Energy Proportionality

Sustain RG, IETF 122

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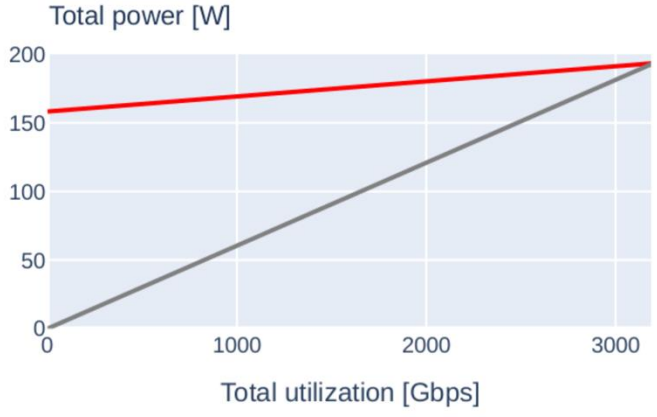
Background

- In the IETF, there seems to be a view that networking does not need to care about load
  - That networks do not have energy proportionality
  - Any Watt/GB are nonsense

- Well, maybe it is nonsense, maybe not…

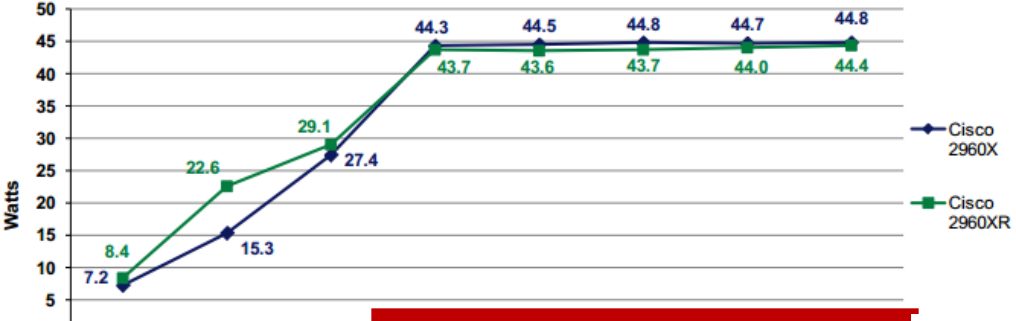
Network equipment not energy proportional

Network switch WEDGE 100BF-32X



2023: https://eng.ox.ac.uk/media/otfje1nf/romainjacob_daily_rate_adaptation_canw.pdf

Figure 2: Cisco Catalyst 2960-X and 2960-XR Power Profile
Layer 2 Traffic with 1518-Byte Frame Size



	Hibernation mode	Initial boot	Idle without link	Idle with link	10%	30%	70%	100%
Cisco 2960X	7.2	15.3	27.4	44.3	44.5	44.8	44.7	44.8
Cisco 2960XR	8.4	22.6	29.1	43.7	43.6	43.7	44	44.4

Source: Miercom, November 2013

Table 15. Power Consumptions of Standalone Cisco Catalyst 3750-X and 3560-X Series

Models	Uplink Module	Power Consumption, W			
		0% Traffic	10% Traffic	100% Traffic	Weighted Average
3750X-24T & 3560X-24T	C3KX-NM-1G	93.6	92.8	93.5	93.0
3750X-24P & 3560X-24P		99.4	98.7	99.3	98.9

