

Power Efficiency of Hypervisor and Container-based Virtualization

University of Amsterdam
MSc. System & Network Engineering
Research Project II

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Significance

- **Growing consumption of cloud services**

Cisco claims: "by 2019, more than 86 percent of all workload will be processed by cloud data centers"

- More **awareness** on **power consumption**

- **Container-based** virtualization is an **emerging technology**

Docker became very popular in a relative short time

Related Work (1)

- Van der Poll [2015]
 - **Power consumption** of two open-source hypervisors, **KVM** and **Xen**
 - **KVM** as a **more green solution** than **Xen**.
- IBM research division [2014]
 - **Performance** comparison of virtual nodes ran by a hypervisor versus Linux containers
 - **Docker** had **equal** or **faster** performance compared to **KVM**
- Ericsson research division [2015] [1]

Empirical Investigation of **power consumption** of **virtualization platforms**

- **Compared number of VMs and Containers**
- Power impact of CPU, memory and HDD
- Used a Power Measurement Device
- Results: virtualization platforms behave similarly in idle state and in CPU/Memory stress test



Figure 1: Power Measurement Device

Image source: <http://media.bestofmicro.com/green-power-cpu-performance,E-o-228600-13.jpg>

Related Work (2)

- Ericsson research division [2015] [2]
 - **Performance** comparison between traditional hypervisors and Linux containers
 - **Containers** achieve generally **better performance** compared to **traditional VMs**

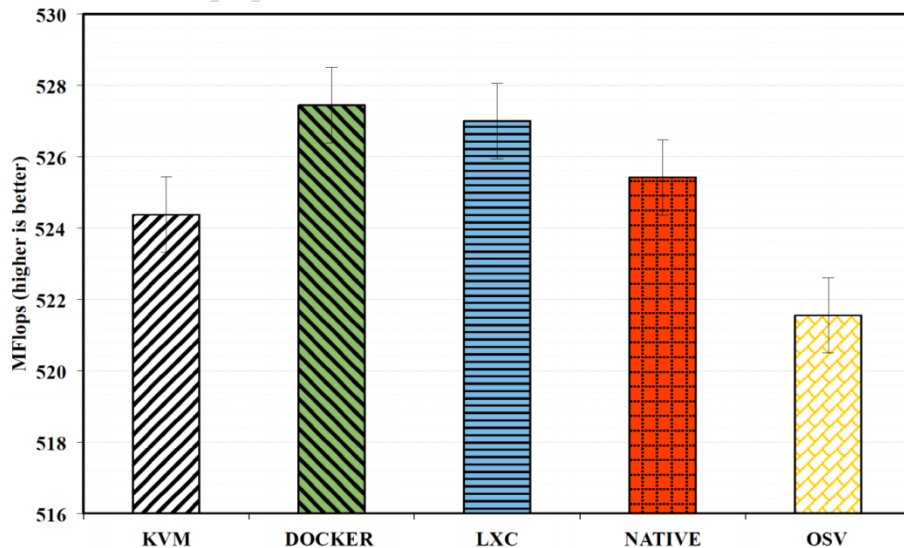


Figure 2: LINPACK CPU performance

Source: Ericsson, Hypervisors vs. Lightweight Virtualization: a Performance Comparison [2015]



Research Question (1)

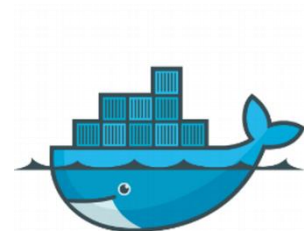
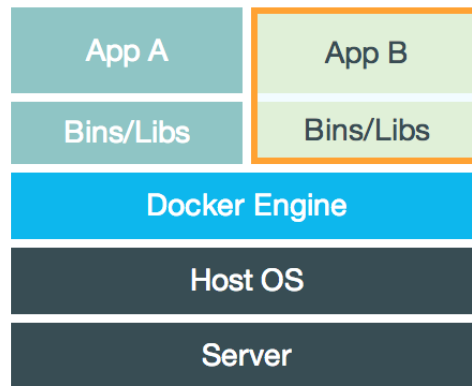
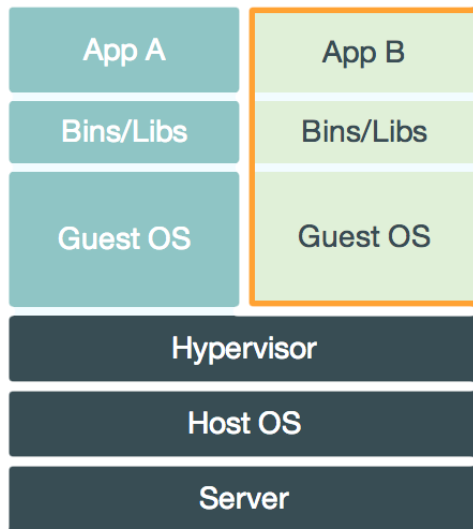
Is there a **difference in power efficiency** under a **traditional hypervisor-based virtualization** versus **Linux containers**?

