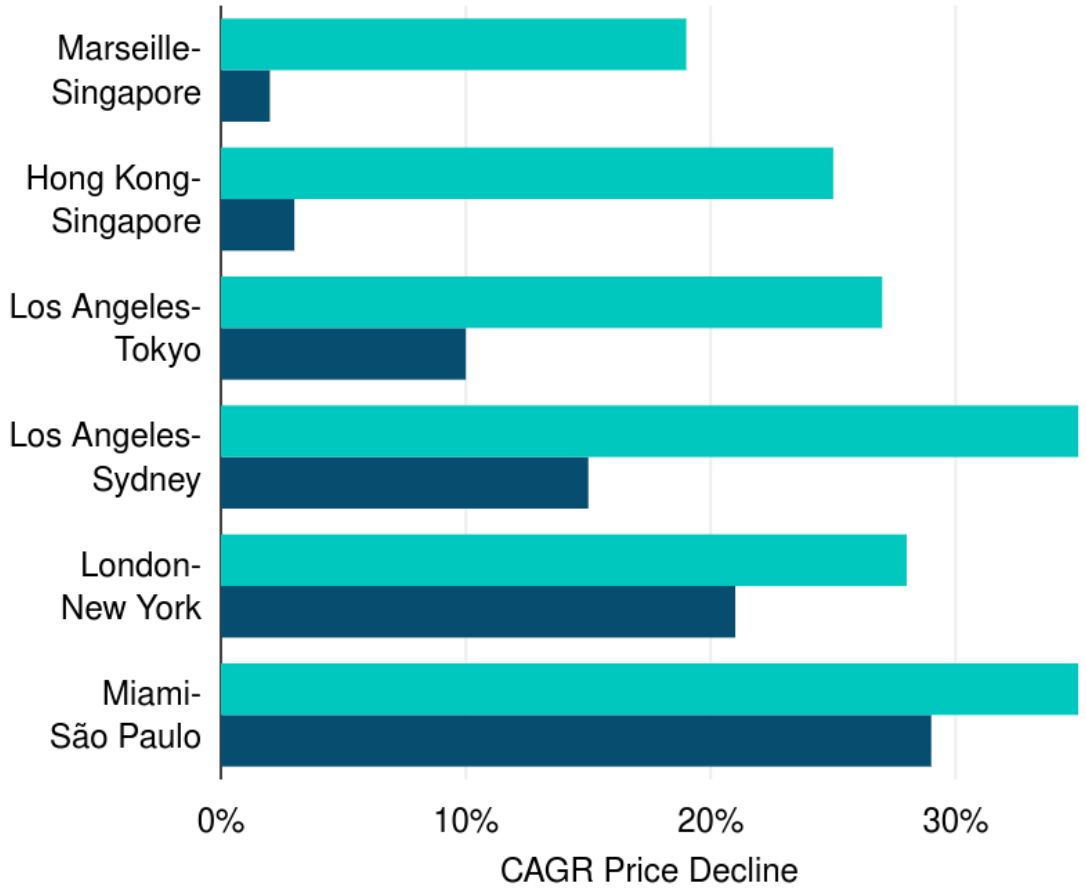
Wavelength prices declining is *Nothing New*



-13%
Average CAGR price decline globally since 2020

Long Story Short, declines slower than earlier eras

Weighted Median 100 Gbps Wavelength CAGR Price Decline, 2017-2020 vs. 2020-2023



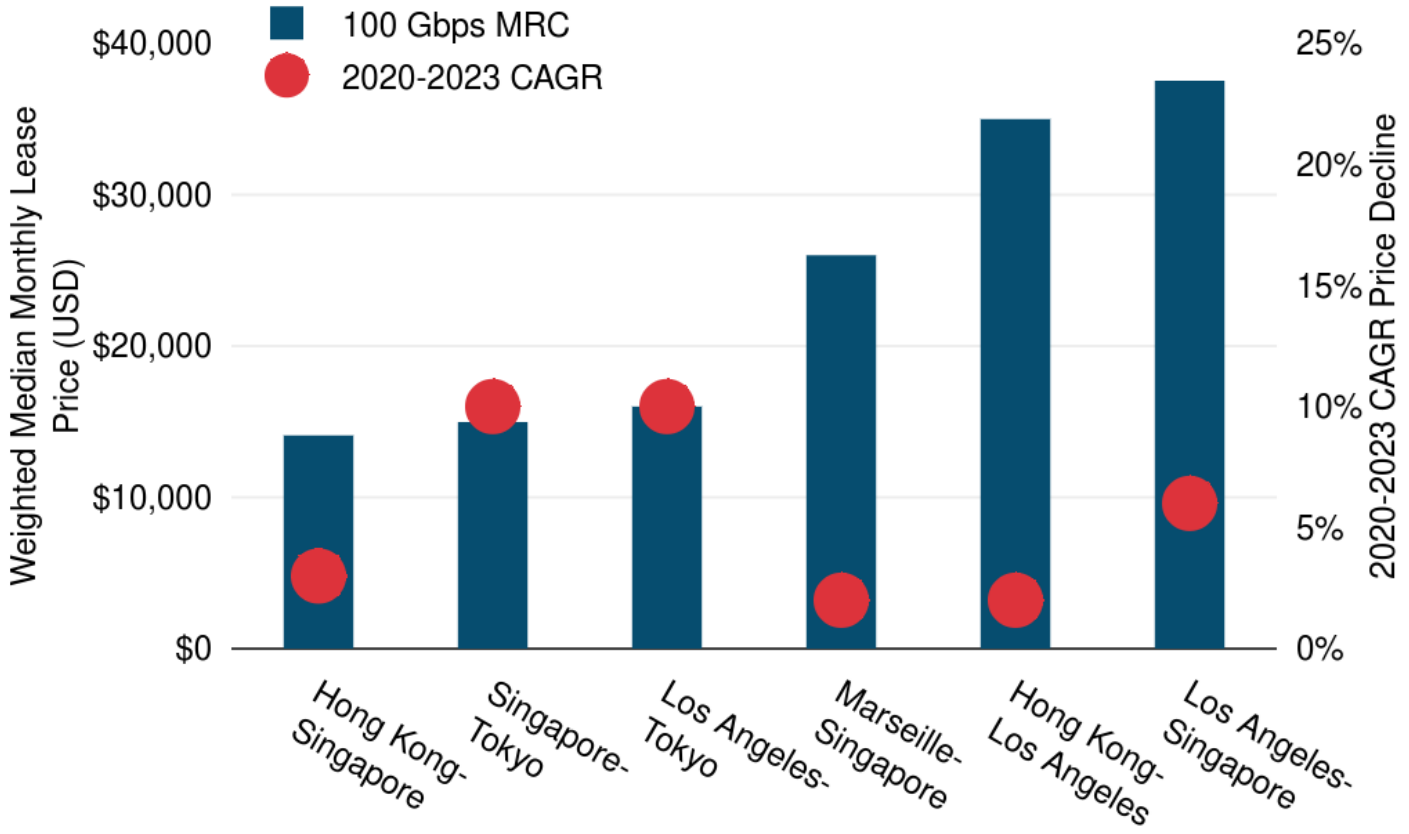
100 GBPS AVERAGE CAGR PRICE DECLINE MAJOR ROUTES

2017-2020
-30%

2020-2023
-13%

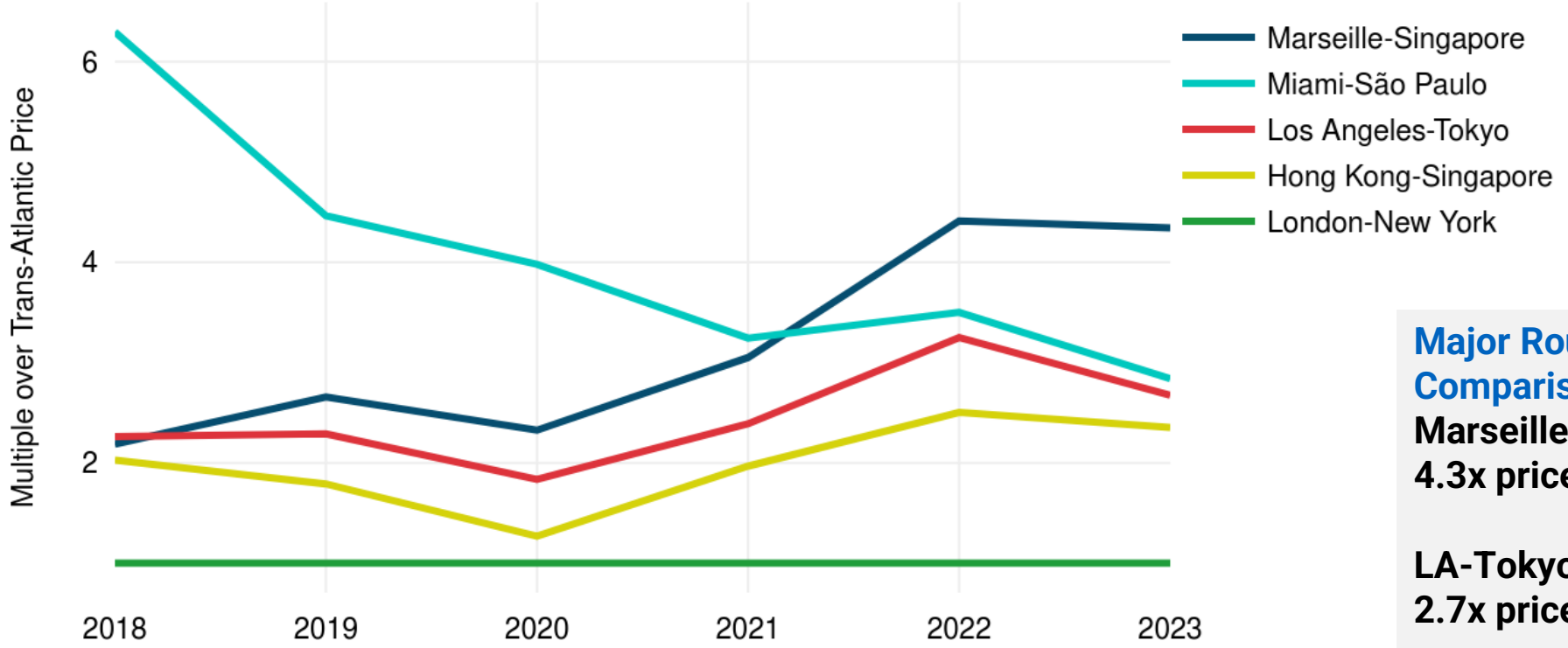
On routes to Asia, erosion has yet to *Begin Again*