Cisco data

Table 17. Power consumption of Standalone Catalyst 9200 Series switches

				Measured P(W)										
				Half port traffic					Full port traffic					Weighted average Pw
SKU	FEP	Uplink	Input	0.01% / EEE	10%	30%	50%	100%	0.01% / EEE	10%	30%	50%	100%	
C9200-24T	125W (C5/C6)	C9200-NM-4X1G	115VAC	33.09	36.08	36.15	36.20	36.34	35.51	41.78	41.89	42.00	42.27	41.20
			230VAC	33.15	35.95	36.00	36.06	36.19	35.36	41.50	41.62	41.74	42.01	40.94
C9200-24T	125W	C9200-NM-4X10G	115VAC	33.62	36.99	37.29	37.58	38.26	35.41	42.00	42.55	43.11	44.49	41.588
			230VAC	33.70	36.85	37.13	37.41	38.10	35.40	41.75	42.30	42.85	44.22	41.364
C9200-24P	600W (C5/C6)	C9200-NM-4X1G	115VAC	43.57	47.37	47.42	47.47	47.68	46.82	53.79	53.91	54.02	54.30	53.14
			230VAC	43.38	46.92	46.95	47.03	47.18	46.35	53.23	53.34	53.45	53.76	52.59

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https://sg-repo-production-photos.s3.eu-central-1.amazonaws.com/aikido/cache/4968a18dca5bf8b60a58e94e59093f77.pdf

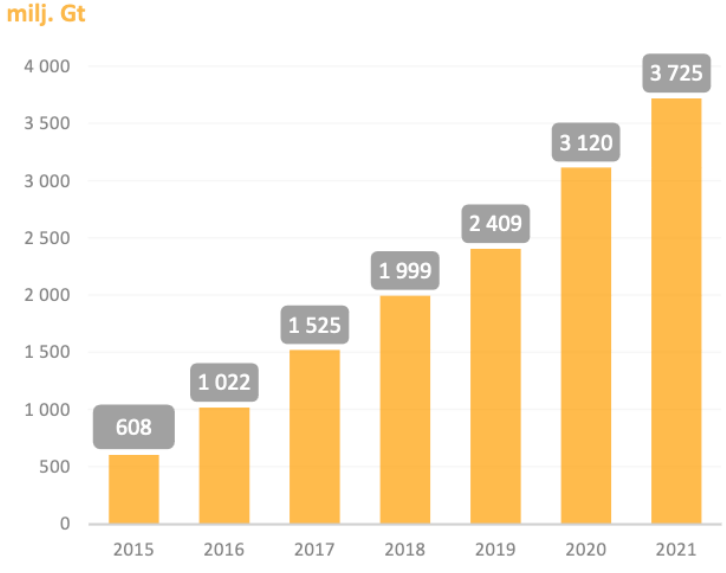
But cellular is different

- The most common access tech
- Many who travelled here looked at SIMs to buy
  - All talk about data volume (some limit top speeds)
- The radio network has finite capacity, and it fluctuates a lot
- Operators monitor and base their business on data volumes
  - Also energy consumption can be directly calculated
  - Even “unlimited” data plans are based on an expected volume, and there are no guarantees for the service

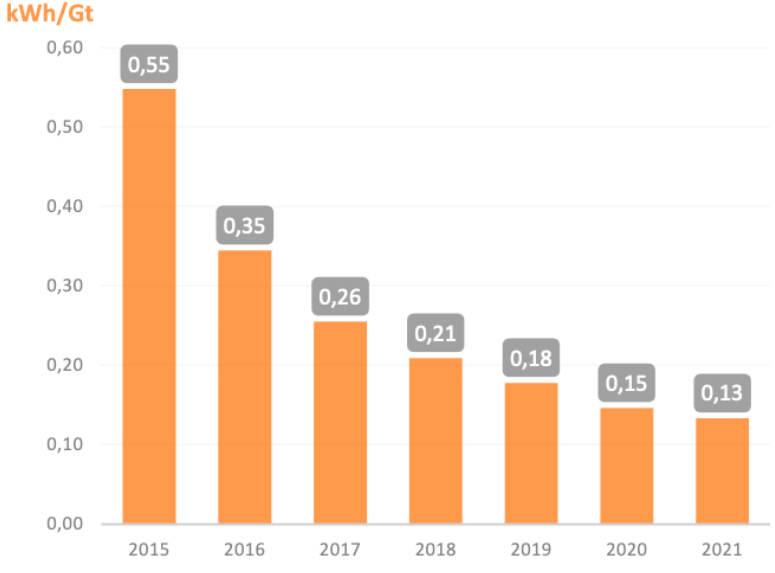
Electrical energy consumption of mobile data in Finland

MOBIILIDATAN SÄHKÖNKULUTUS

Mobiilidatan määrä kasvoi
yli kuusinkertaiseksi suomalaisten teleoperaattoreiden verkoissa vv. 2015–2021.