VMs and Containers

- Container virtualization is a **lightweight** alternative to hypervisor-based virtualization
- Container runs on top of the **same shared host OS kernel**
 - While VMs install a full Guest OS
- Containers **do not isolate** resources as well as hypervisors



Xen 4.5.1



Docker 1.9.1

Approach

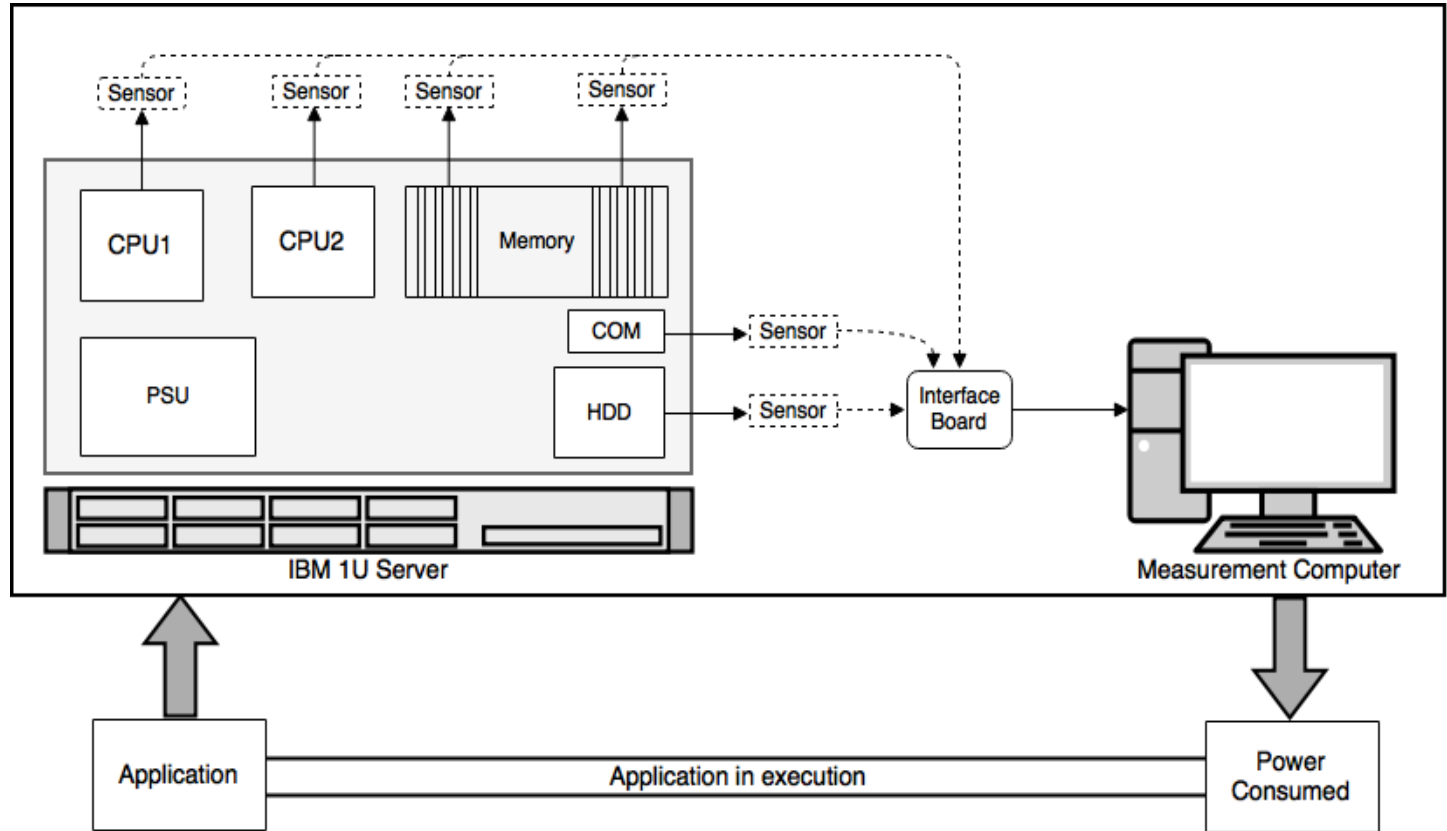


Figure 4: Power Measurement Setup

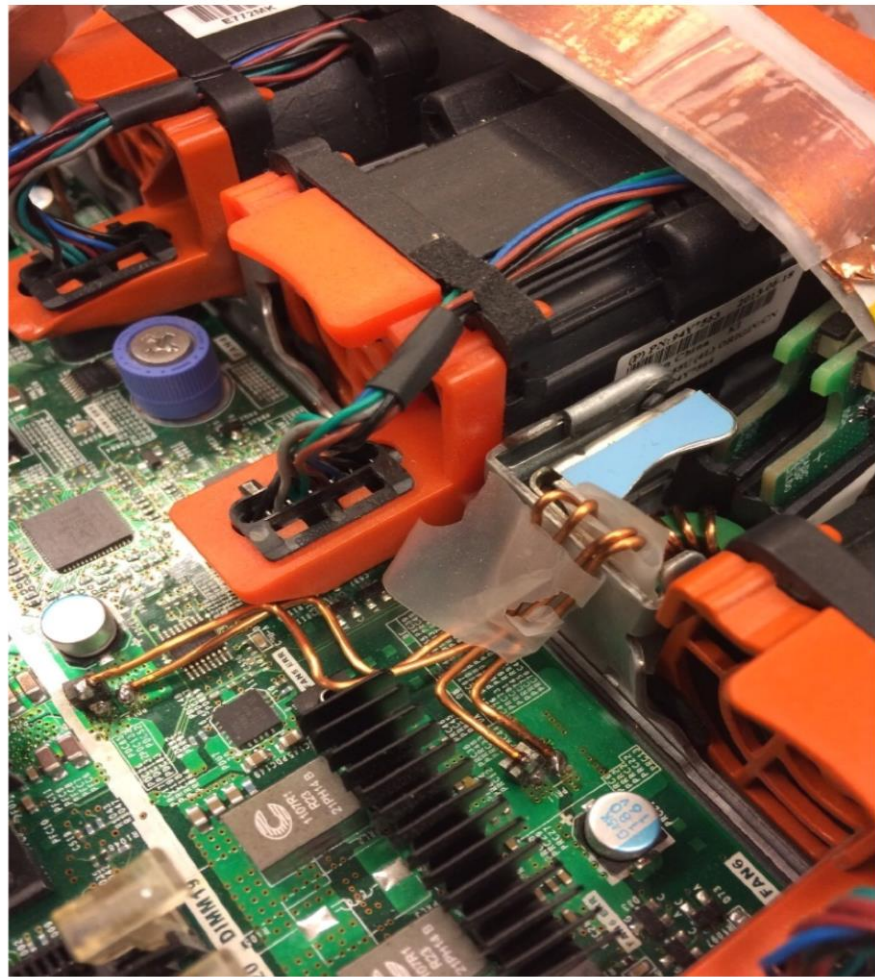
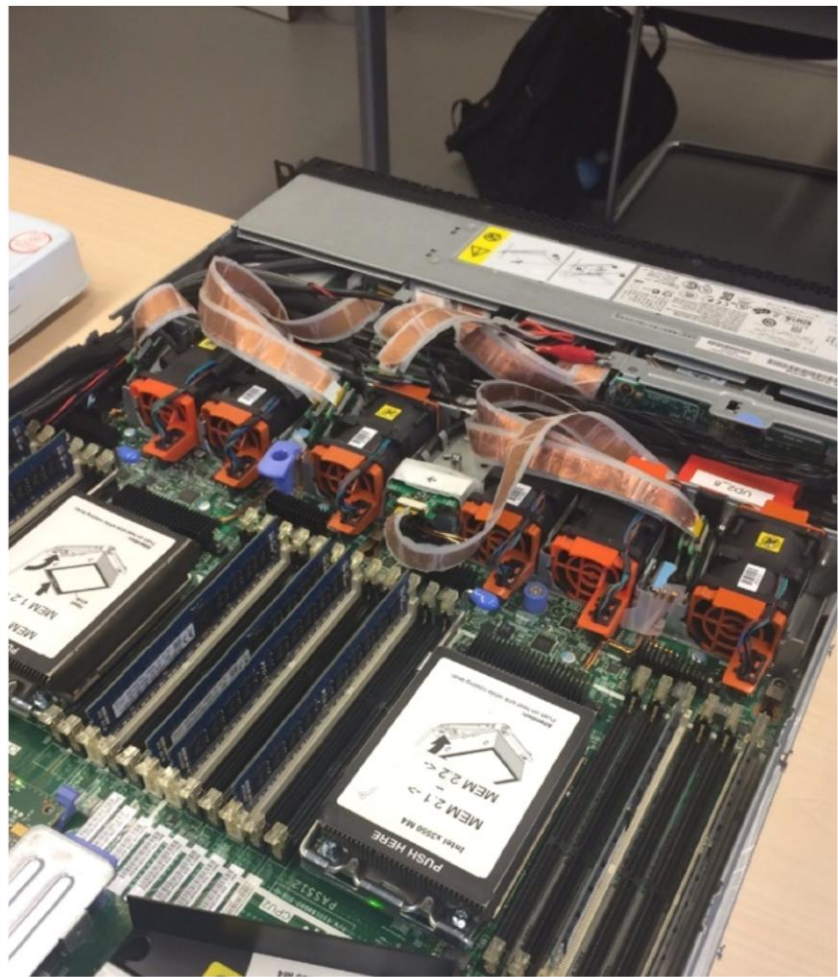
Measurement Setup

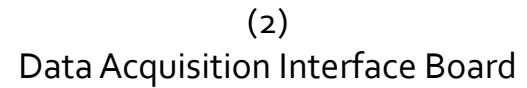
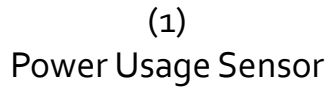
	System Information
Model	IBM System x3550 M4 7914B3G Server (Firmware version 1.9)
Motherboard	IBM 00D3449
Power Supply	IBM Emerson 550W (80+ Platinum Certification)
Processors	2x Intel Xeon E5-2609 v2 @ 2.50 GHz, 8 cores, 6.4 GT/s, 25 MB Cache
Memory	64 GiB (8 GiB x 8 Slots) Hynix DDR3 PC3 1333MHz 14900R, 13-12-B1
HDD	HP 146 GB 2.5-inch SCSI SAS, 3.0 GB/sec, 10,000 RPM