Weighted Median 100 Gbps Wavelength Prices & CAGR Price Decline



That's When modest price erosion maintains global price differences

Weighted Median 100 Gbps Monthly Lease Prices Relative to London-New York



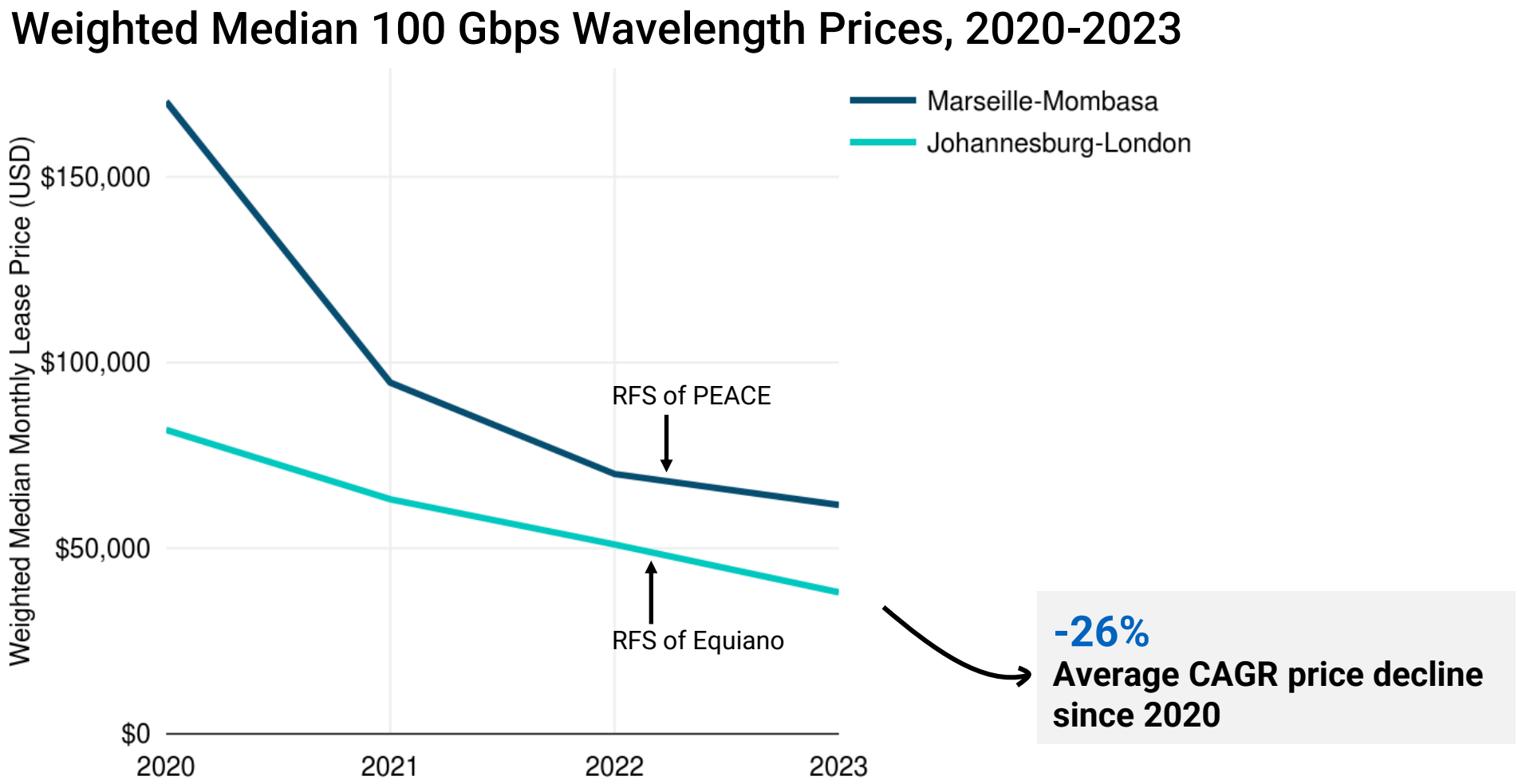
Major Route Price Comparisons

Marseille-Singapore
4.3x price of Lon-NY

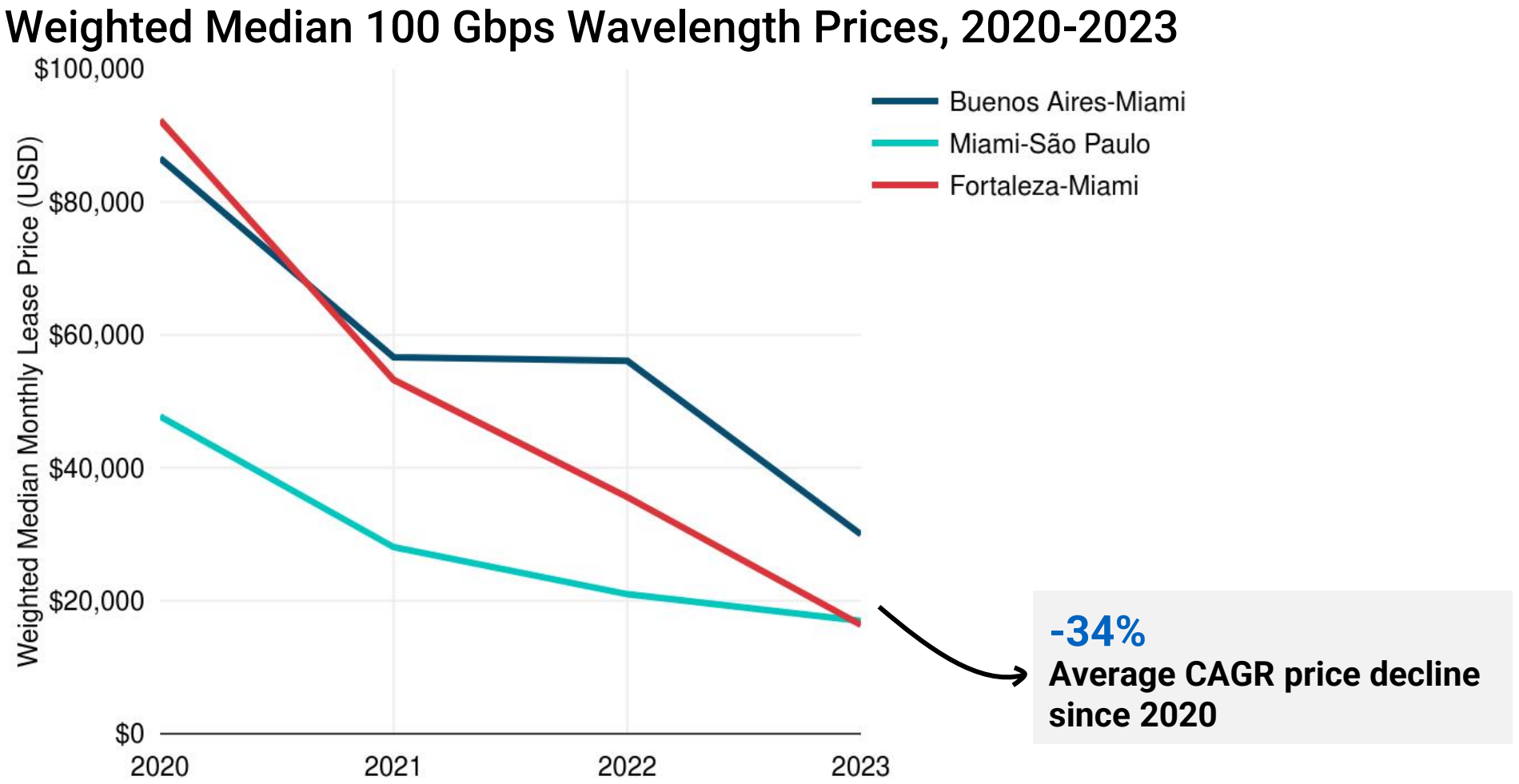
LA-Tokyo
2.7x price of Lon-NY

Miami-São Paulo
2.8x price of Lon-NY

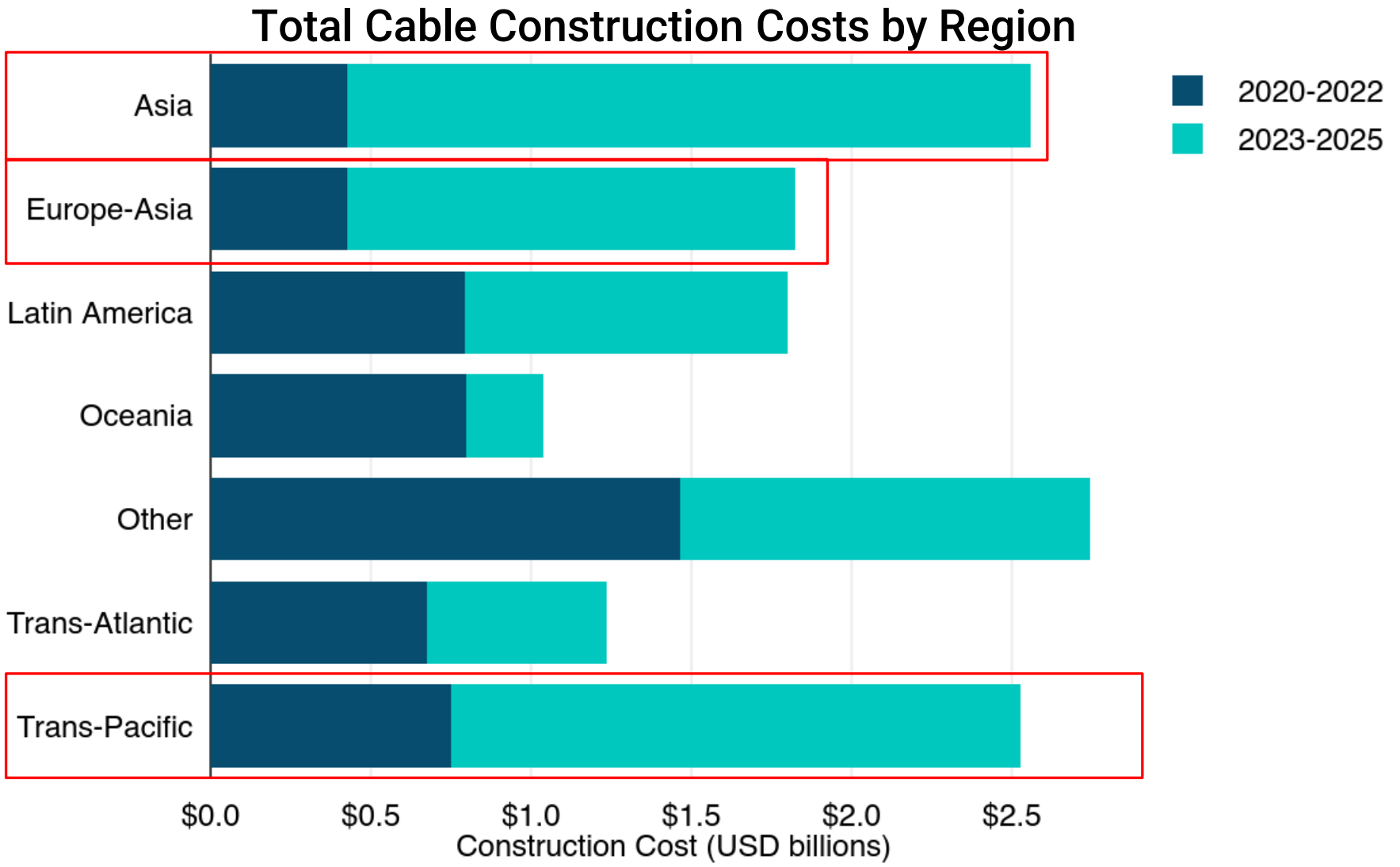
But it's been a *Cruel Summer* on other routes



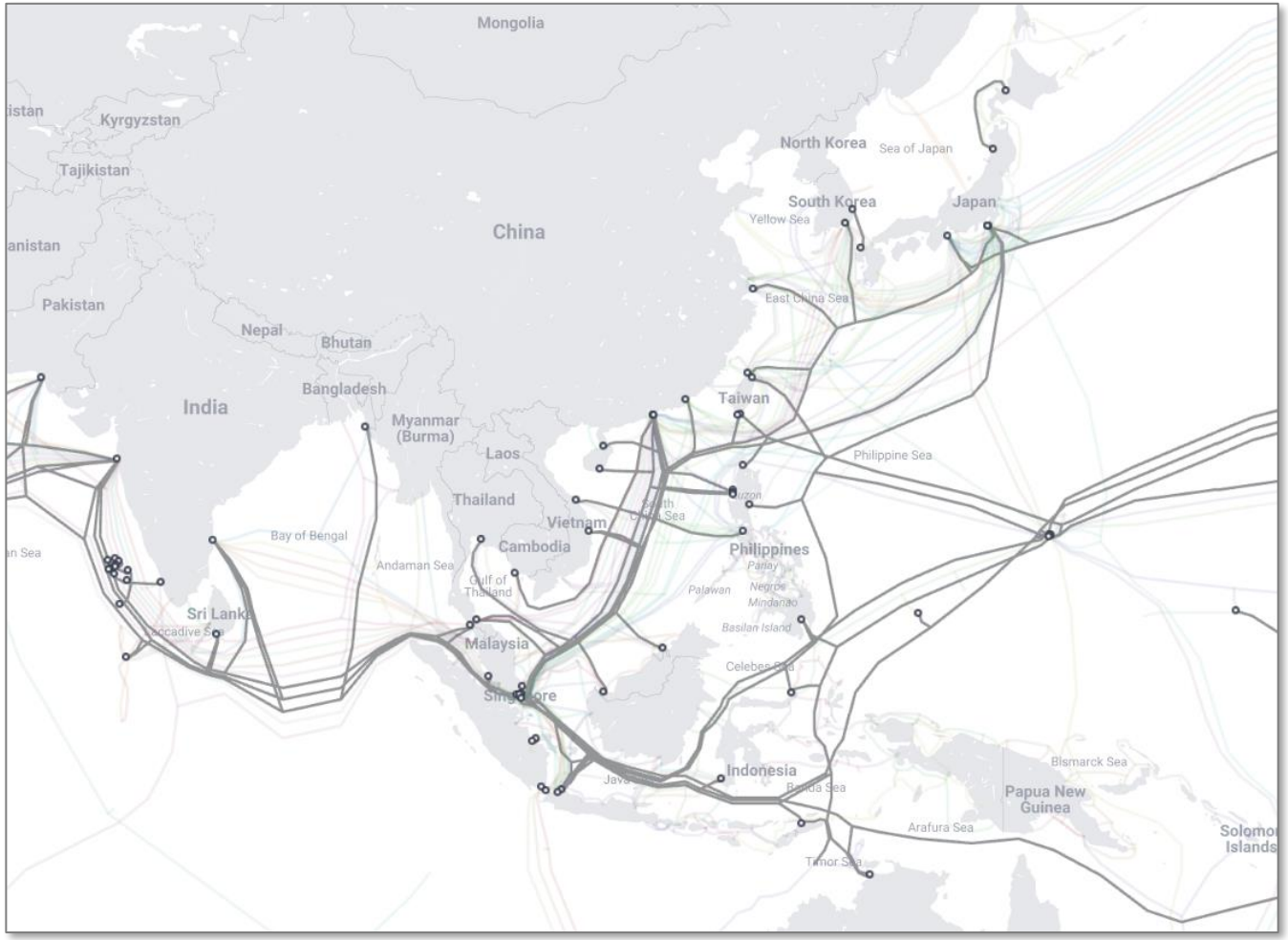
But it's been a *Cruel Summer* on other routes



New cable construction isn't going out of *Style*



New cable construction isn't going out of *Style*



https://www.submarinecablemap.com/status/planned

So, are we *Out of the Woods* yet?

- Delays in capacity upgrades and new cable activation
  - Global supply chain disruptions and card shortages have largely resolved themselves, but geopolitical issues (such as those in the South China Sea & the Red Sea) continue to delay new network projects.
  - Fewer cables with inventory at one time = less competitive price pressure.
  - On routes with recent upgrades, new supply, and pre-sales on new systems, price erosion returning to higher levels.
- *Look what you made me do*
  - Uncertainty on the timeline of future supply on some routes has changed customer purchasing patterns.
  - Supply is snatched up before it becomes available or bought in bulk. Customers taking capacity at the price that is offered helps maintain price points.

400 Gbps Pricing

...Ready for it?

I Can See You: 400 Gbps pricing models taking shape

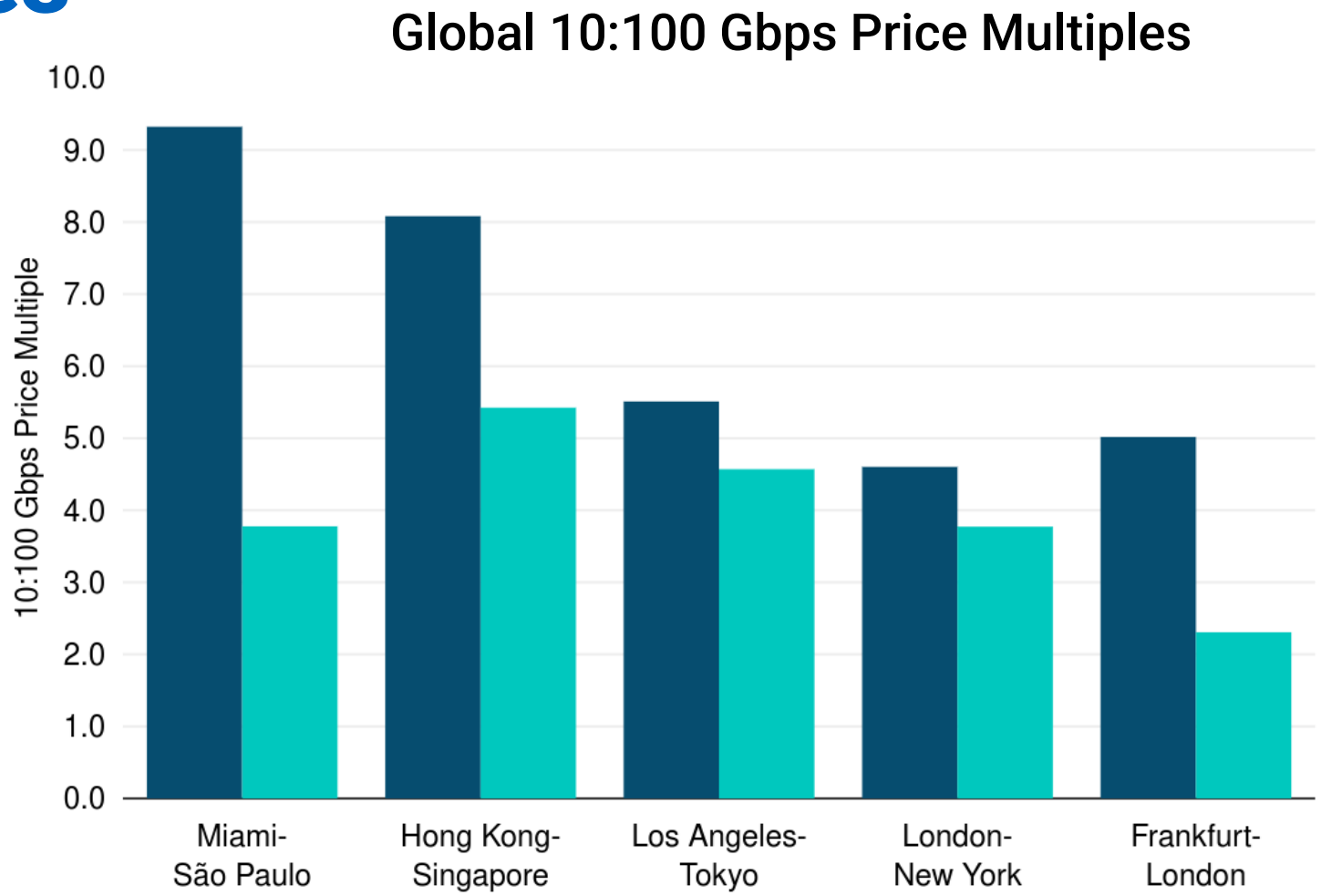
Global 400 Gbps Prices & Price Multiples

100:400 GBPS AVERAGE GLOBAL PRICE MULTIPLE

Terrestrial
3.5x

Subsea
3.9x

The Last Time: Evolution of 10:100 Gbps price multiples



10:100 GBPS AVERAGE GLOBAL PRICE MULTIPLE

2016
6.5x

2023
4.0x

400 Gbps Pricing …*Ready for it*?

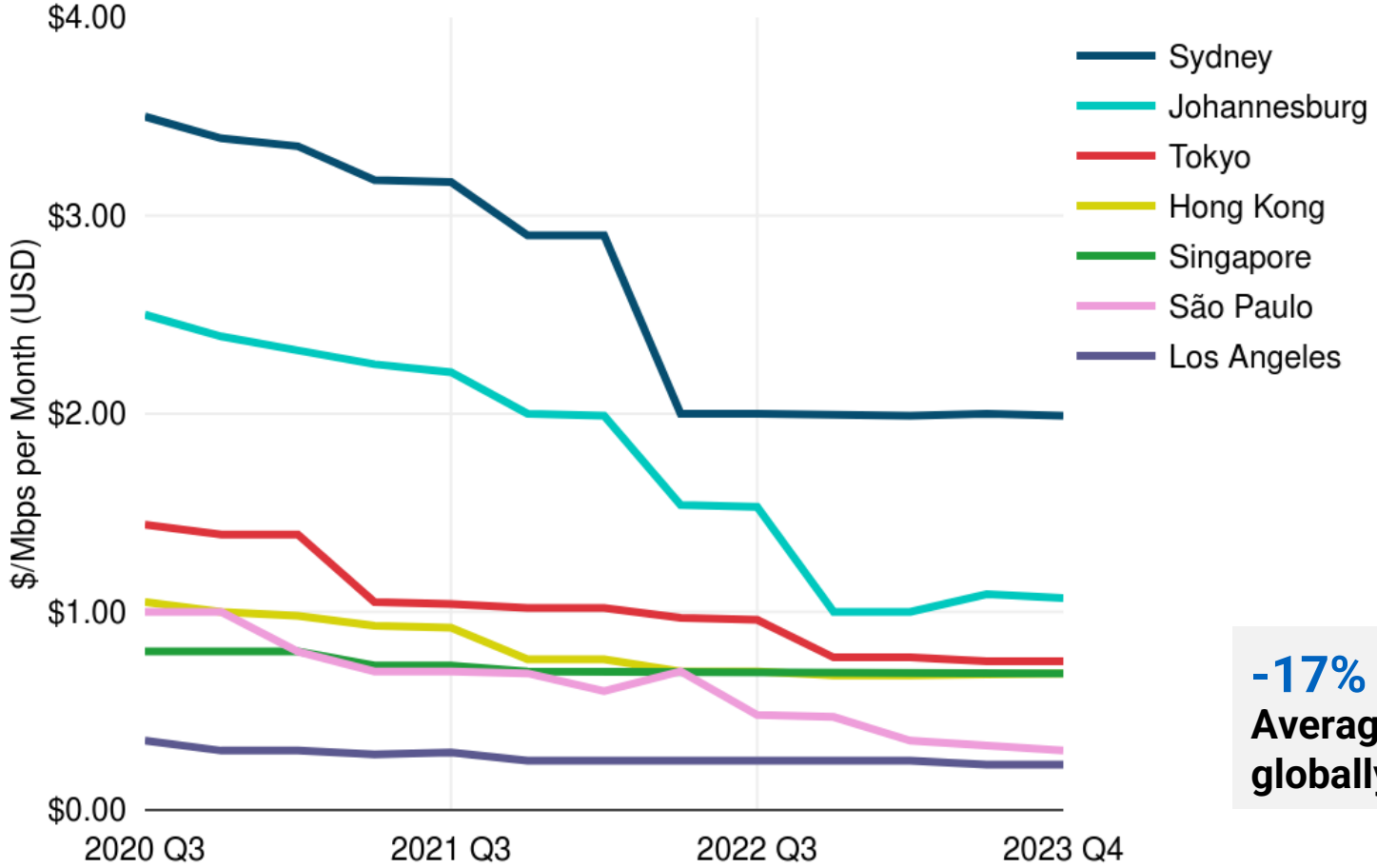
- 400 Gbps uptake reportedly slower than initially anticipated.
  - Sales limited to shorter terrestrial routes within Europe and the U.S, & trans-Atlantic.
  - Asia and Oceania reporting limited demand so far.
- As a result, only a slight discount between 100 & 400 Gbps.
  - Low multiples of 2.5-3x on terrestrial routes have been reported.
  - As demand picks up, multiples will erode.
- Additional savings on install, cross-connect charges, and power consumption compelling for higher capacity buyers.