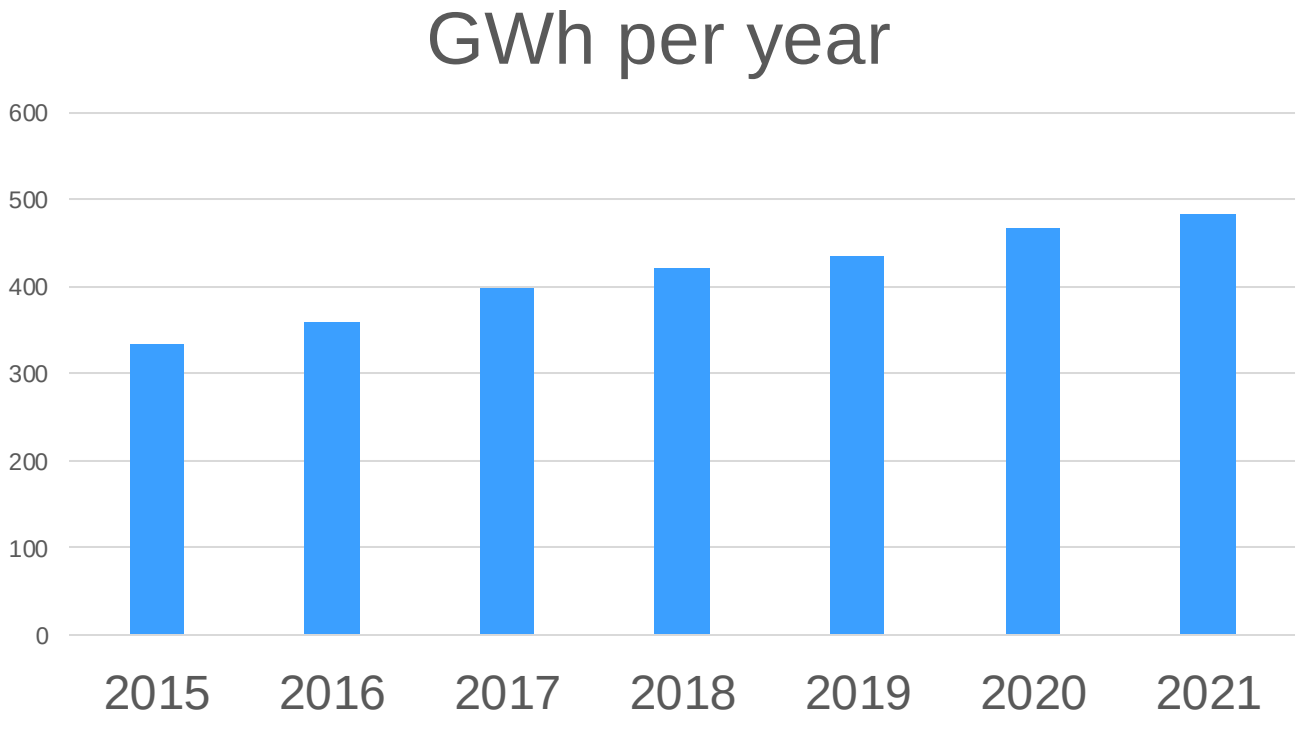


Energiatehokkuus parantui
ja datasiirron sähkönkulutus laski yli 75 % vv. 2015–2021.