Table 1: IBM 1U Server Specifications

Running Ubuntu 15.10 x64







Measurement results

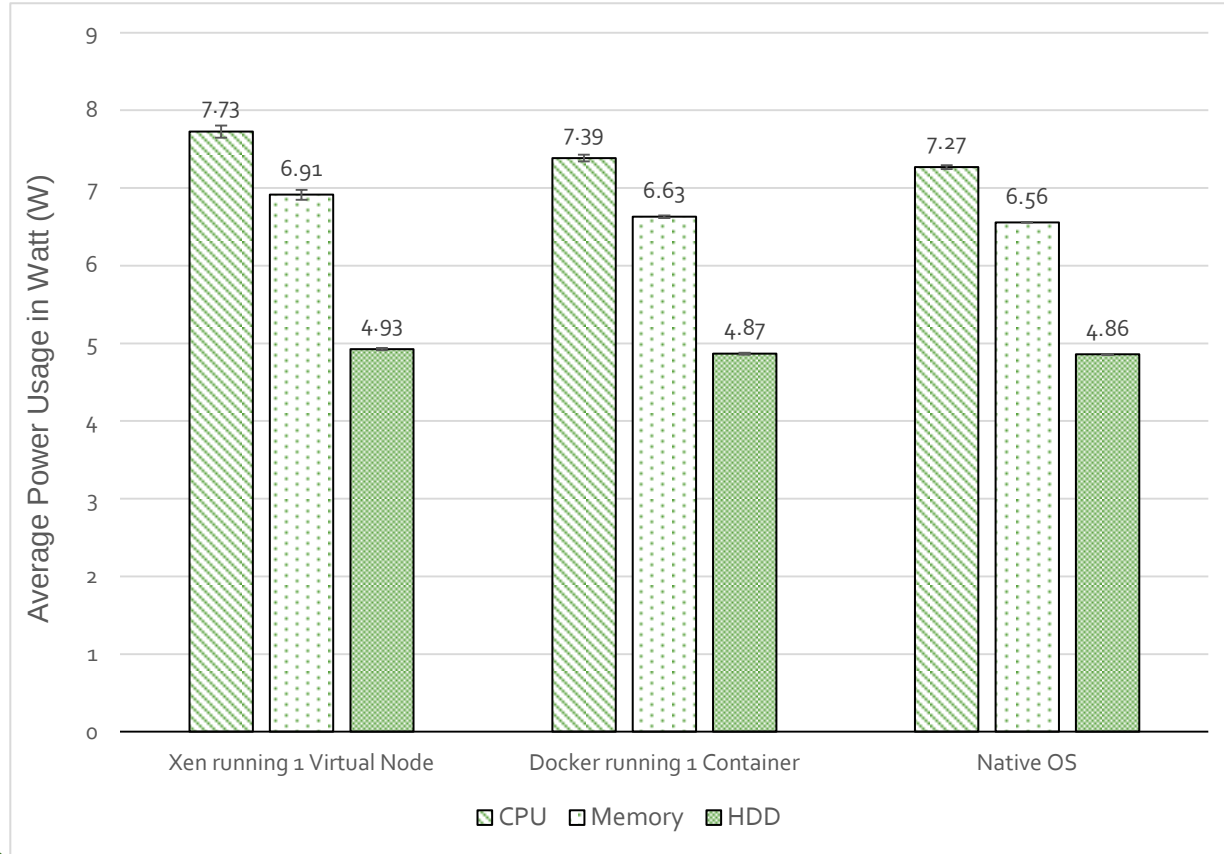
Synthetics Applications

Dominant Hardware Component	Benchmark Application
Processors	Intel Optimized LINPACK
Memory	sysbench
HDD	Bonnie++

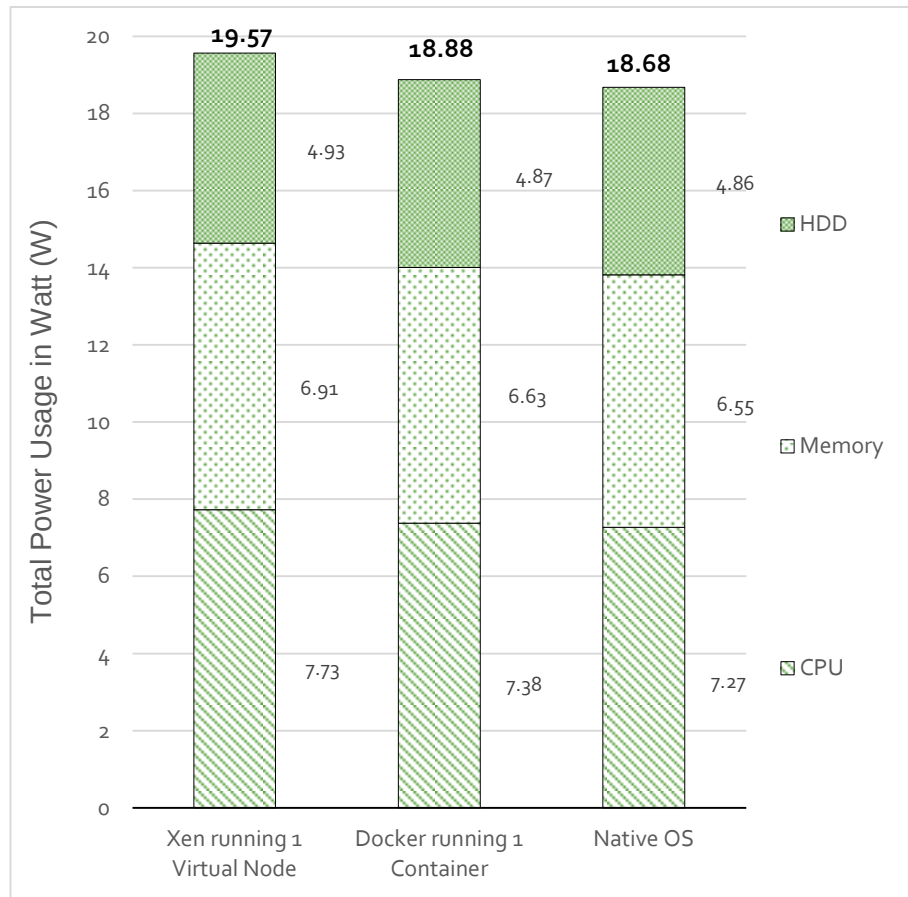
Table 2: Dominant components and their synthetics benchmark applications

But first, IDLE is measured as a baseline

IDLE Power consumption (1)



Total IDLE Power consumption (2)

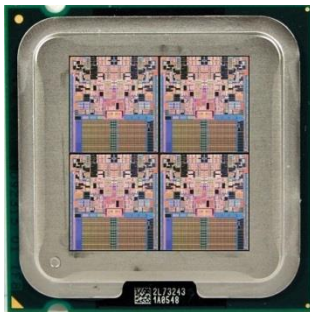


CPUs and Cores

Experiment 1:

4 cores on CPU₁

CPU1



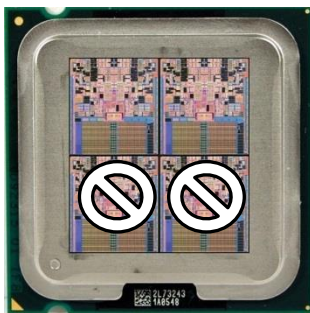
CPU2



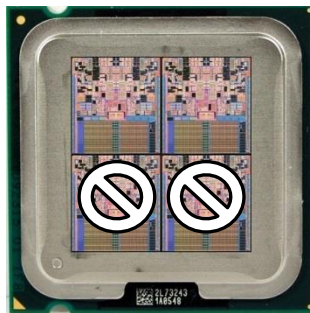
Experiment 2:

2 cores both
CPU₁ and CPU₂

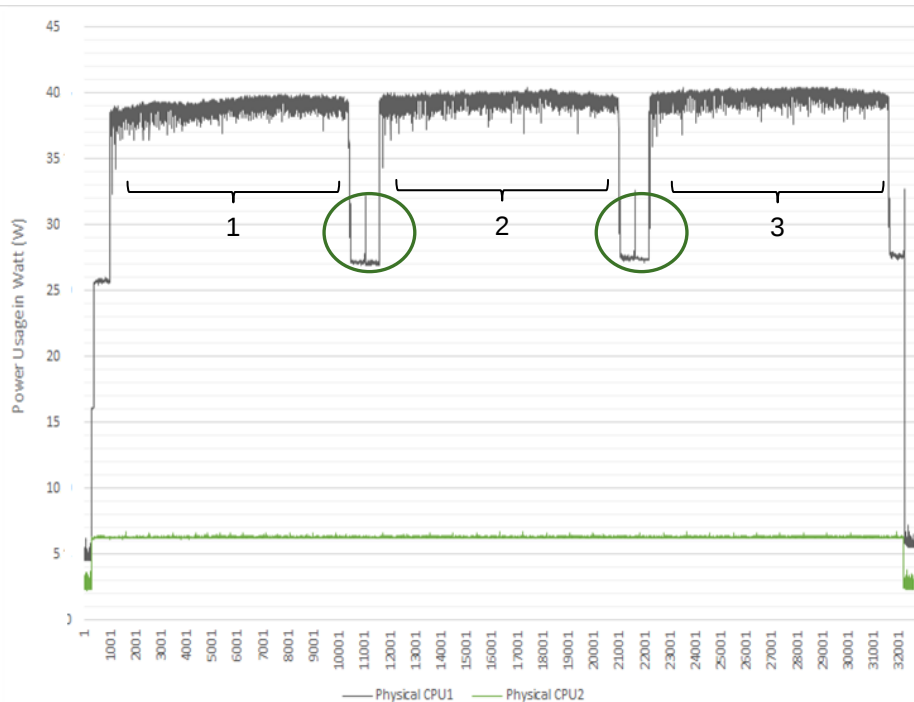
CPU1



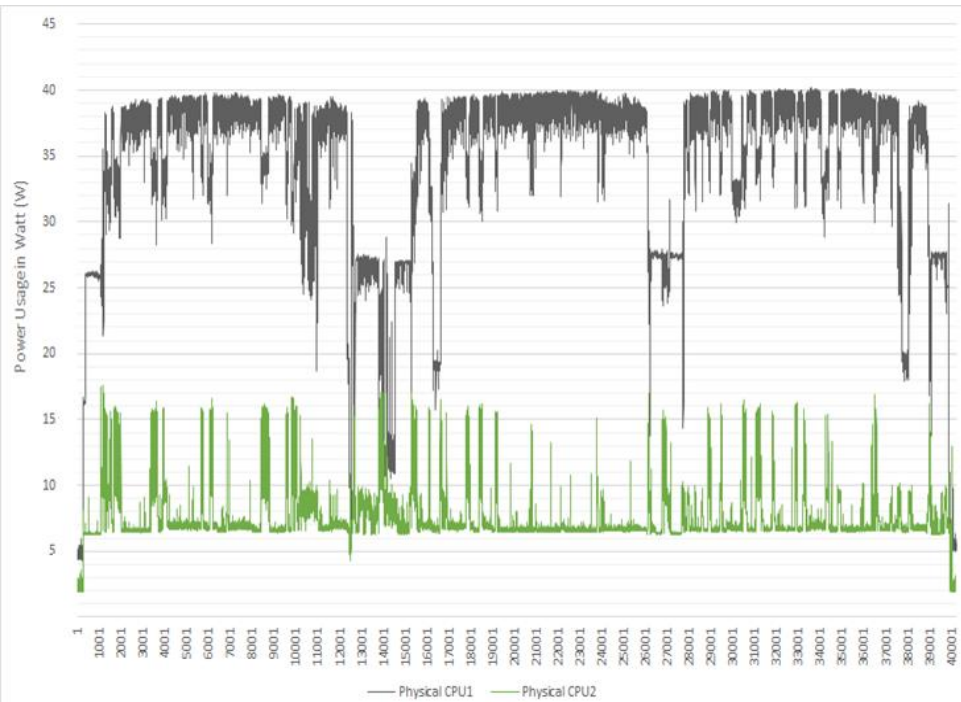
CPU2



Power Consumption during **LINPACK** on **Docker (1)** and **Xen (2)**

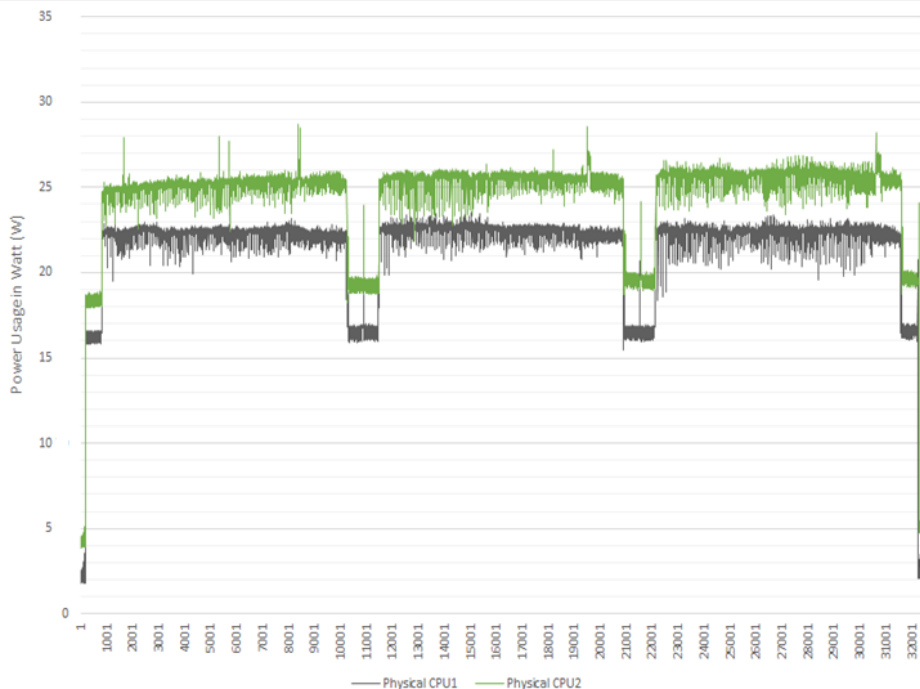


(1) **Docker**: All **4** cores used on **physical CPU1**