IP Transit Pricing

A trend we know *all too well*

Transit prices starting to *Shake It Off*

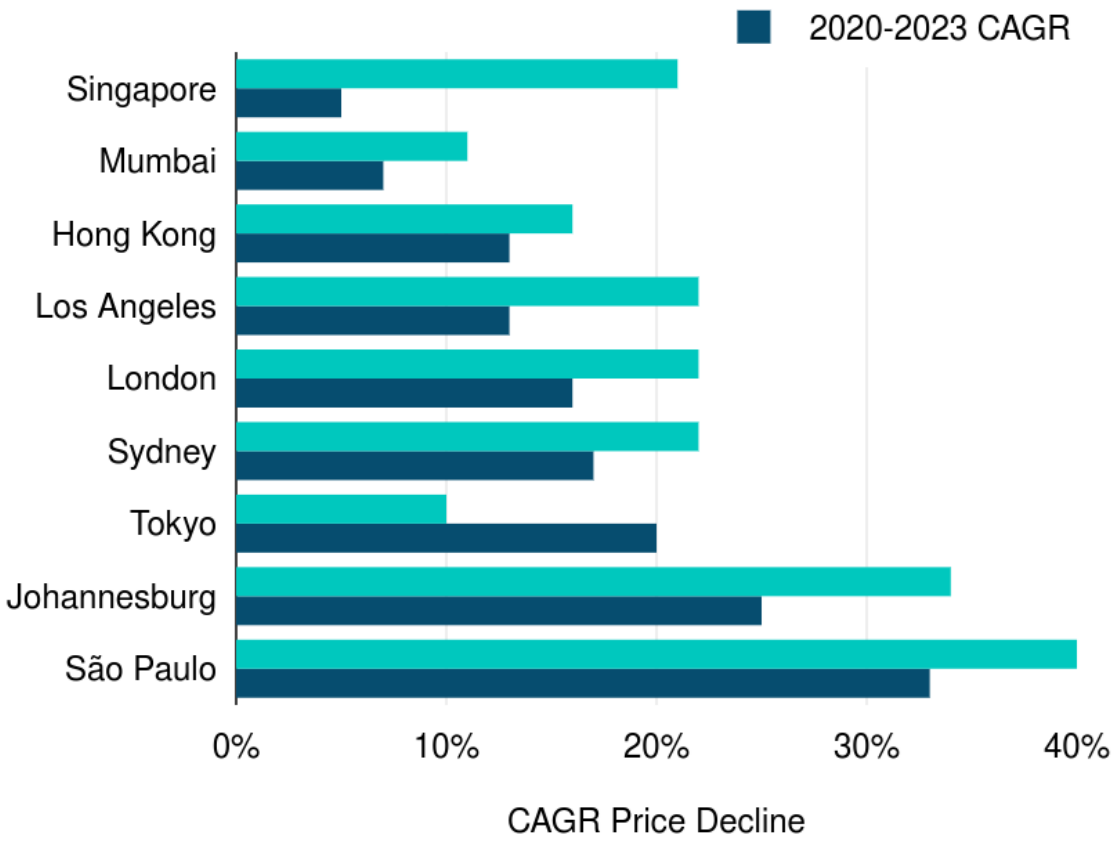
Weighted Median 10 GigE IP Transit Prices in Major Global Cities



-17%
Average CAGR price decline globally since 2020

Returning to that trend we know *All Too Well*

Weighted Median 10 GigE CAGR Price Decline, 2017-2020 vs. 2020-2023



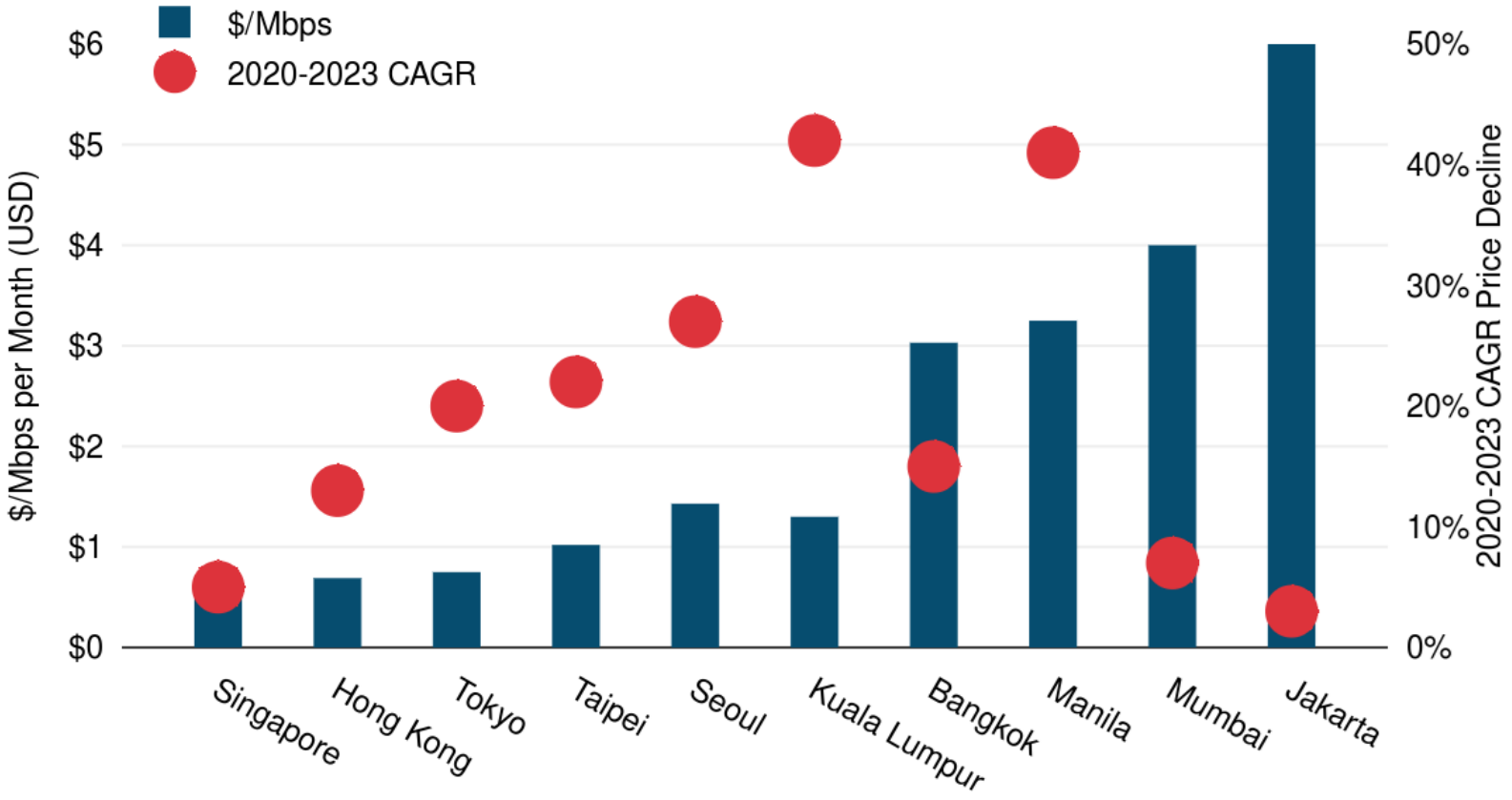
10 GigE AVERAGE CAGR PRICE DECLINE MAJOR ROUTES

2017-2020
-22%

2020-2023
-17%

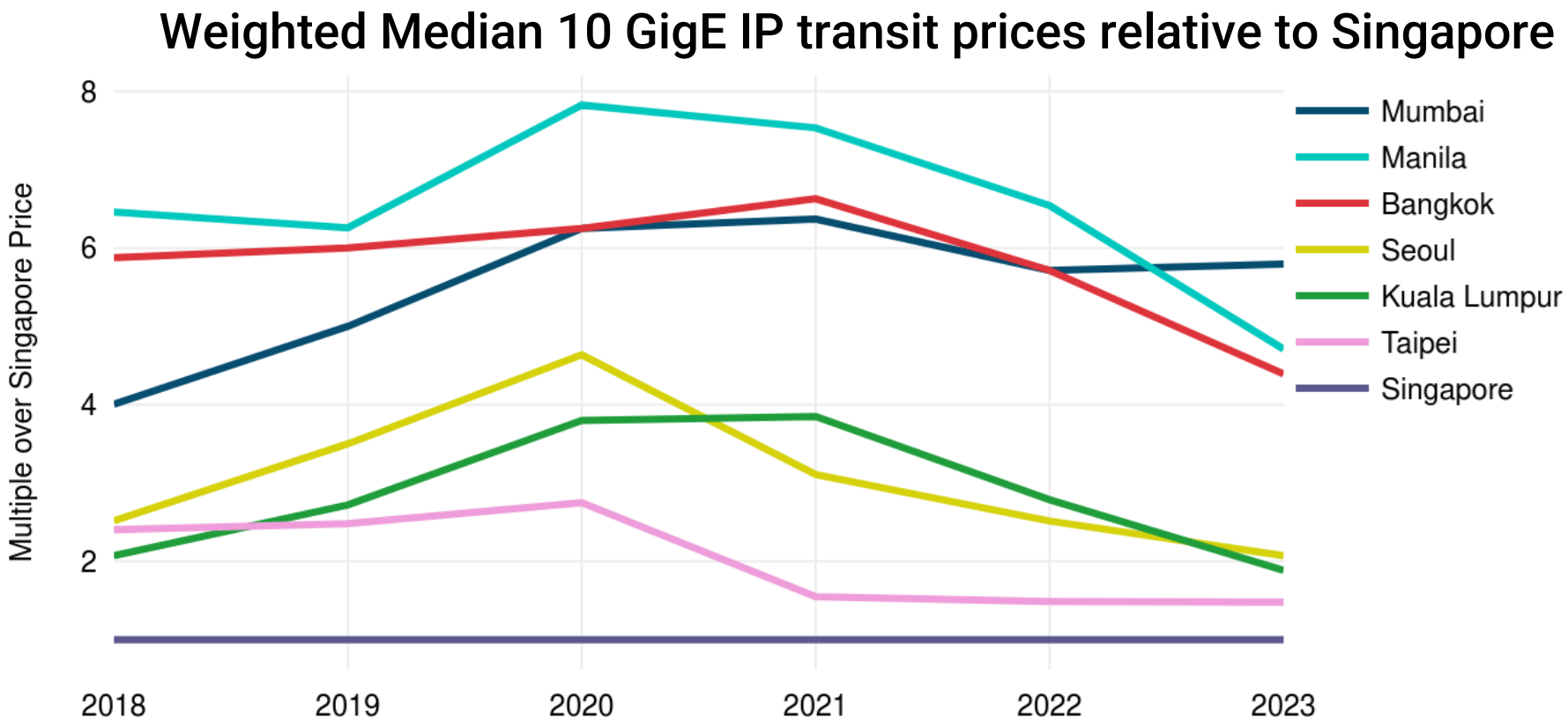
Timeless: Prices falling in APAC

Weighted Median 10 GigE IP Transit Prices & CAGR Price Decline



-20%
Average CAGR price decline since 2020

So It Goes: Reducing premium in secondary markets



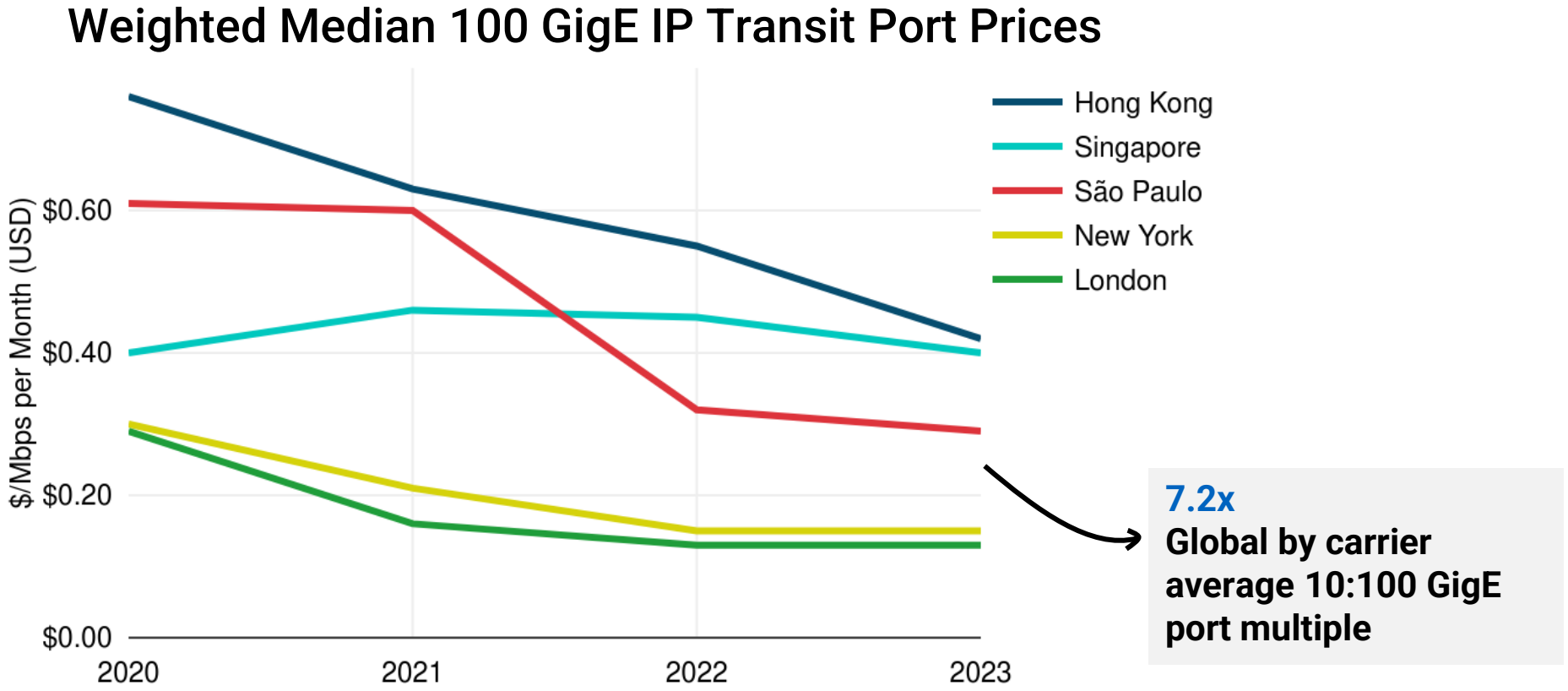
APAC Price Comparisons

Bangkok
4.4x price of Singapore

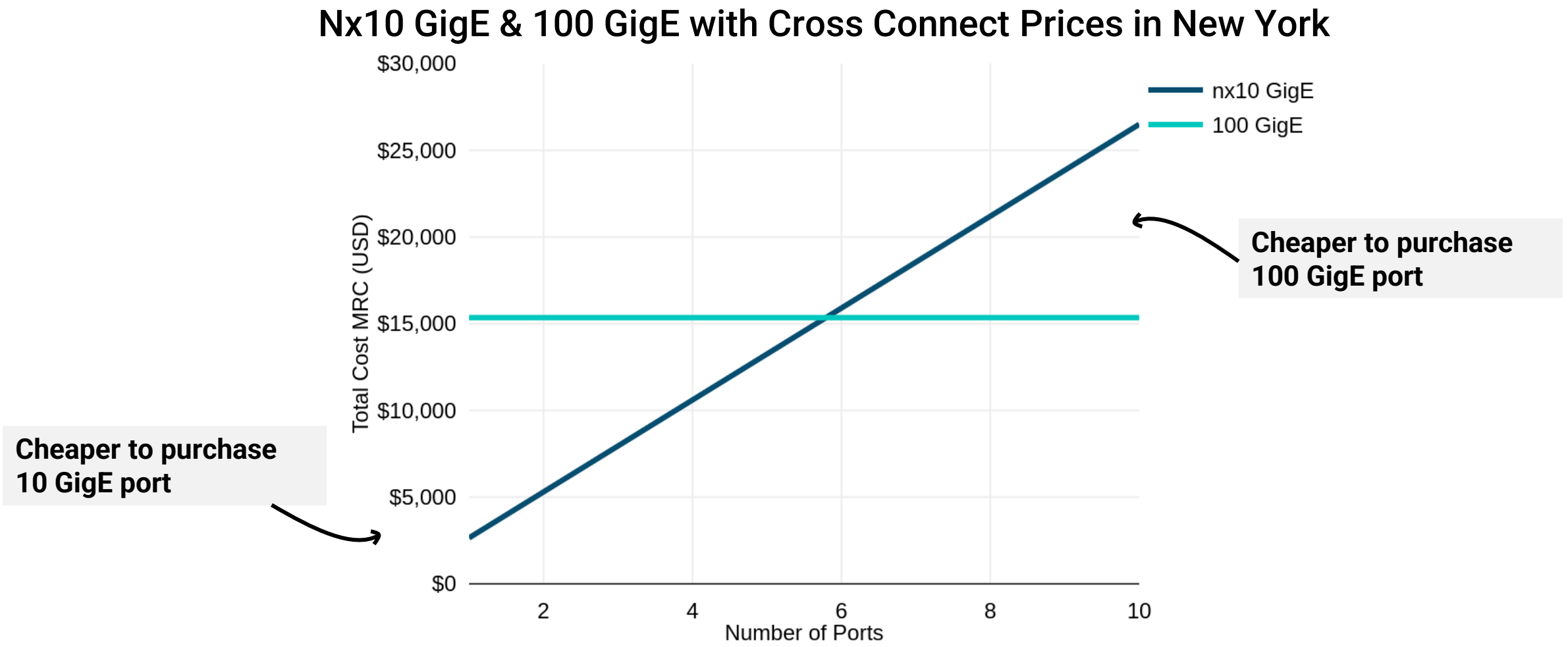
Manila
4.7x price of Singapore

Taipei
1.5x price of Singapore

Change to 100 GigE in global hubs



It's Time to Go: Assessing the case for 100 GigE



IP Transit Prices

- Return to a trend we know *all too well*
  - Global IP transit prices continue to fall at a steady pace.
  - In established hubs declines enabled by escalating volumes & lower unit costs.
  - In secondary markets declines drive by reductions in the underlying cost of transport and increasing local traffic exchange.
- 100 GigE ports now represent majority of sales in key hubs
  - Price multiples remain high, but savings on install, cross connects & ease of management are compelling factors.