FiCom

Energy needed to serve Finnish mobile users



+44% 2015 -> 2021

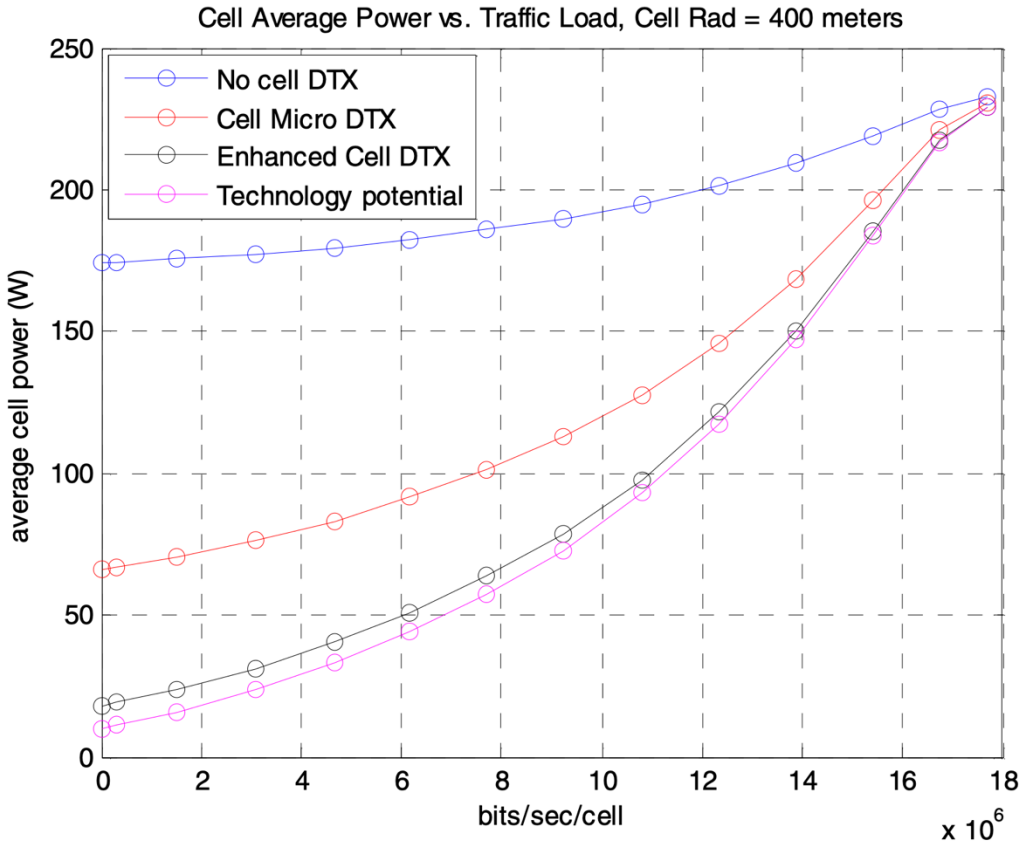
Urban cell towers in Helsinki

Saving energy in cellular networks

- GSMA: “Energy consumption constitutes between 20 – 40% of network OPEX”
- 5G has even increased the energy consumption
  - Operators have (idle) 5G hardware along the old 4G
- There are multiple methods to achieve this
  - All methods are a trade-off with service quality / peak throughput
- What is “good enough”
  - Is a decrease of peak throughput from 800 Mbps to 700 Mbps during low demand acceptable if it saves 200W per base station and megawatts network wide ?

Some solutions

- DTX: Discontinuous Transmission is a feature that allows switching off radio components when no transmission takes place
- The downside is increased latency since traffic is buffered to make transmission more energy efficient



P. Frenger, P. Moberg, J. Malmodin, Y. Jading and I. Godor, "Reducing Energy Consumption in LTE with Cell DTX," 2011 IEEE 73rd Vehicular Technology Conference (VTC Spring), Budapest, Hungary, 2011, pp. 1-5, doi: 10.1109/VETECS.2011.5956235.