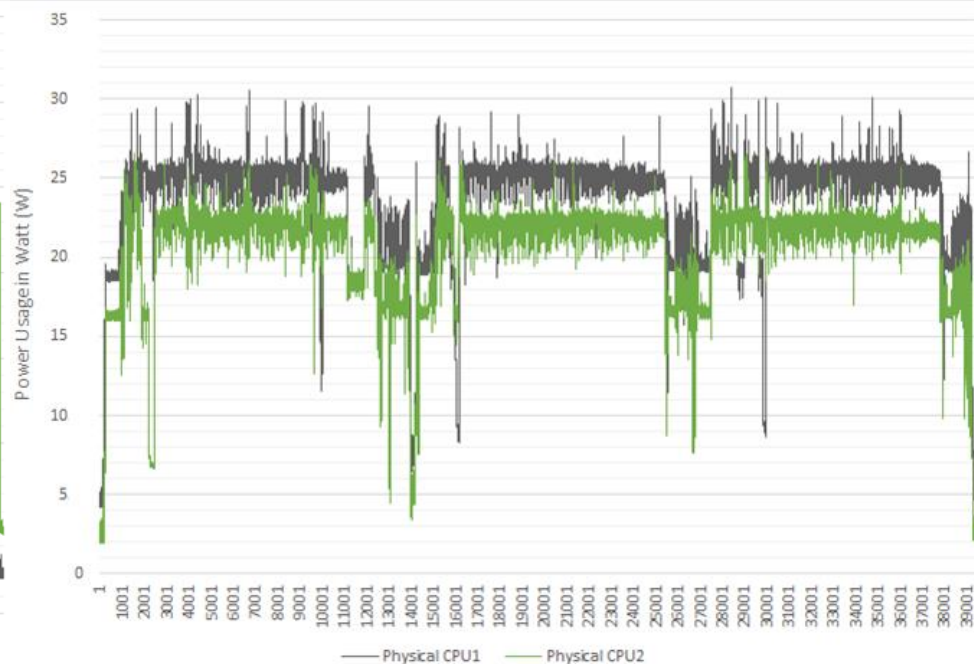


(2) **Xen**: All **4** cores used on **physical CPU1**

Power Consumption during **LINPACK** on **Docker (1)** and **Xen (2)**

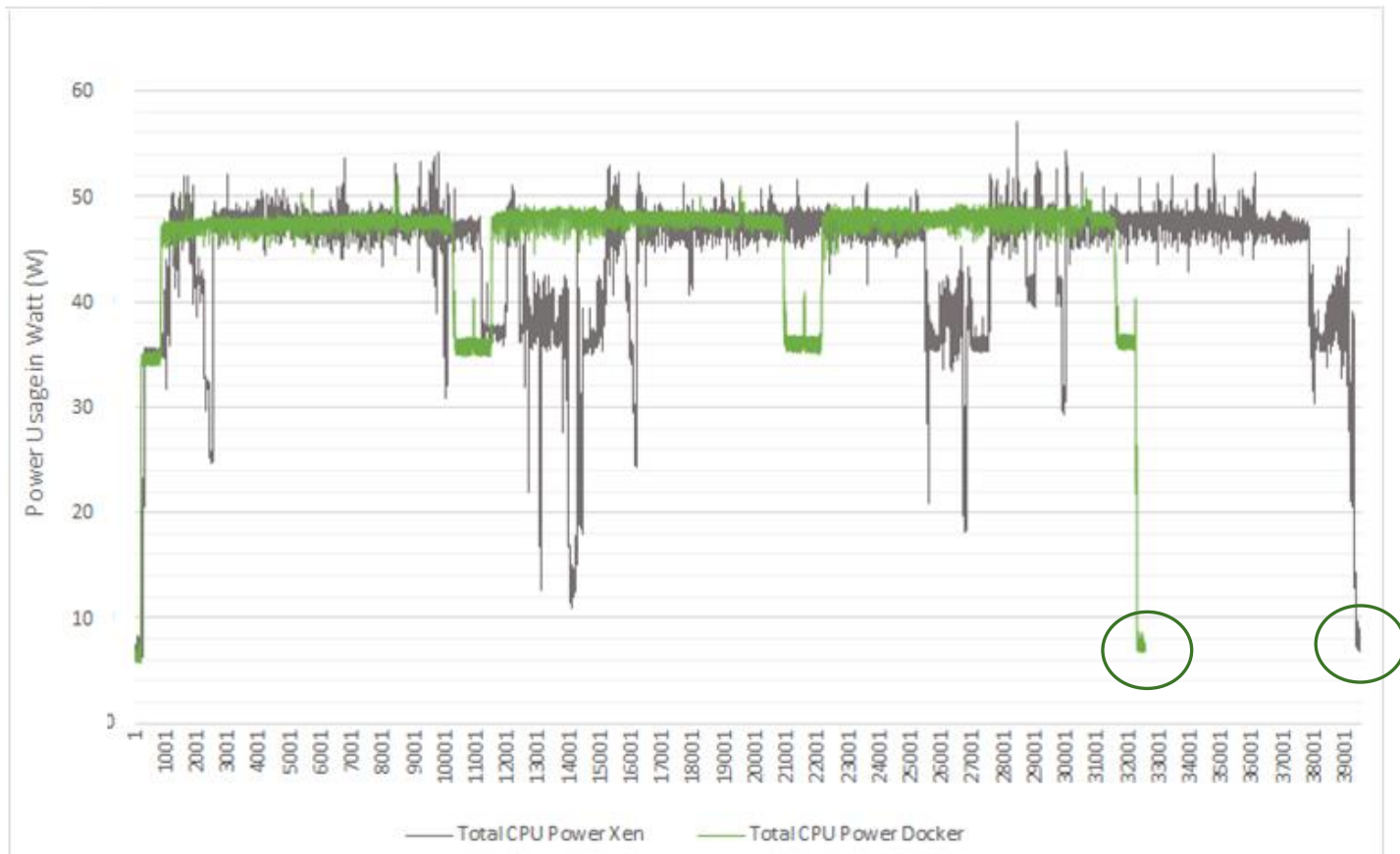


(1) **Docker**: 2 cores used of each **CPU1** and **CPU2**