Our Next Era

- Will price erosion return to normal? Or is there a “new normal?”
  - While supply chain constraints are largely resolved, geopolitical issues still delaying new submarine cable systems on some routes.
- Change in the competitive landscape
  - Approaching an era of cable retirements, which could change the number of bandwidth suppliers on some routes.
- Change in customer purchasing patterns
  - When does it make sense to purchase a fiber pair/spectrums vs leasing wavelengths?
  - Fiber pair pricing is very cable specific and not subject to the same pricing trends we are used to.
- More local market growth for IP transit

Towards an Interconnection Index:
Ranking the World's Greatest Hubs

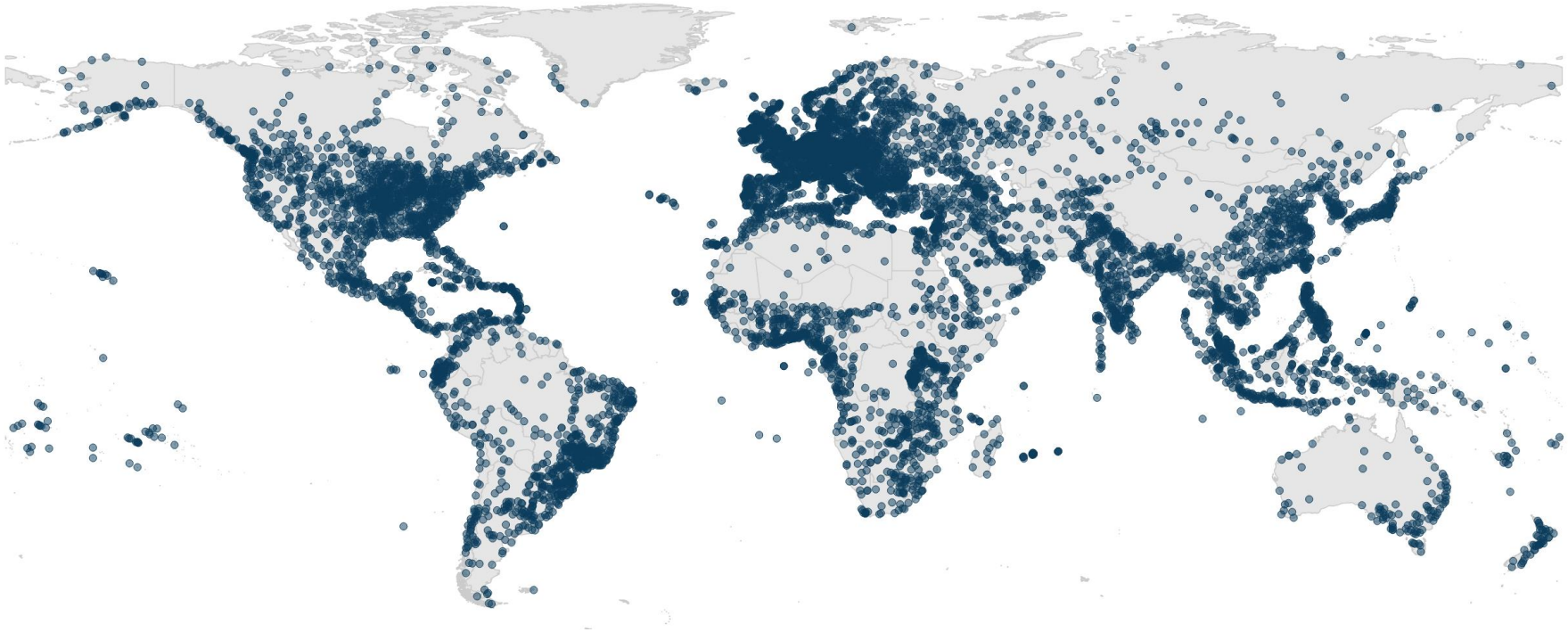
Tim Stronge

PTC

January 21, 2024

The interconnection index: what we're doing

- Questions we're often asked
  - What is the next emerging hub in region x?
  - How do various hubs compare to each other?
  - Where should I expand in country X besides the largest city?
- We will solve with data and *maps*
  - 🤓



Let’s think about the data sets for each city

- Data Centers
  - Data center infrastructure
  - Internet exchange infrastructure
- Network Connectivity
  - Cloud infrastructure
  - Long-distance internet
  - Long-distance transport
  - Pricing
- Market Potential
  - Geography and demographics
  - Local access
  - Power
  - Regulations and governance

Example city: Osaka

Data Group	Category	Value	Normalized Score
Geography and Demographics	GDP per Capita	$39,734	17.7
Geography and Demographics	Population	12,815,240	39.8
Geography and Demographics	Population in Nearby Cities	20,298,215	25.2
Geography and Demographics	**Group Average**		**27.6**

Smallest city = 500 pop.

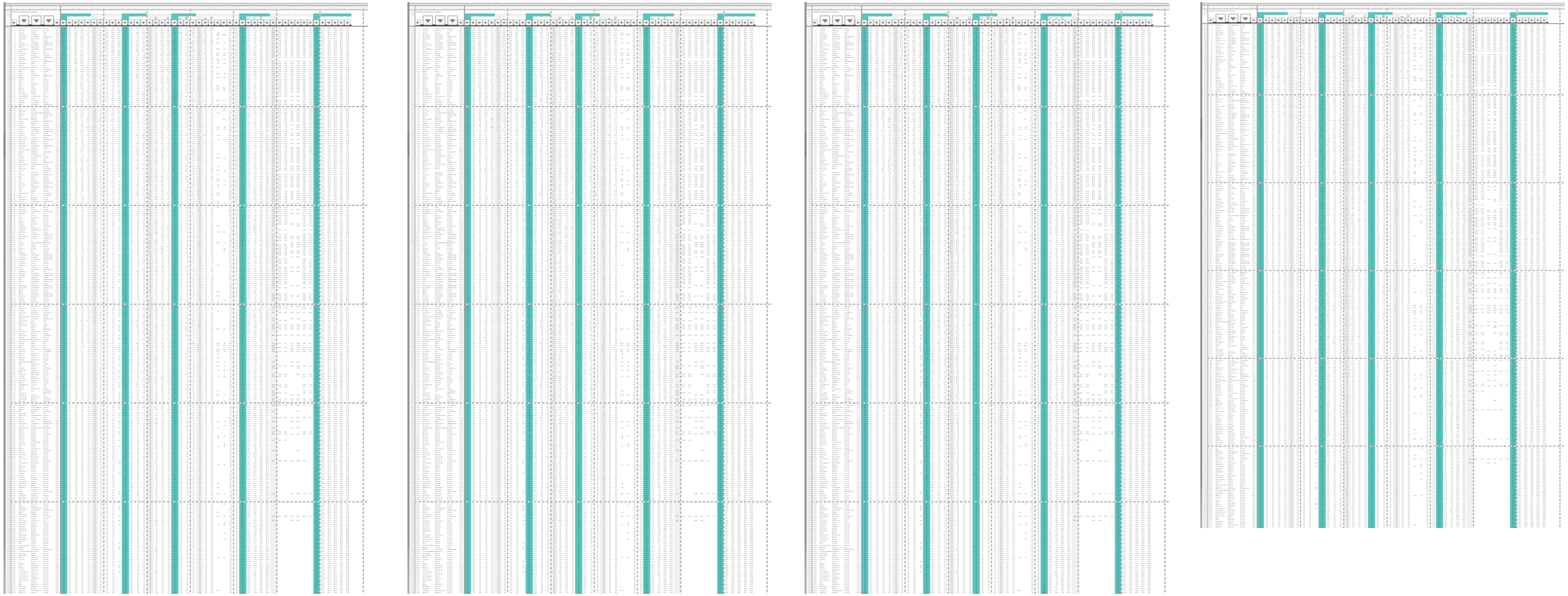
Largest city = 32,224,328 pop.

Osaka is 39.8% between the MIN and MAX cities

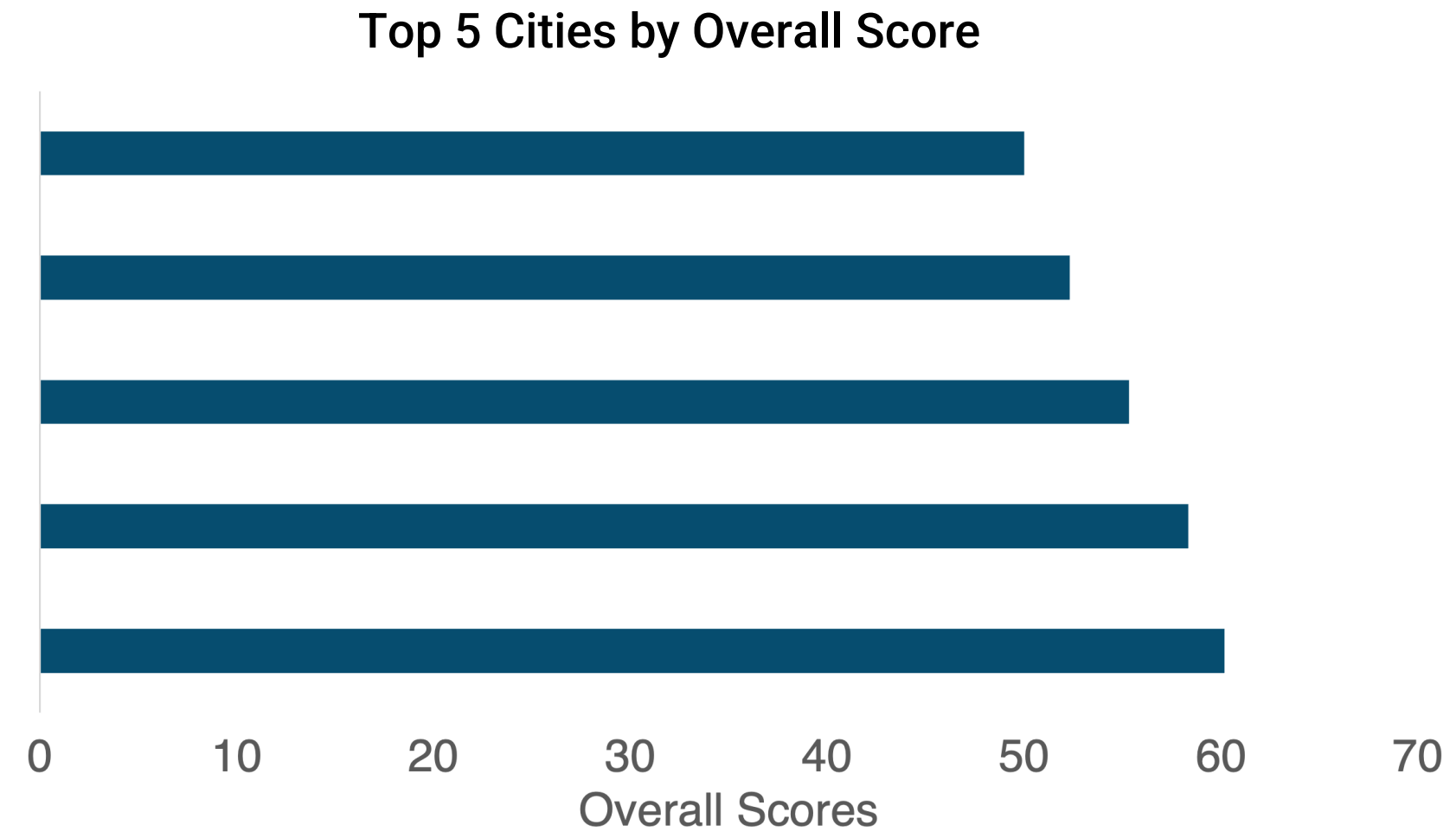
Example city: Osaka

Data Group	Category	Value	Normalized Score
Geography and Demographics	Group Average		27.6
Cloud Infrastructure	Group Average		28.3
Data Centers	Group Average		31.8
Internet Exchanges	Group Average		18.0
Local Access	Group Average		36.3
Long-Distance Transport	Group Average		13.7
Power	Group Average		30.8
Pricing	Group Average		85.3
Regulations and Governance	Group Average		84.4
	Overall Score		**39.6**

Screenshot of full list: 600k data points

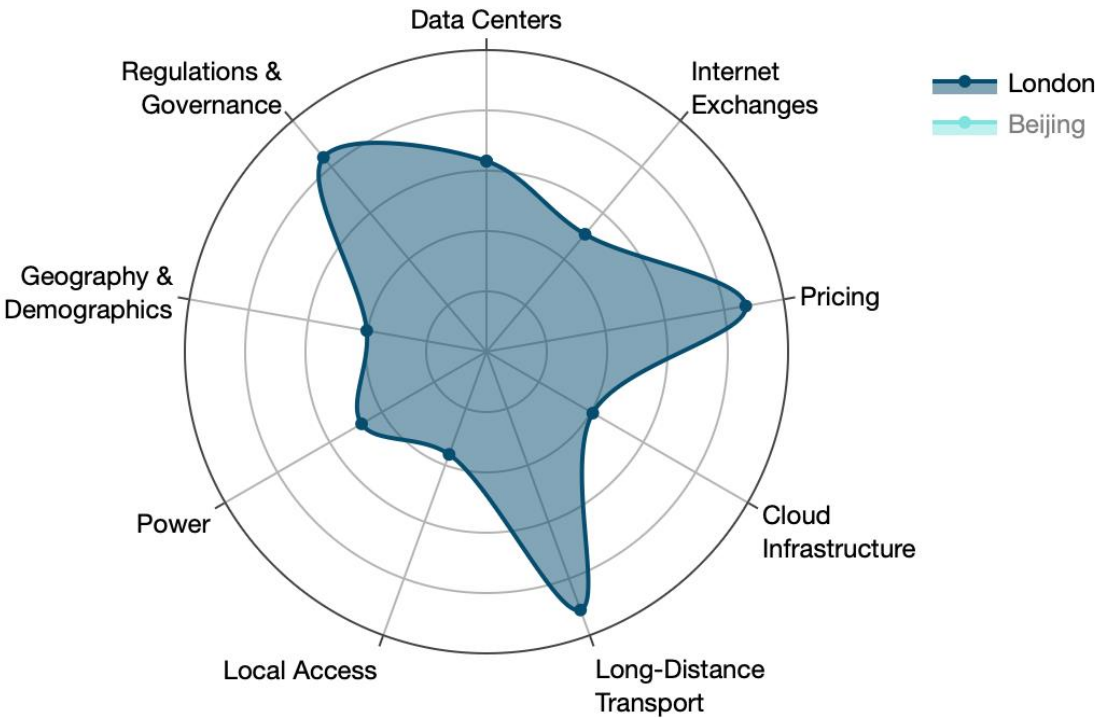


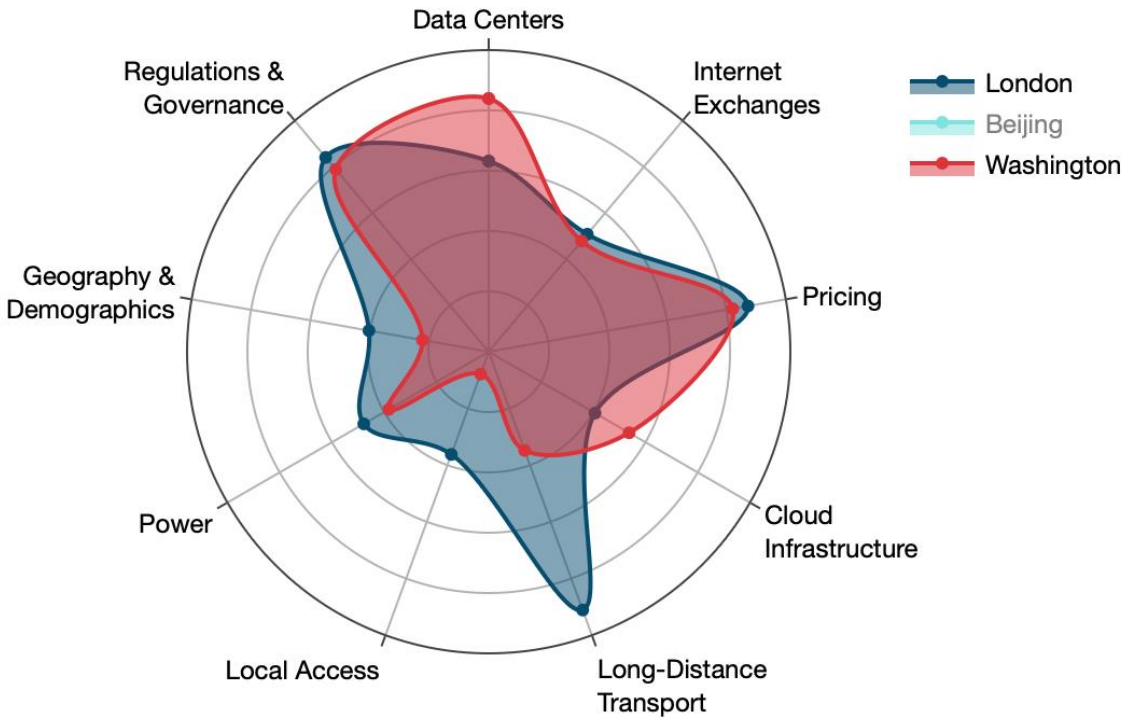
What are the highest-scoring hubs?



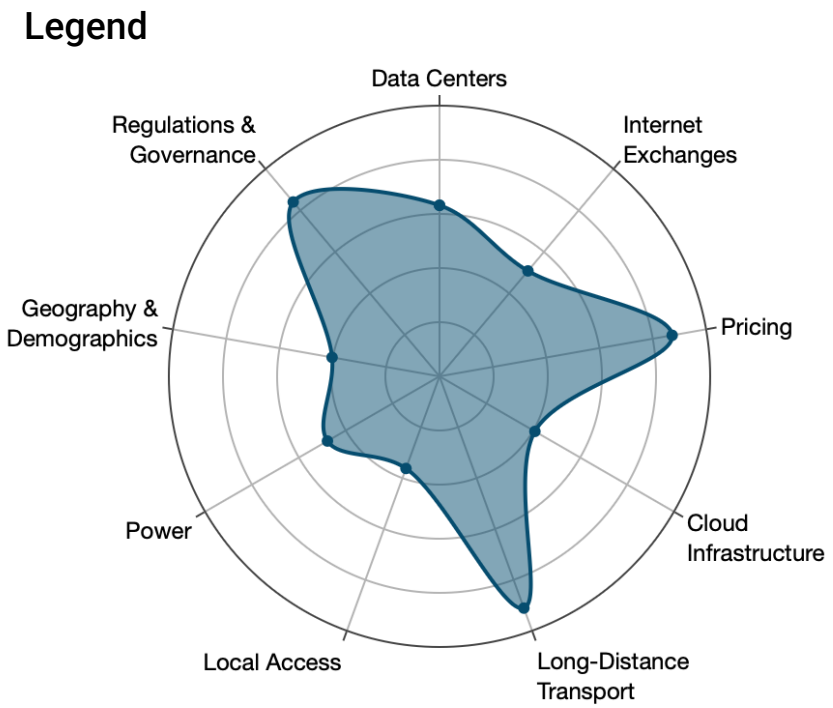
Overall quantity isn't all that matters

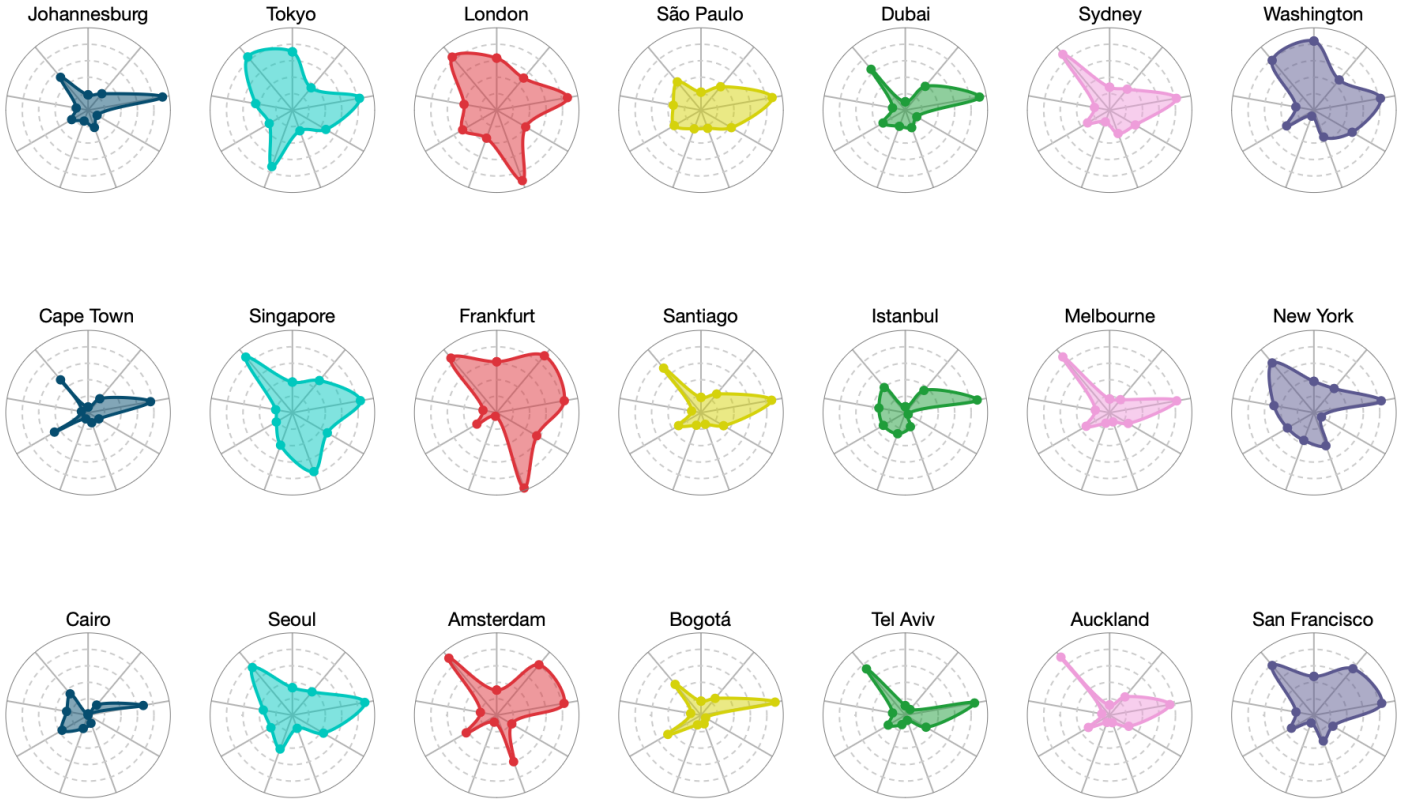
The "shape" of a city's interconnection assets matters too!