MIMO Muting

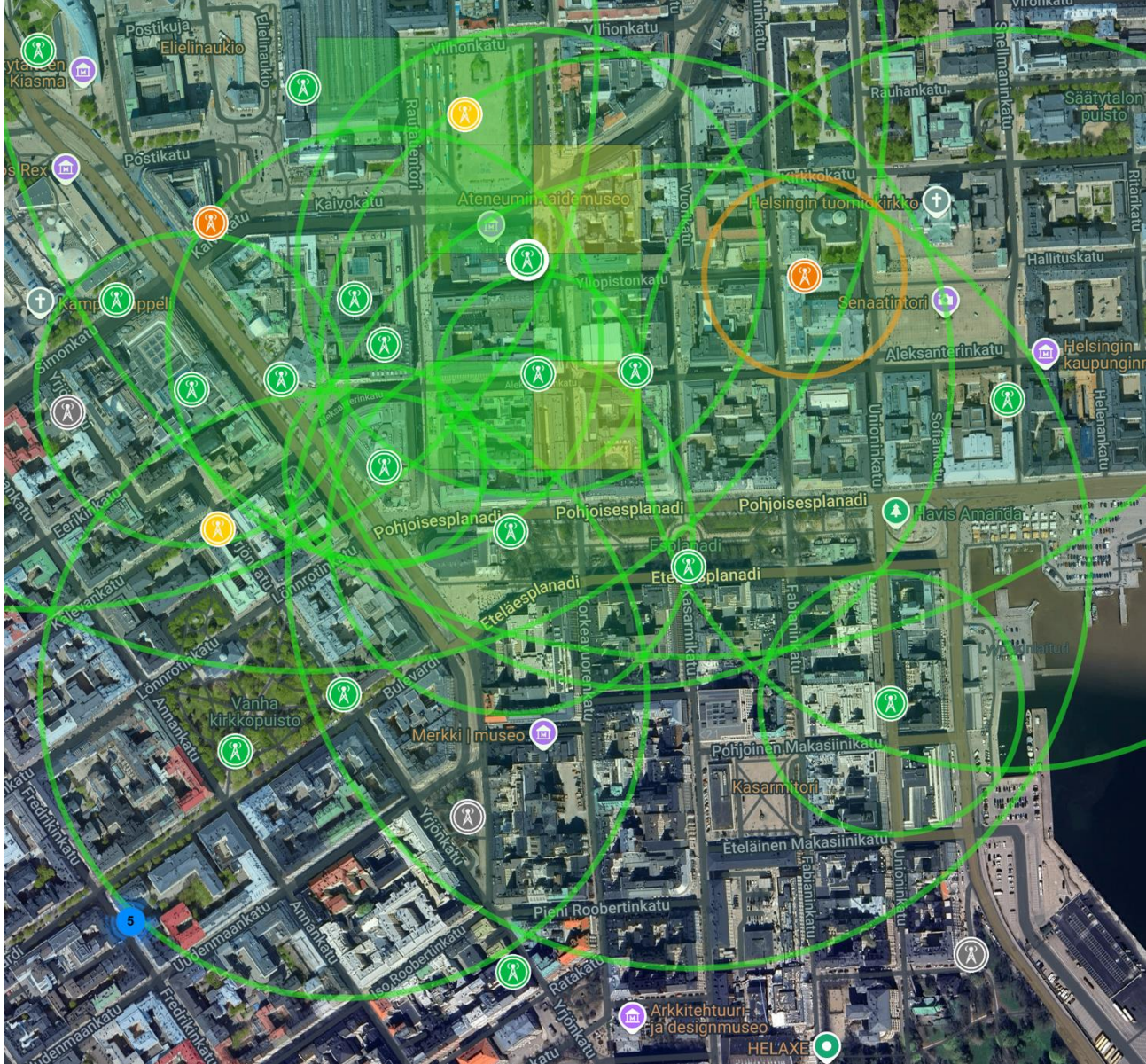
- **Modern radio modules use high MIMO counts for high spatial efficiency.**
  - During low traffic scenarios, not all transmitting antennas are needed.
  - Some can be switched off to save energy at the cost of peak throughput.
  - For example switching a 4T4R 4G cell into a 2T4R cell saves about 10% power and lowers peak throughput by about 10%.