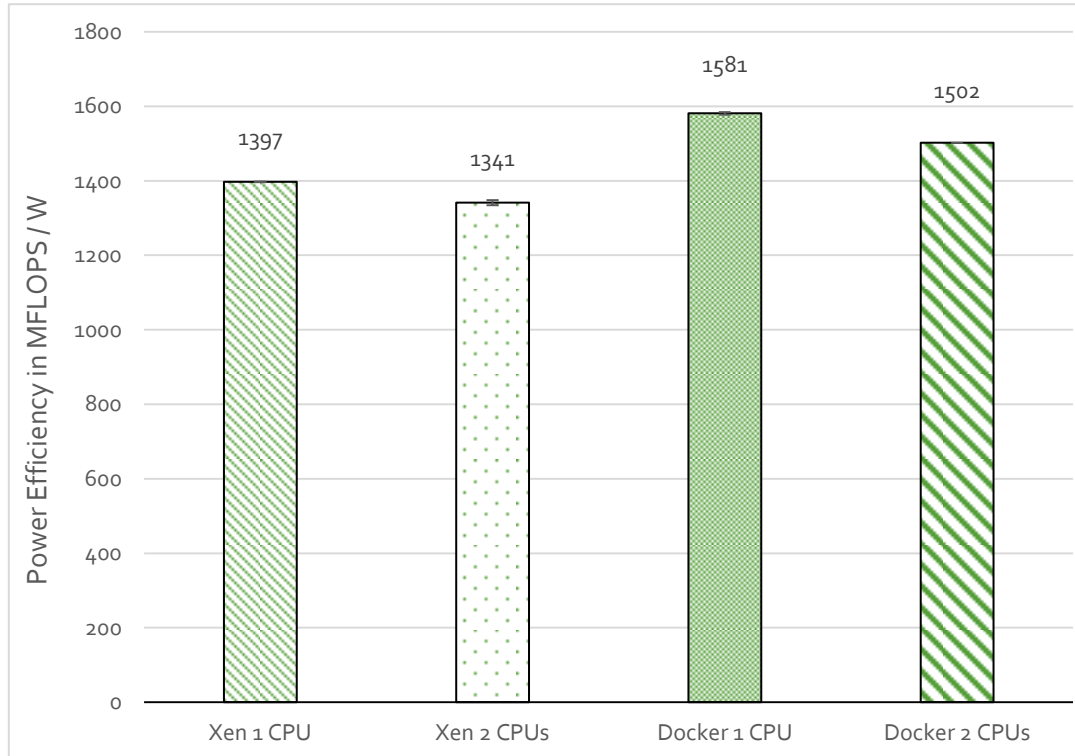
(2) **Xen**: 2 cores used of each **CPU1** and **CPU2**

Total Power consumption of LINPACK CPU Docker and Xen

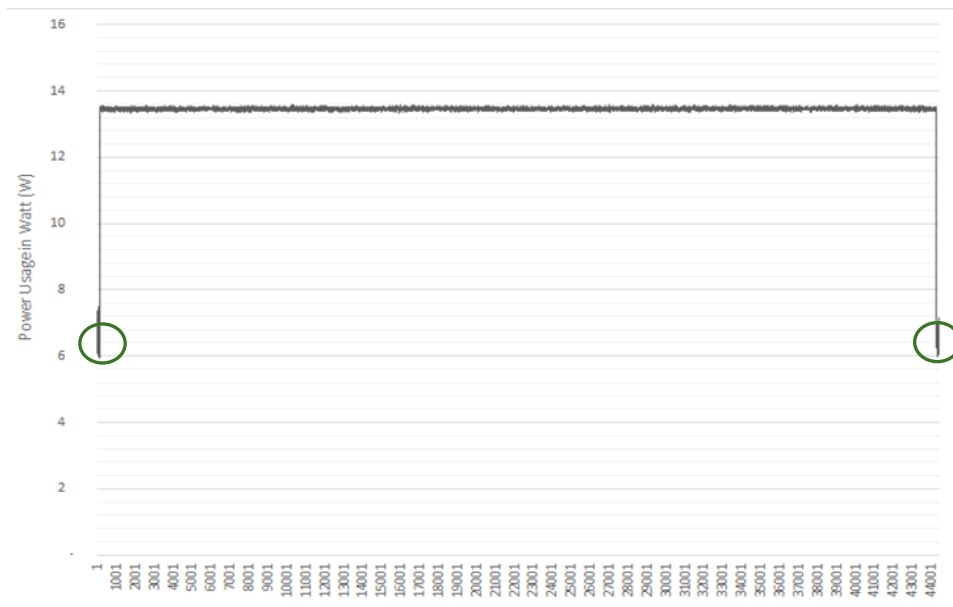


Energy efficiency during **LINPACK** (CPU intensive)