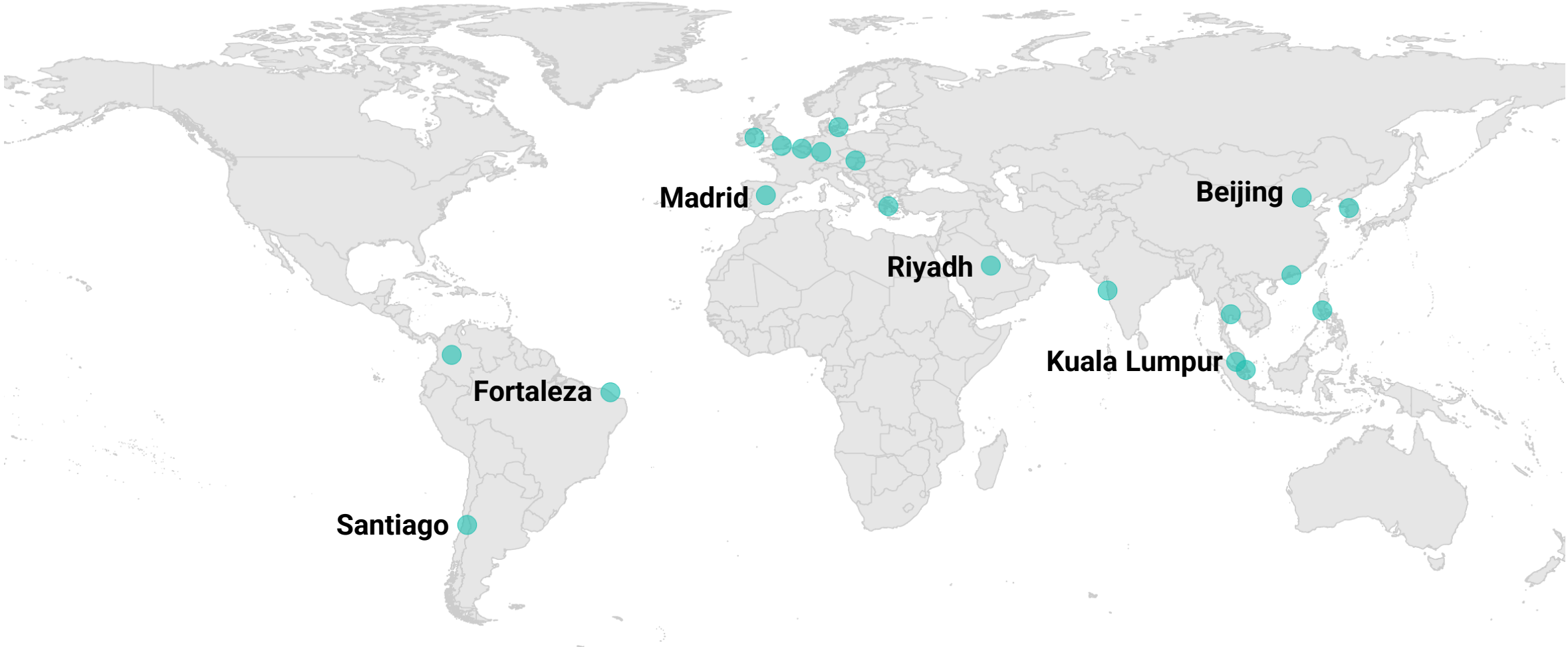
Top 3 hubs in each region





Biggest gainers in near term

Top 20 Cities with Fastest Expected Gains in Next Two Years



Laws matter

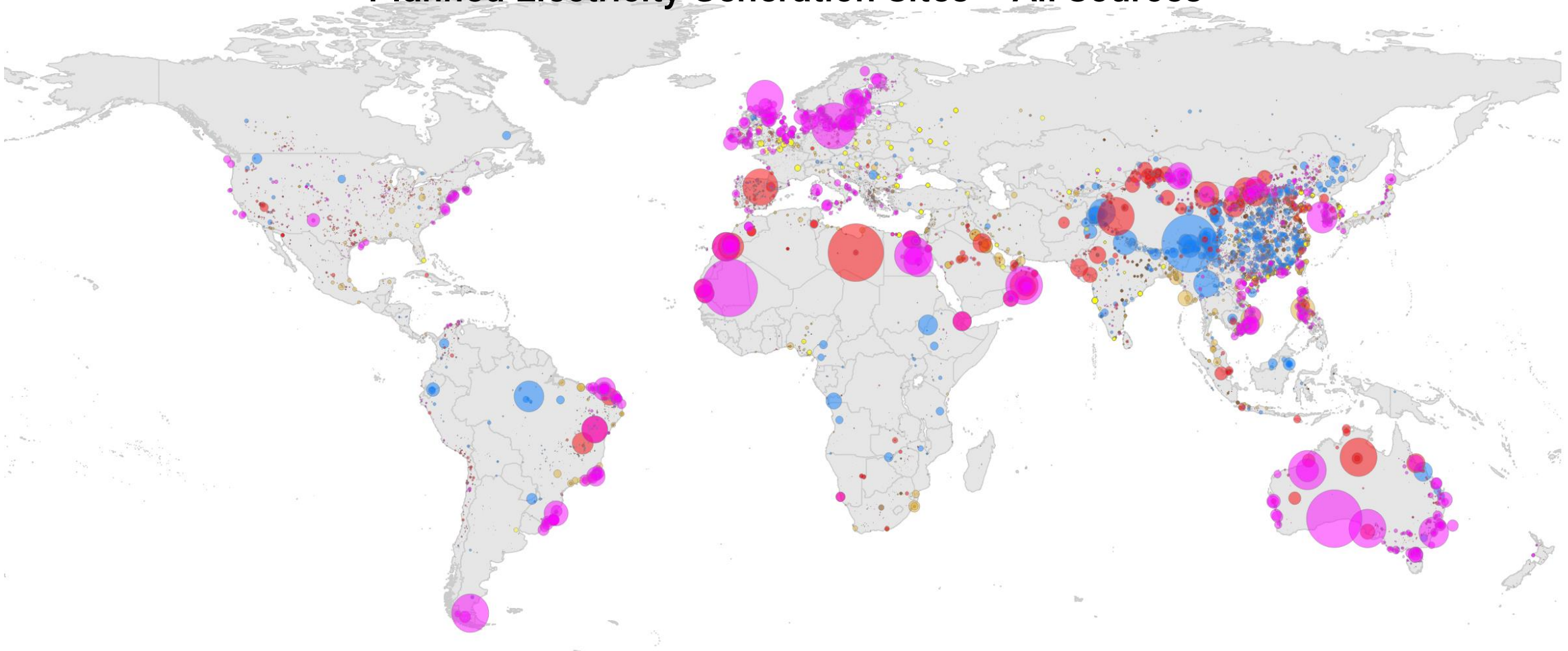
Governance Scores for Selected Asian Hubs

City	Control of Corruption	Government Effectiveness	Regulatory Quality	Rule of Law	Voice and Accountability	Average
Tokyo	80	88	83	91	80	84
Singapore	93	100	100	96	52	88
Seoul	61	82	77	81	76	76
Beijing	44	64	43	53	11	43
Jakarta	33	62	56	49	57	52
Kuala Lumpur	49	75	66	67	53	62
Bangkok	33	56	56	55	37	47
Manila	31	54	53	42	52	46
Darwin	85	86	93	89	88	88

Underlying data source: Daniel Kaufmann and Aart Kraay (2023). Worldwide Governance Indicators, 2023 Update (www.govindicators.org),

Let’s talk electricity

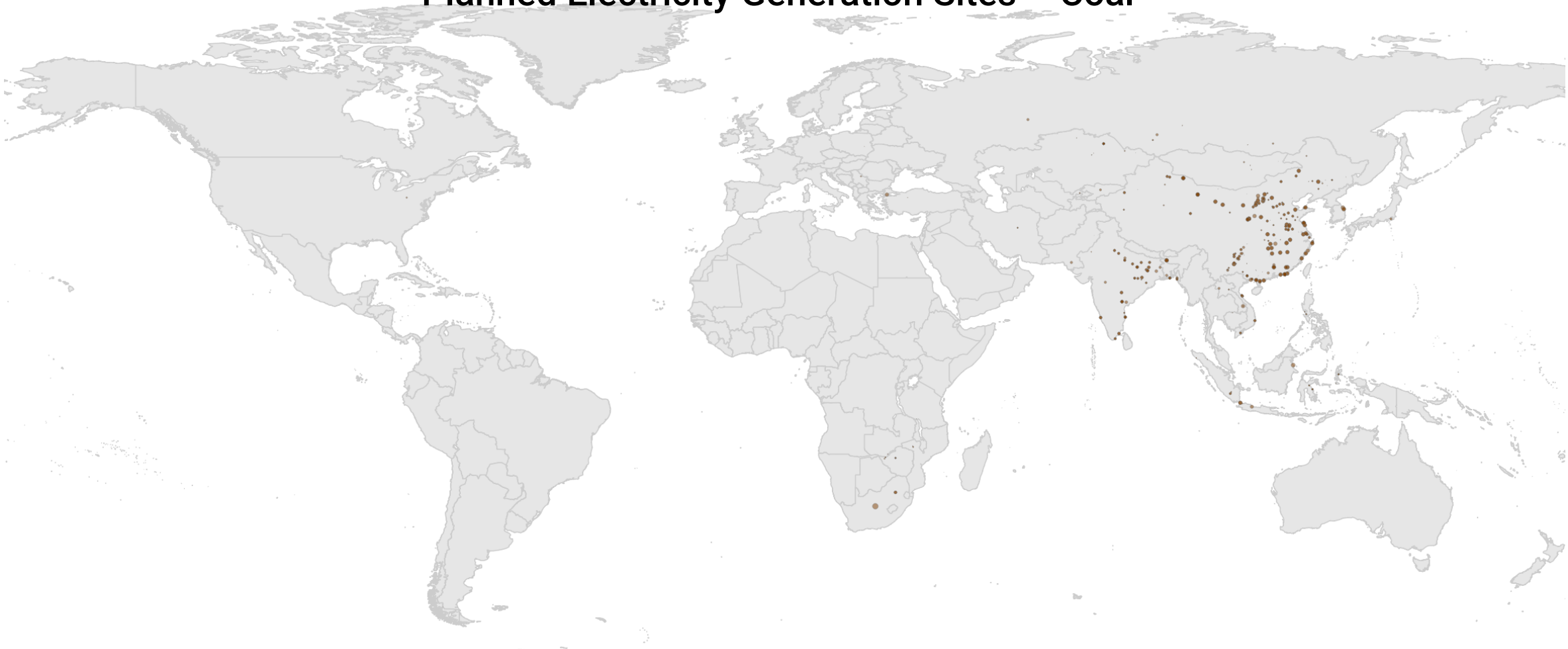
Planned Electricity Generation Sites – All Sources



Underlying data source: Global Energy Monitor (https://globalenergymonitor.org/)

Can you guess the source of power?

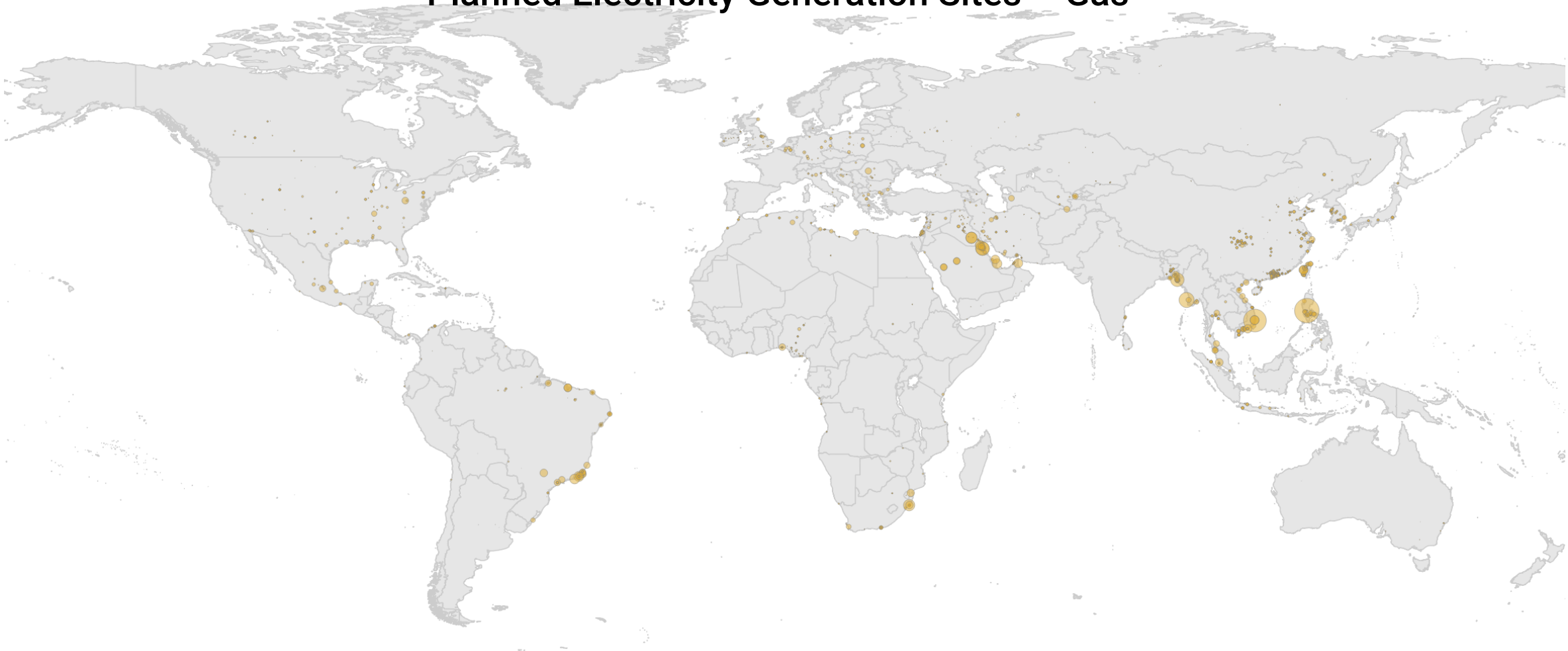
Planned Electricity Generation Sites – Coal



Underlying data source: Global Energy Monitor (https://globalenergymonitor.org/)

Can you guess the source of power?

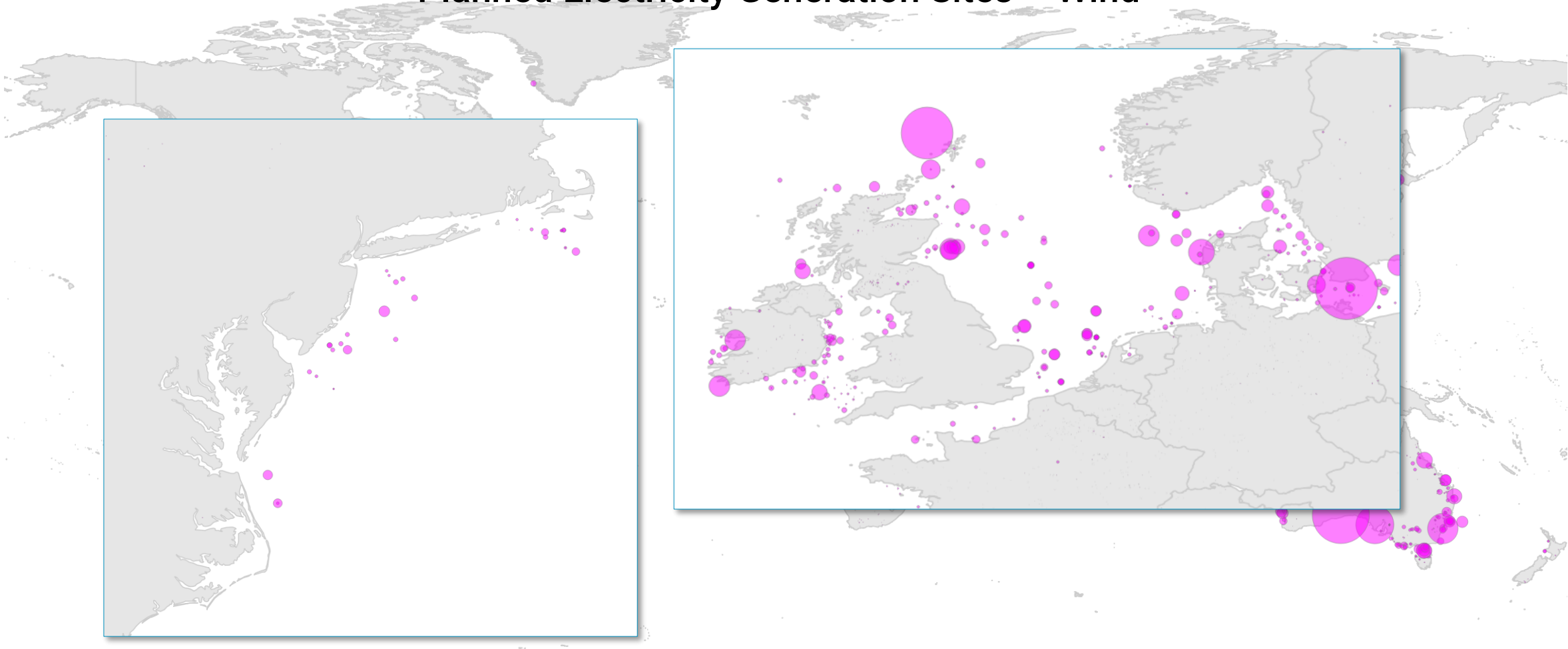
Planned Electricity Generation Sites – Gas



Underlying data source: Global Energy Monitor (https://globalenergymonitor.org/)

Can you guess the source of power?