Cell Sleep

- **Cell sleep saves the most energy but has a large service impact**
- **Network coverage is usually built in layers**
  - Low band (700-900 MHz) cells offer coverage
  - Mid- to high band (1800-26 000 MHz) cells offer capacity
- **During low demand periods capacity cells can be shut down partly or entirely to save 50-100% of power**
- **Coverage cells remain operational to serve users and sense demand levels, powering new cells as needed**
- **The downside is that cells take 5-15 minutes to become operational again, which can appear as sluggishness to users.**

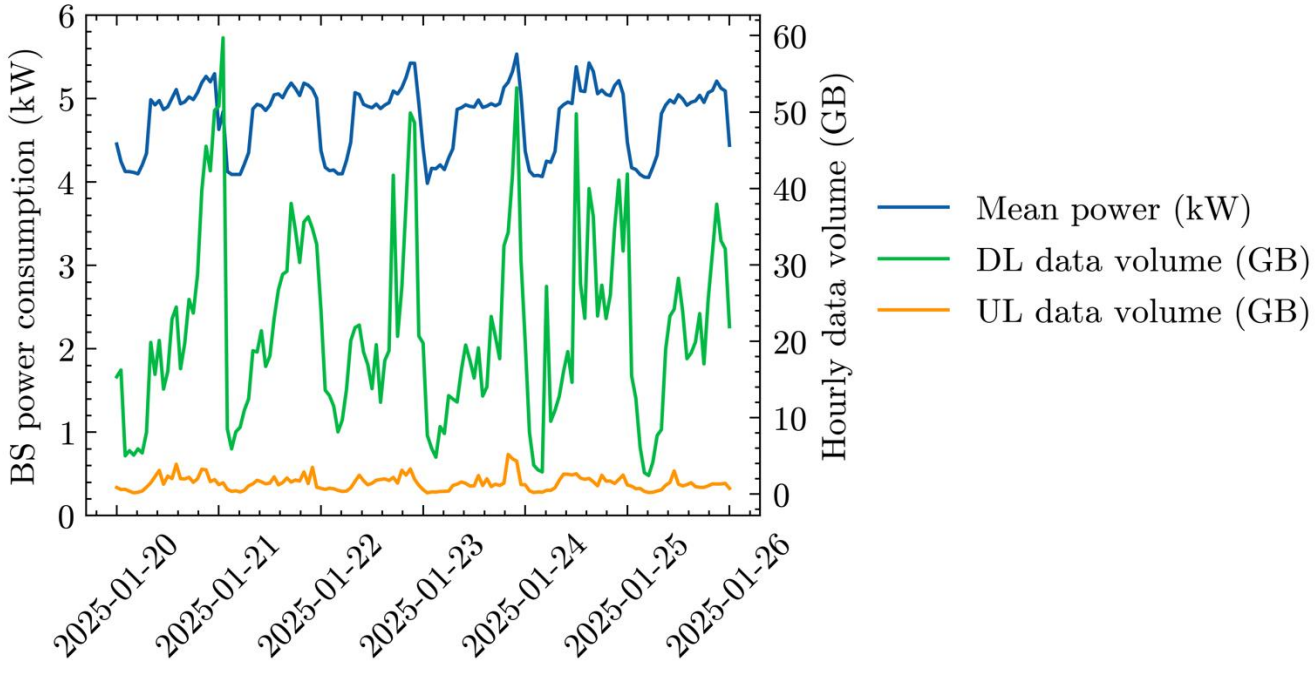
- **Real data from downtown Helsinki**
- **A lot of overlapping cells with different coverage areas**

Netradar, 2025



Energy consumption of a cell site

- **One cell site, one week**
- **Data by Roope Lahti**



Energy-efficiency of 4G vs 5G

Detailed measurement study of Telia's cellular network in Finland 2023

High frequency sites (2.6/3.5GHz)

Typical urban base station has multiple radios and SM, so idle consumption can be c. 3.5kW