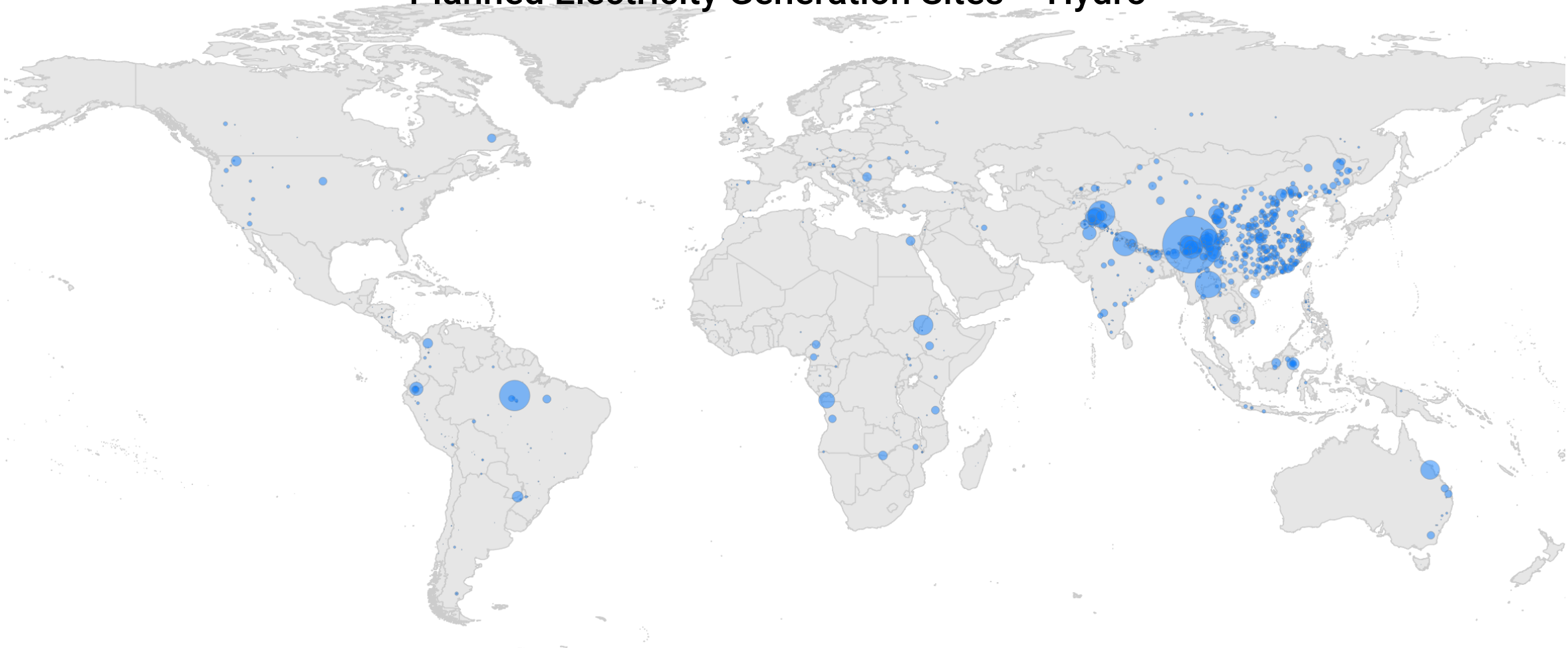
Planned Electricity Generation Sites – Wind



Underlying data source: Global Energy Monitor (https://globalenergymonitor.org/)

Can you guess the source of power?

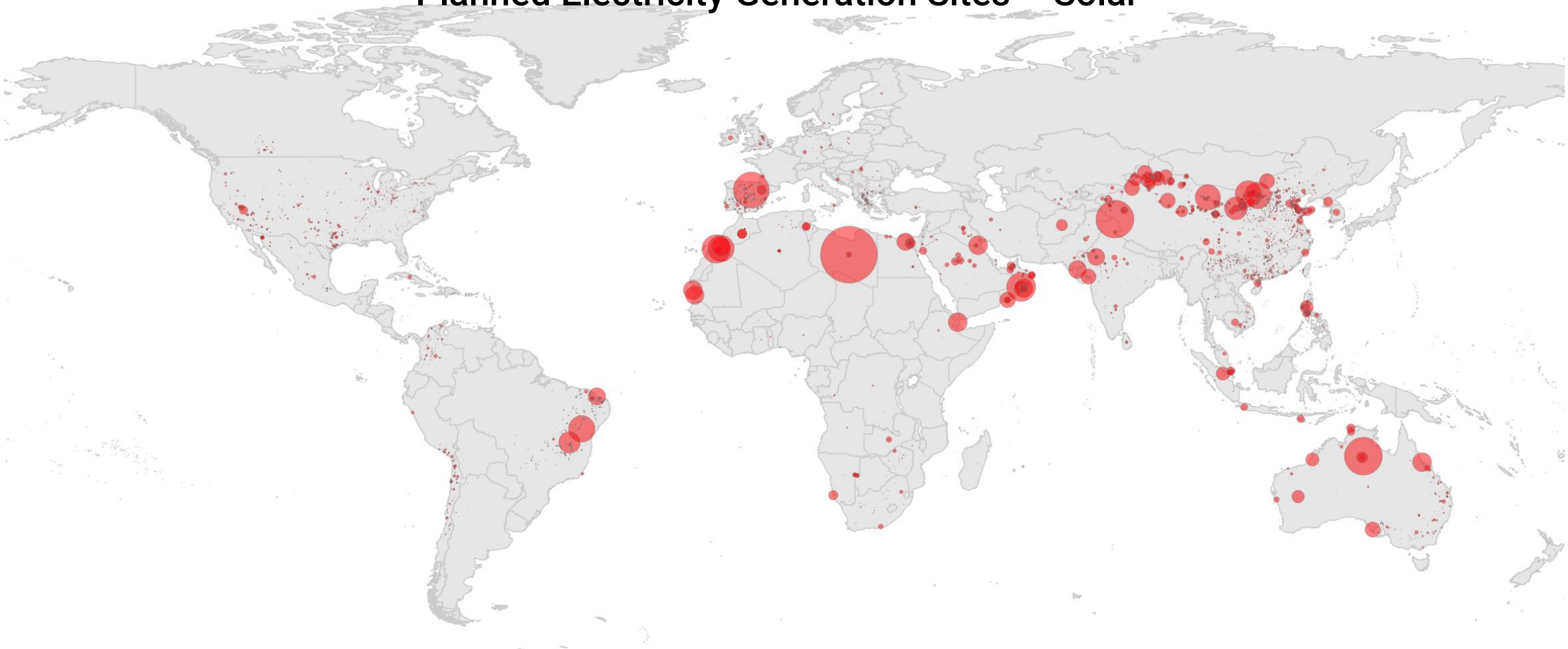
Planned Electricity Generation Sites – Hydro



Underlying data source: Global Energy Monitor (https://globalenergymonitor.org/)

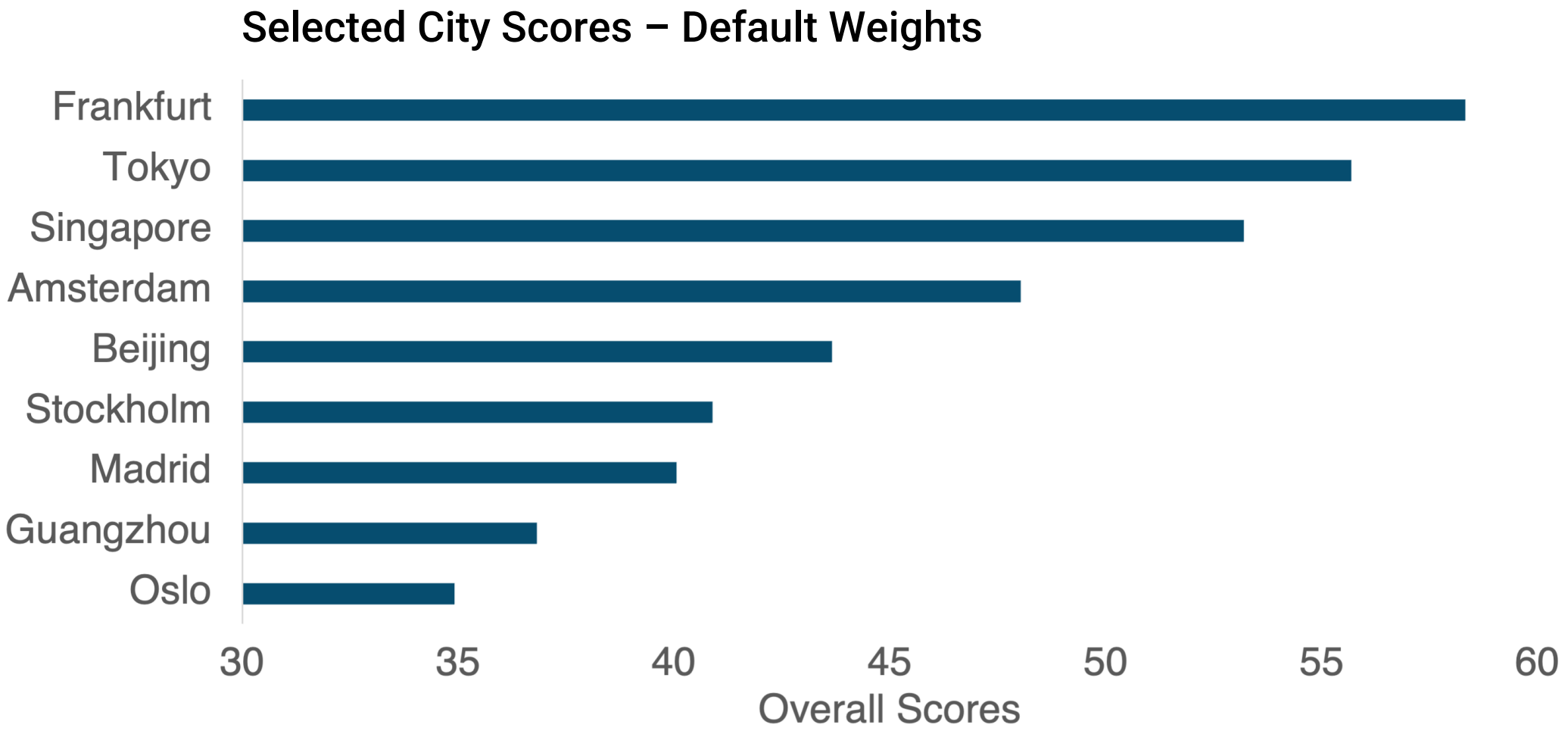
Can you guess the source of power?

Planned Electricity Generation Sites – Solar

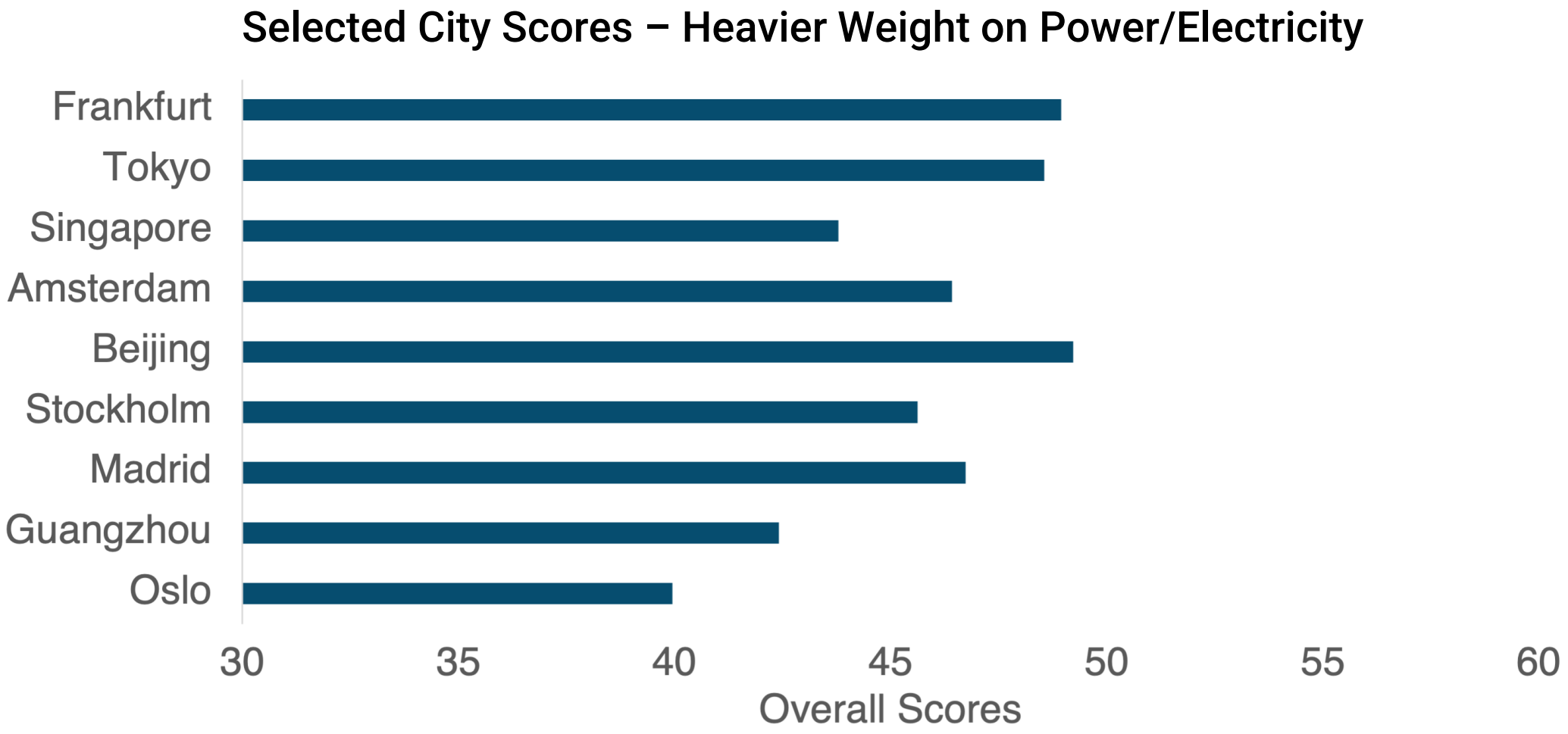


Underlying data source: Global Energy Monitor (https://globalenergymonitor.org/)

The importance of weighting



The importance of weighting



Final thoughts

- All the stuff you've just seen is subject to change
- We need your help!
  - What data sets are important to you?
  - What weights should we assign?

Sources

- Telecom and demographic:
  - https://www2.telegeography.com/data-center-research-service
  - TeleGeography proprietary datasets
- Power:
  - https://globalenergymonitor.org
  - Global Energy Monitor
- Governance:
  - https://www.govindicators.org
  - Daniel Kaufmann and Aart Kraay (2023). Worldwide Governance Indicators.

TeleGeography

The Data Center Market Blazes a New Trail

Jon Hjembo

PTC

21 January 2024

Themes we'll investigate

Exploring the APAC frontier

Is power the new gold?

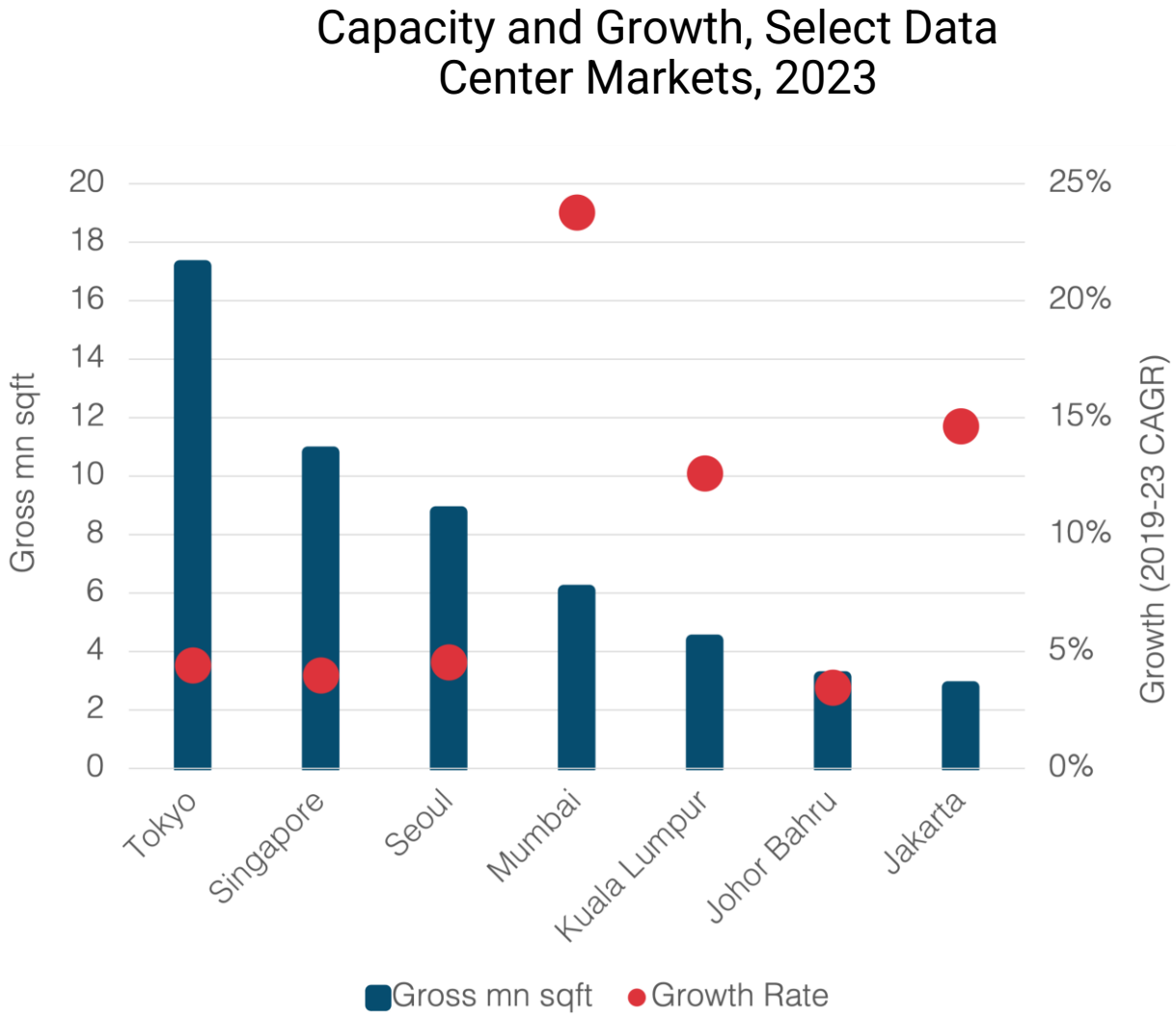
Coping with high costs

Exploring the APAC frontier

Source: National Geographic. "Admiral Zheng He, surrounded by the "treasure ships"" by Hong Nian Zhang

The market has already ventured forth

- Singapore: few sites have opened since moratorium began
- Mumbai: among the 20 largest global markets, Mumbai's growing the fastest
- Kuala Lumpur and Jakarta already experiencing rapid growth that will only gain momentum



And continues to develop new markets

Singapore: Pipeline limited to license winners + SingTel

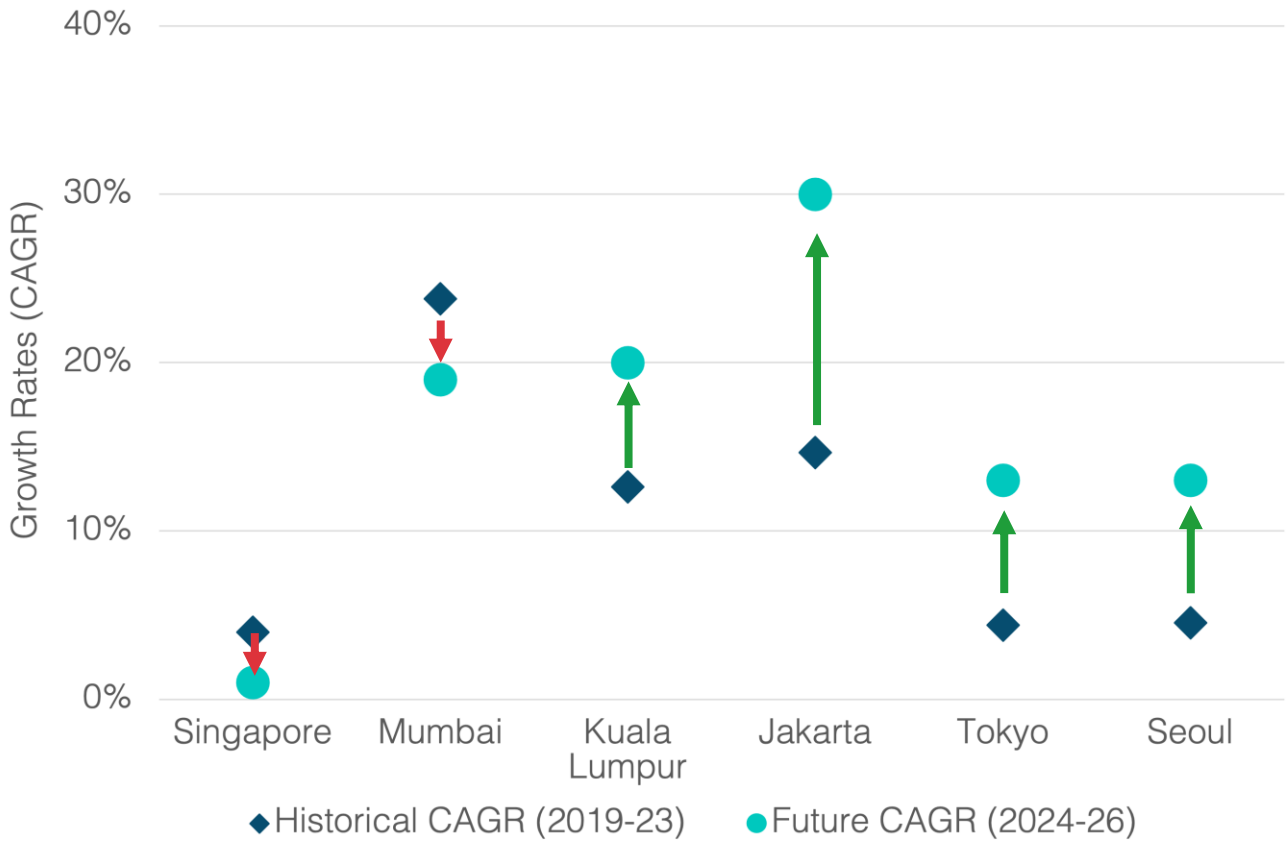
India 3rd only to U.S. and China globally for number of new projects

Chinese and U.S.-based operators converging in **Malaysia**

International providers snapping up land in **Malaysia** and **Indonesia**

Lots of global operators building into **Japan** and **Korea**

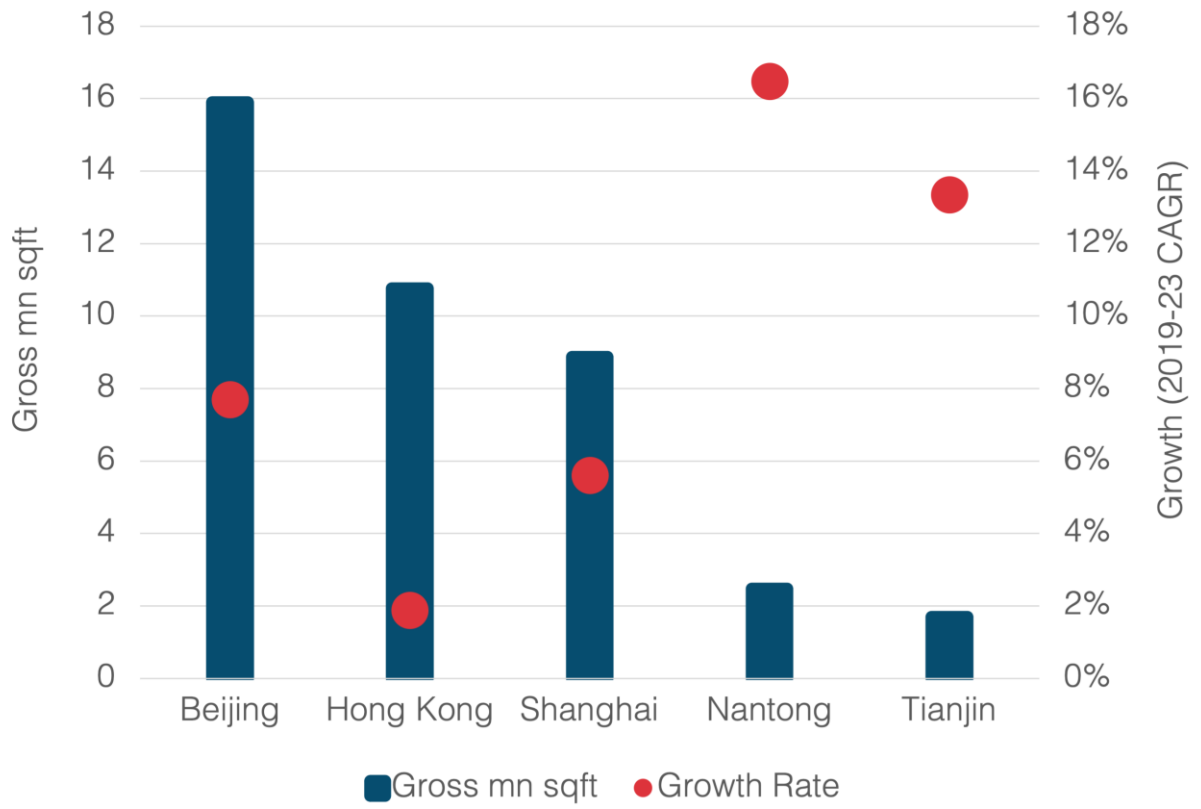
Changes in Growth,
Gross Data Center Capacity, Select Markets



Chinese development pushes inland

- Very slow growth for Hong Kong
- Strong growth in Yangtze River Delta and capital region
- Focus has moved to the mainland and will continue to do so

Capacity and Growth, Select Data Center Markets, 2023



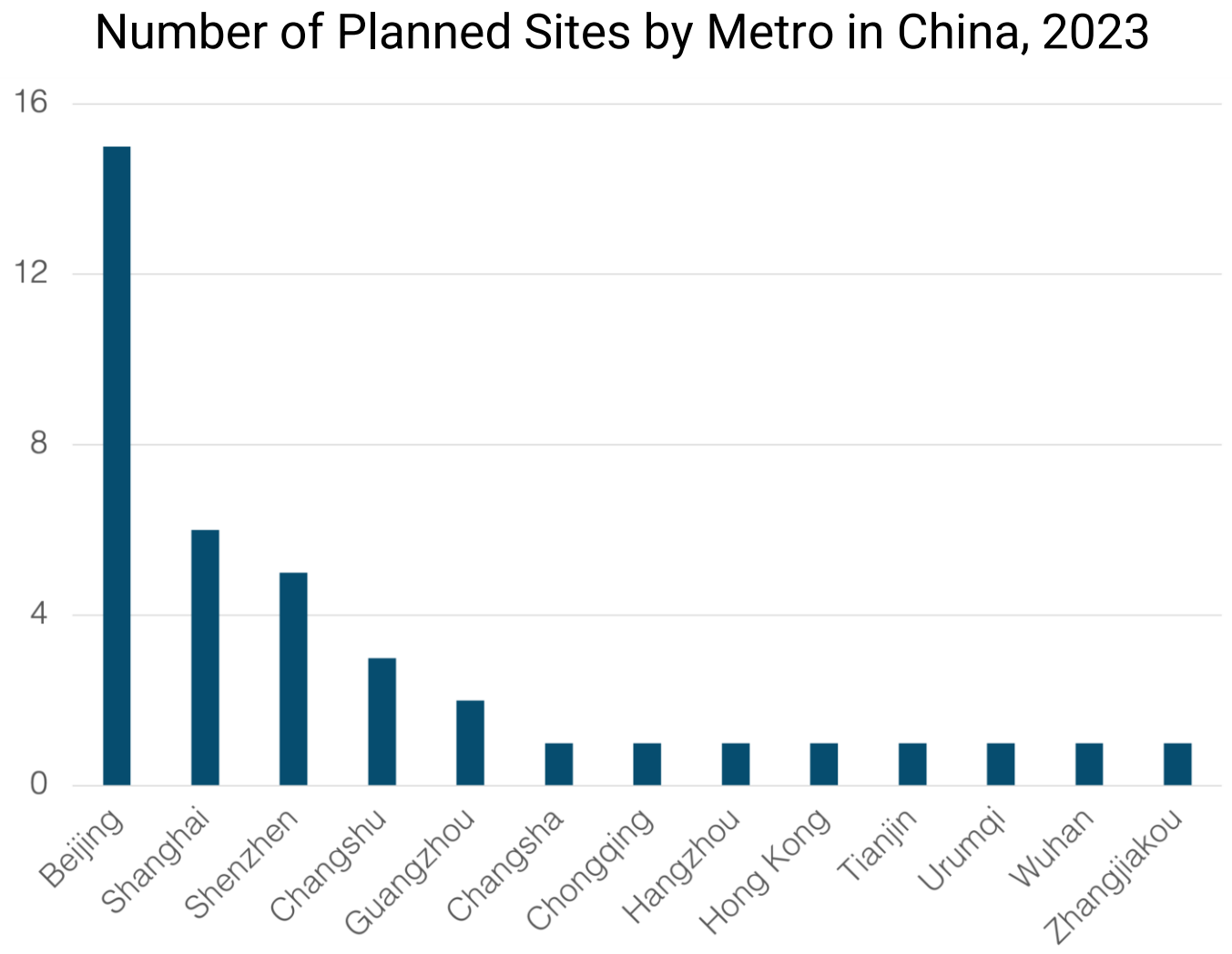
Chinese development pushes inland

Chinese policy: “Eastern Data, Western Compute”

- Eastern Data: low-latency applications for large population centers
- Western Compute: data storage in areas with more abundant power

Significant pipeline development:

- North – Beijing
- Yangtze Delta – Shanghai
- Greater Bay Area – Shenzhen, Guangzhou
  - Hong Kong? Not so much

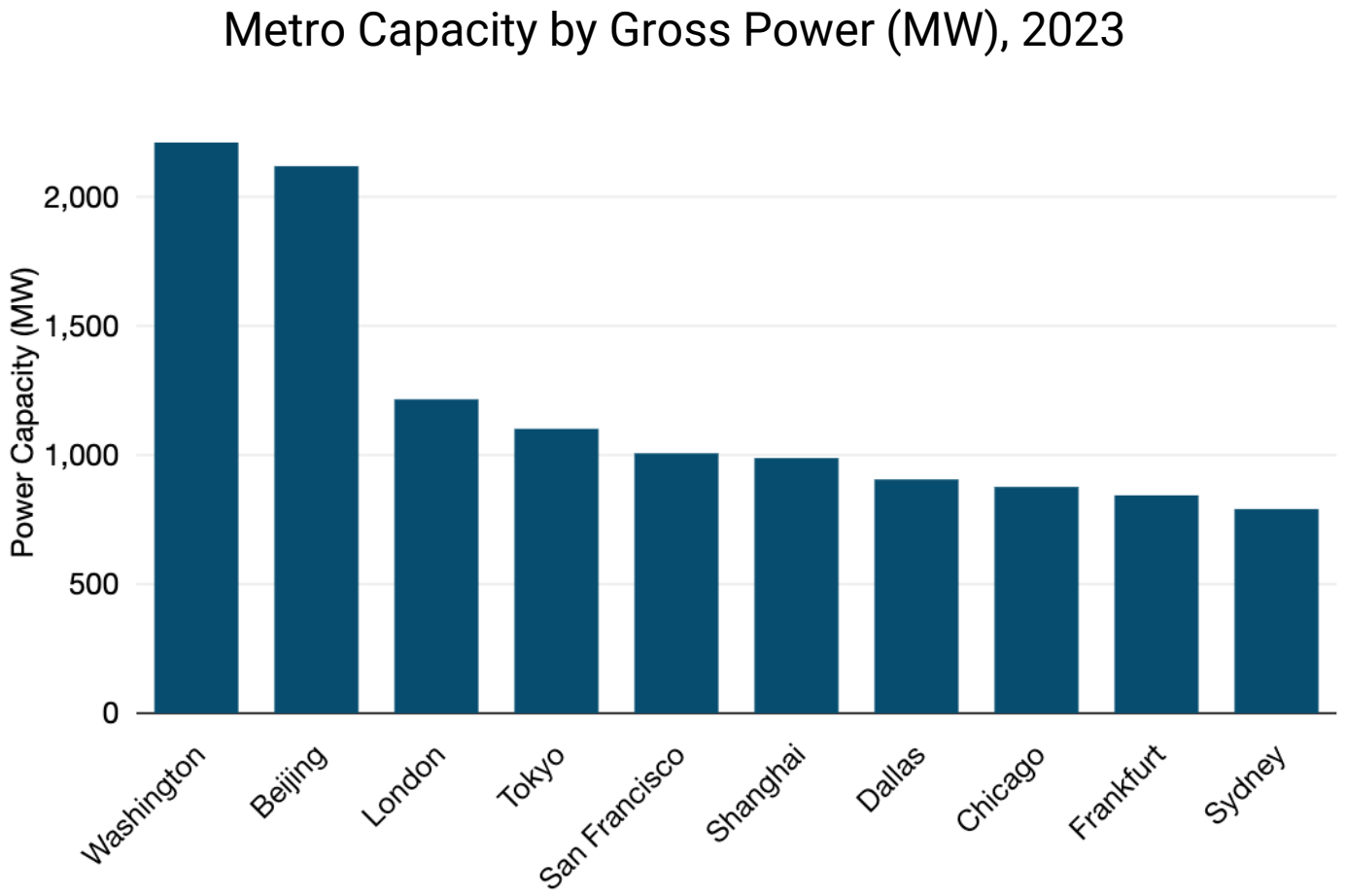


Is ~~data~~ power the new gold?

How much power do data centers use?