And with 3 operators: 10.5kW

Paper submitted for peer review by Roope Lahti

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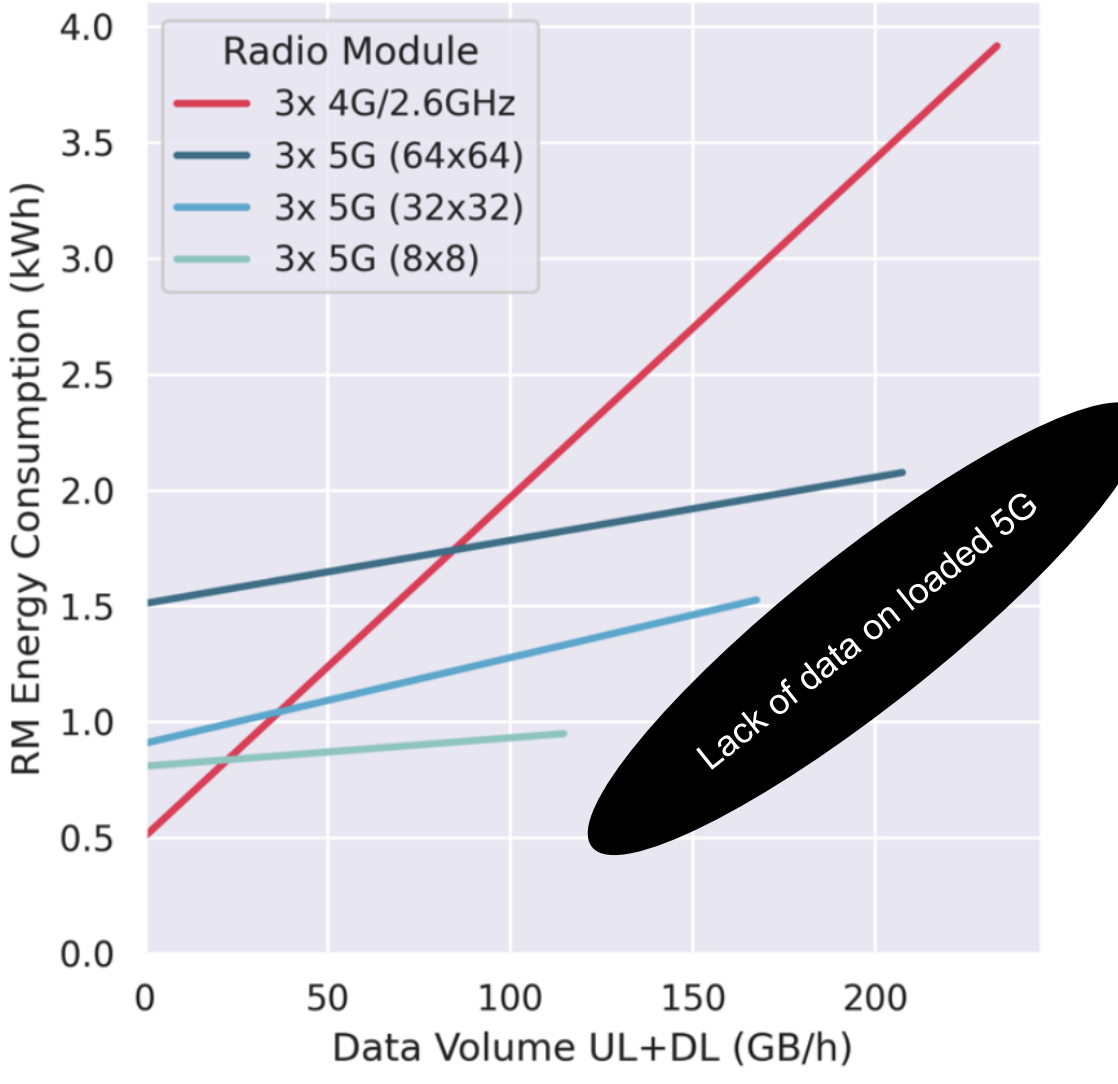

Fig. 4. Energy efficiency of 4G versus 5G RMs

Summary

- **Cellular networks and hardware does (must) have energy proportionality**
  - OPEX a major concern of cellular providers
- **Cell sleep and other techniques can lower the consumption**
- **Always an optimization question: energy vs quality**
  - What is good enough ?
- **All networking should follow the same principle**