Commercial operators in these ten data center markets consume about 12 gigawatts (GW) of power

- That's roughly the same amount of power used by 9 million homes…for about 1,000 data centers



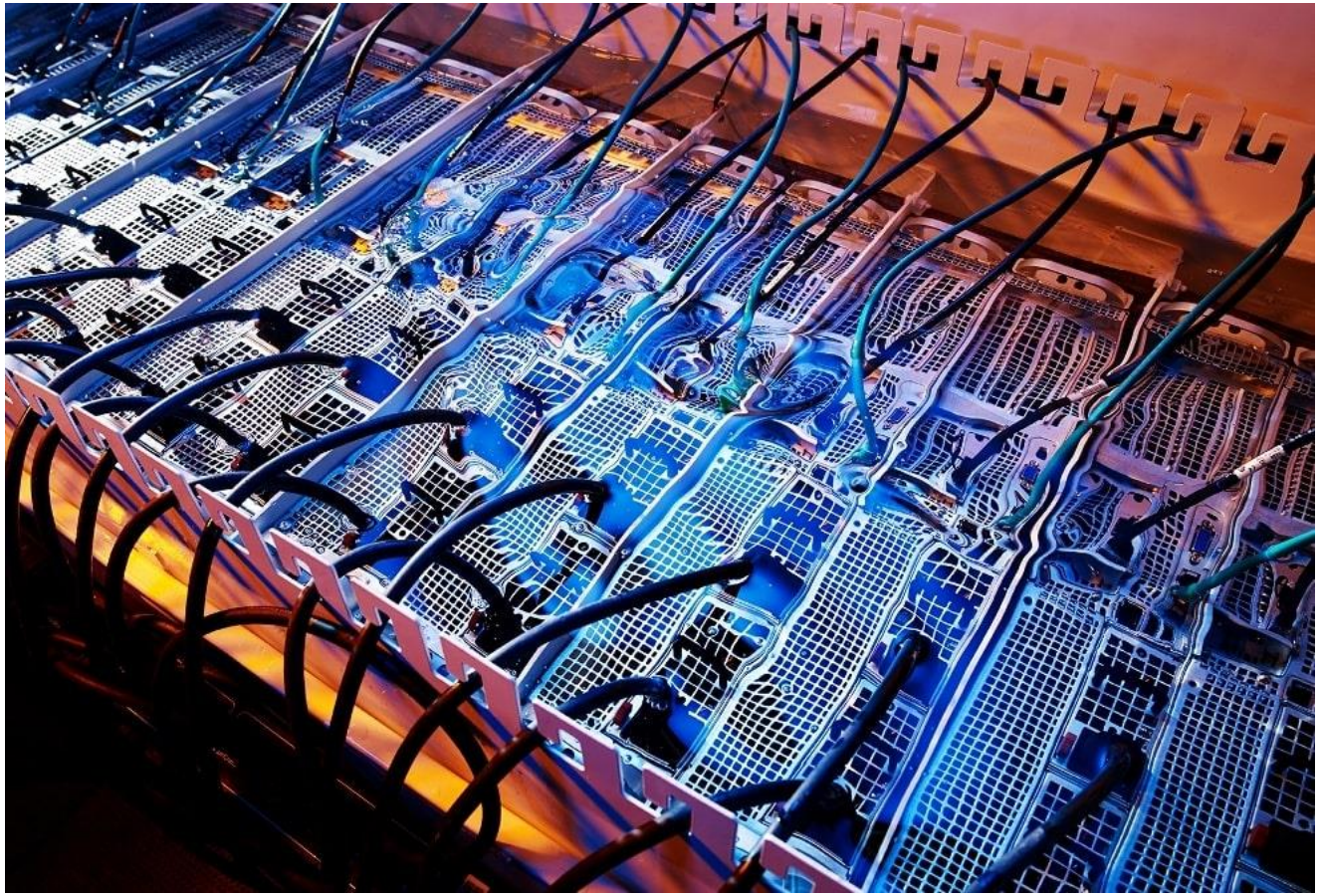
Scarcity is already an issue

- Singapore: limited pool of licenses
- Netherlands: zoning laws effectively ban hyperscale
- Germany: Federal Energy Efficiency Act adds restrictions
- Dublin: operators must provision own energy generation, but projects still may not be approved
- UK: Ofgem urgently cleaning up power connection queue
- Dominion in NoVA is out of transmission capacity

AI will only make this situation tougher

Amount of power needed is staggering

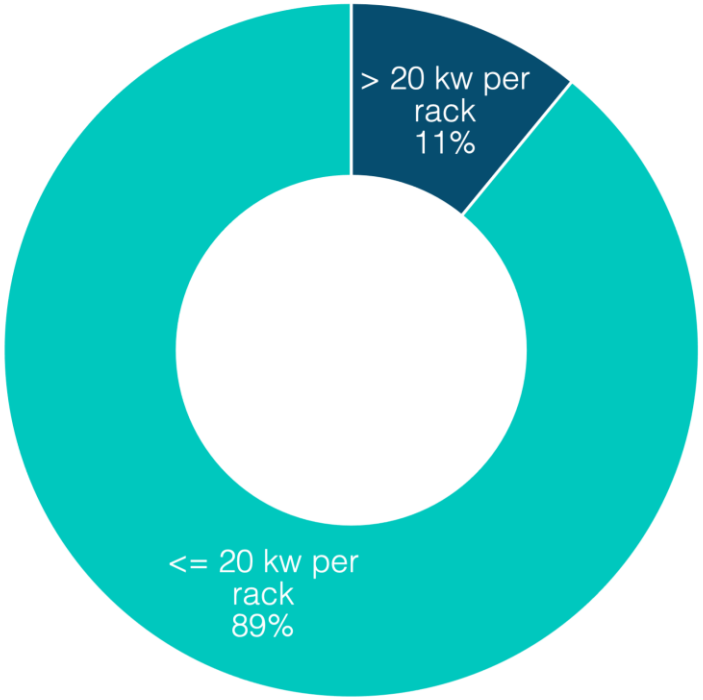
- Estimates that AI data centers will require 2-5x capacity of other cloud data centers
- Latest gen of individual Nvidia GPU chips can use as much or more power than entire cloud servers.
- H100 and H200 Tensor Core GPUs tout up to 700W max thermal design power



Most sites can’t handle the density needed

- Nvidia GPUs use about 6.5-11 kW per 6U box.
  - So about 45-80 kW per 42U rack
- Vast majority of sites can’t support even 20 kW/rack

Supportable Colocation Rack Density, Share of Sites Globally (kW/rack), 2023



How far can we go in searching for power?

- Will data centers be constrained by location in their hunt for power?
  - Training - perhaps less constrained
    - Could open opportunities to deploy to less crowded, more cost-effective locations with more abundant power
  - Inference – more constrained due to latency requirements
    - Compounds demand for capacity in already congested locations

Source: Bulk Infrastructure

Adapting to the situation

Strong utility partnerships and creative power solutions will be key

- Location: Proximity to utility providers for access to generation
  - AWS in Louisa County, VA with Rappahannock Cooperative near nuclear plant
  - Digital Realty procuring hydropower from Süwag near Hattersheim campus (FRA)
- Conversion: Site-based mini generator solutions to convert gas power to electricity
  - Expensive but plausible
- Making use of waste heat: Heat transfer for resourceful use of power
  - Germany: will be increasingly mandated to transfer waste heat.
  - Telehouse to share in FRA via the Mainova district heating network

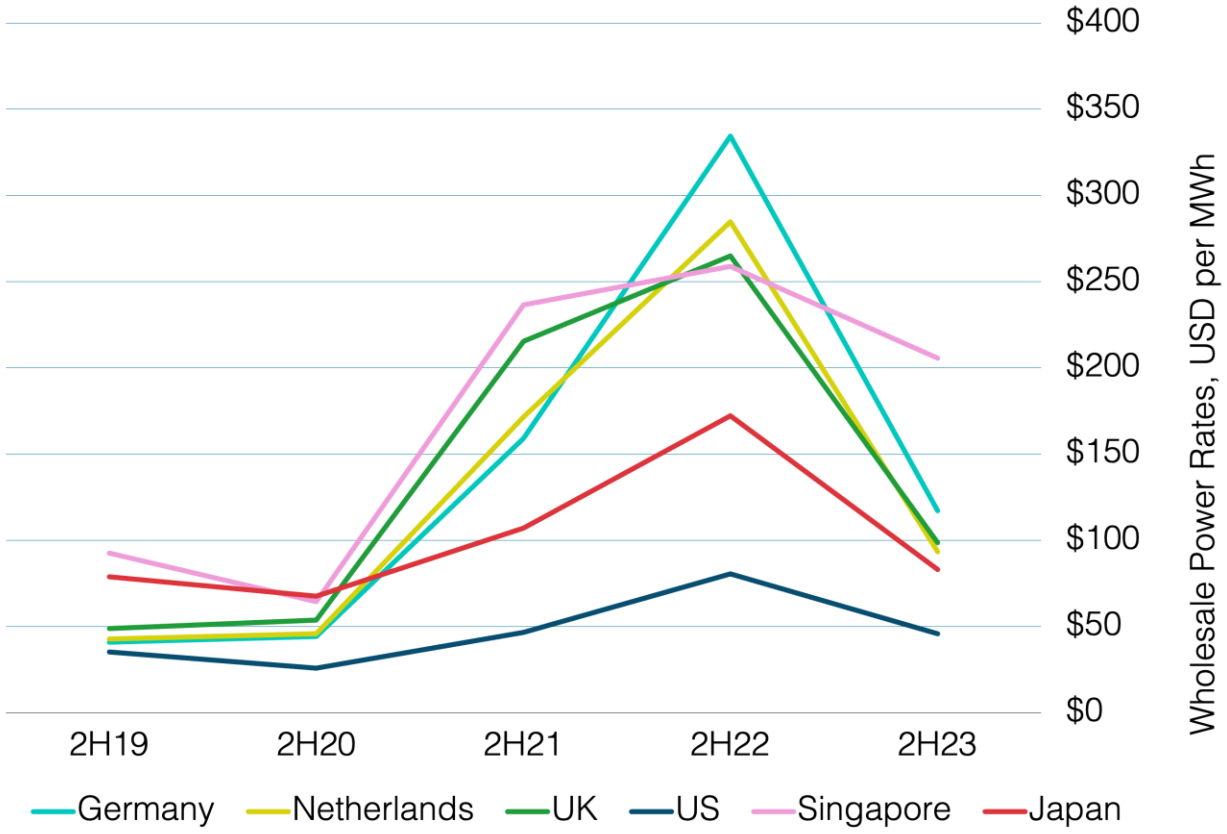
Coping with High Costs

Some tech workers fleeing San Francisco for Austin

Energy prices have dropped, but still sit higher than before

- Prices have generally fallen since 2020-2022 surge but sit historically higher than before 2020
- European rates down more than 60% Y-o-Y but still more than double what they had been
- Singapore sits 2x higher than Eur rates
- Rise and fall relatively moderate in U.S.

IEA Wholesale Electricity Rates, 2H19-2H23



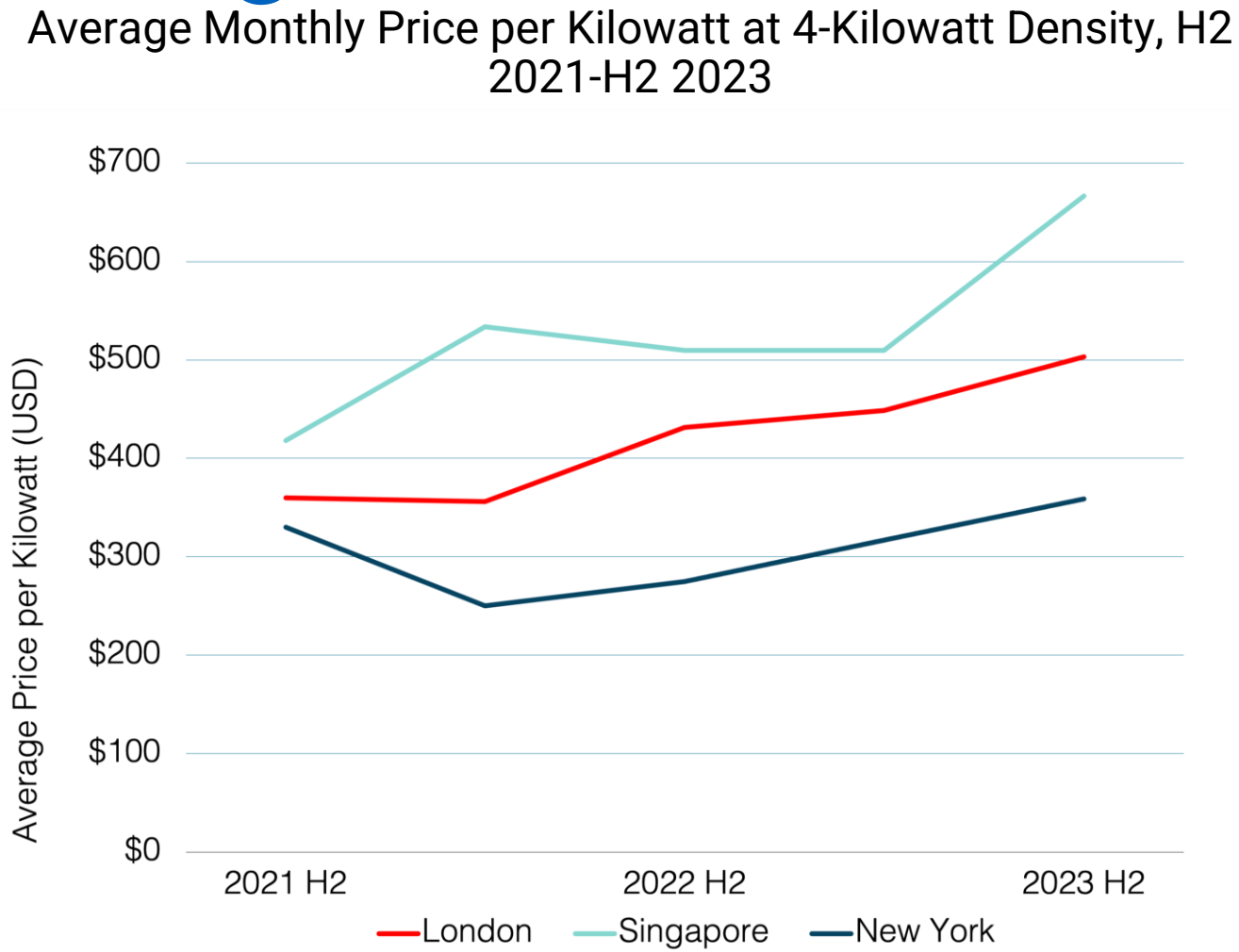
Source: IEA Real-Time Electricity Tracker

Do colocation prices rise with utility rates? It's complicated

- Long-term contracts and lag effect
- Pass-through vs. rolling increases
- Hiding inflationary costs elsewhere– cross connects, base colocation rate, etc
- Government subsidization

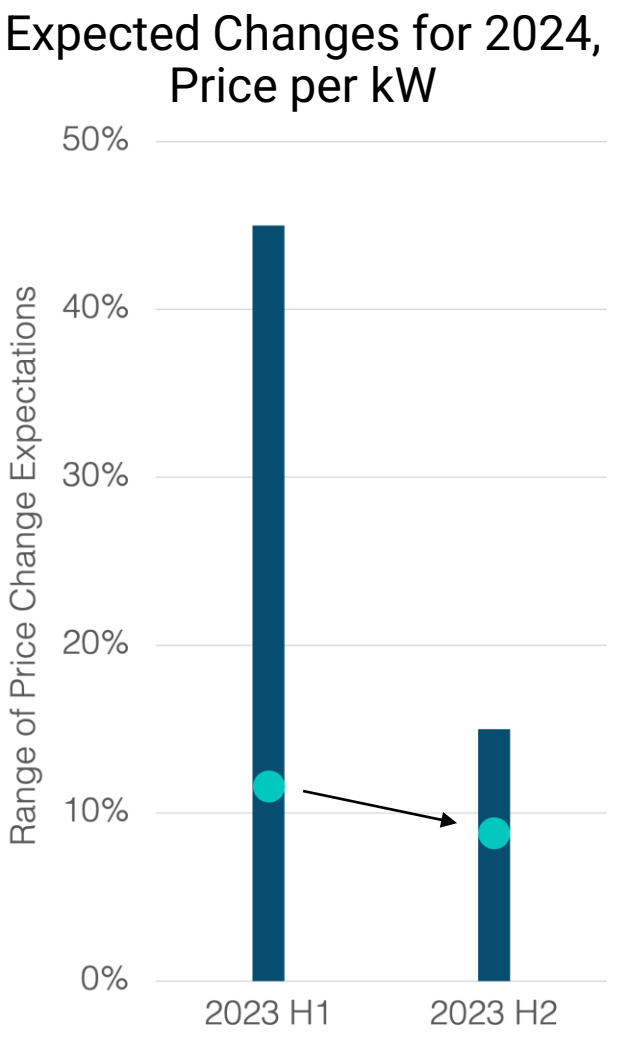
Colocation prices are higher too

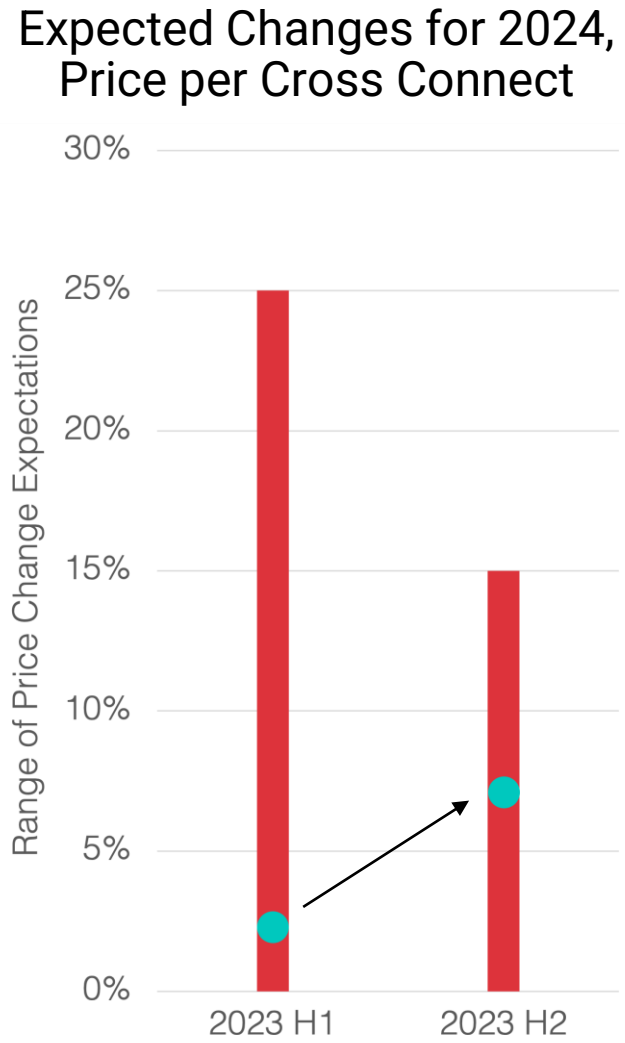
- European rates rose about 40% between 2H21 and 1H23 and have leveled off
- Asian hub rates continue to climb north of $500/kW (driven by Singapore)
- U.S. has lagged at more competitive level due to localized competitive pressure



Will rates continue to rise?

- Still inflationary expectation but outliers are much less extreme
- Average expectation for price inflation per kW slightly slower than H1
- Average expectation for higher cross-connect rates has risen. Think lag effect and hidden cost





Note: Columns represent high to low reported expectations of change, and light blue circles represent average.

The takeaways?

- As Singapore's growth is curtailed, there's a concerted push into other subregional markets:
  - South Asia – **India**
  - Southeast Asia – **Malaysia**
  - North Asia - **Japan**
- And as new infrastructure investment in Hong Kong diminishes, China's focus moves further into the mainland

- Commercialized generative AI compounds difficulties in sourcing power

- Inflation is slowing, but rates in many markets are settling at higher levels

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https://www2.telegeography.com/ptc-2024

Thank You

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