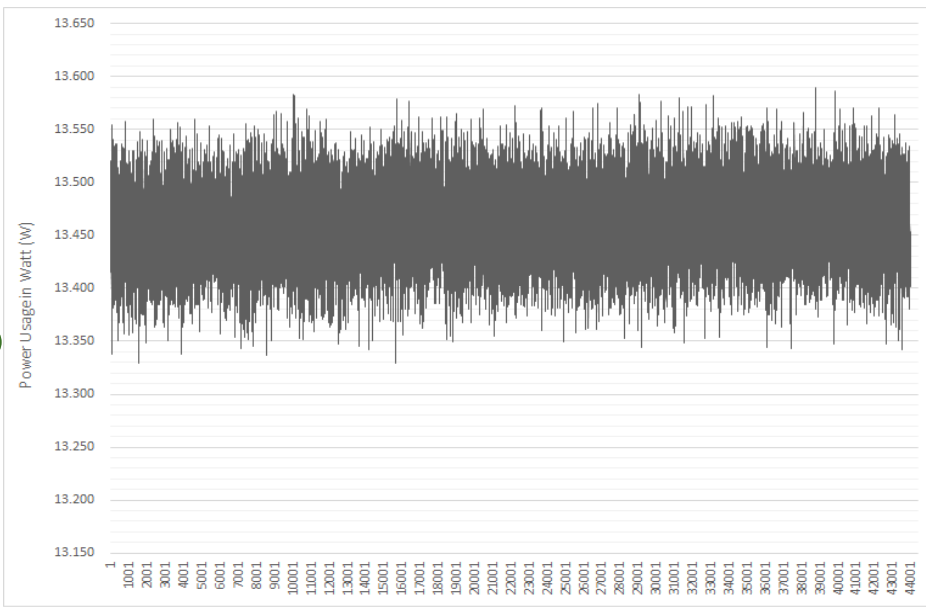
$$\text{Power Efficiency} = \frac{\text{Average Compute Performance}}{\text{Average Power}}$$



Power Consumption during **sysbench** 350GiB memory transfer

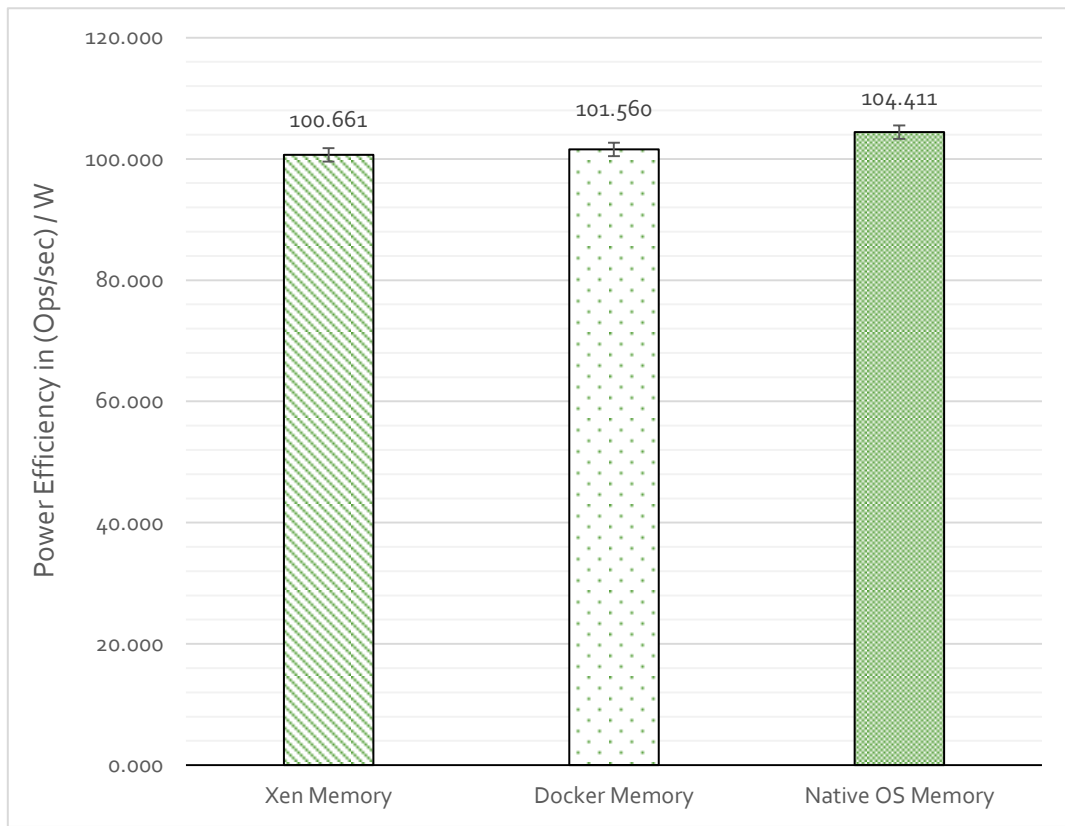


Power Usage of all memory banks (1)

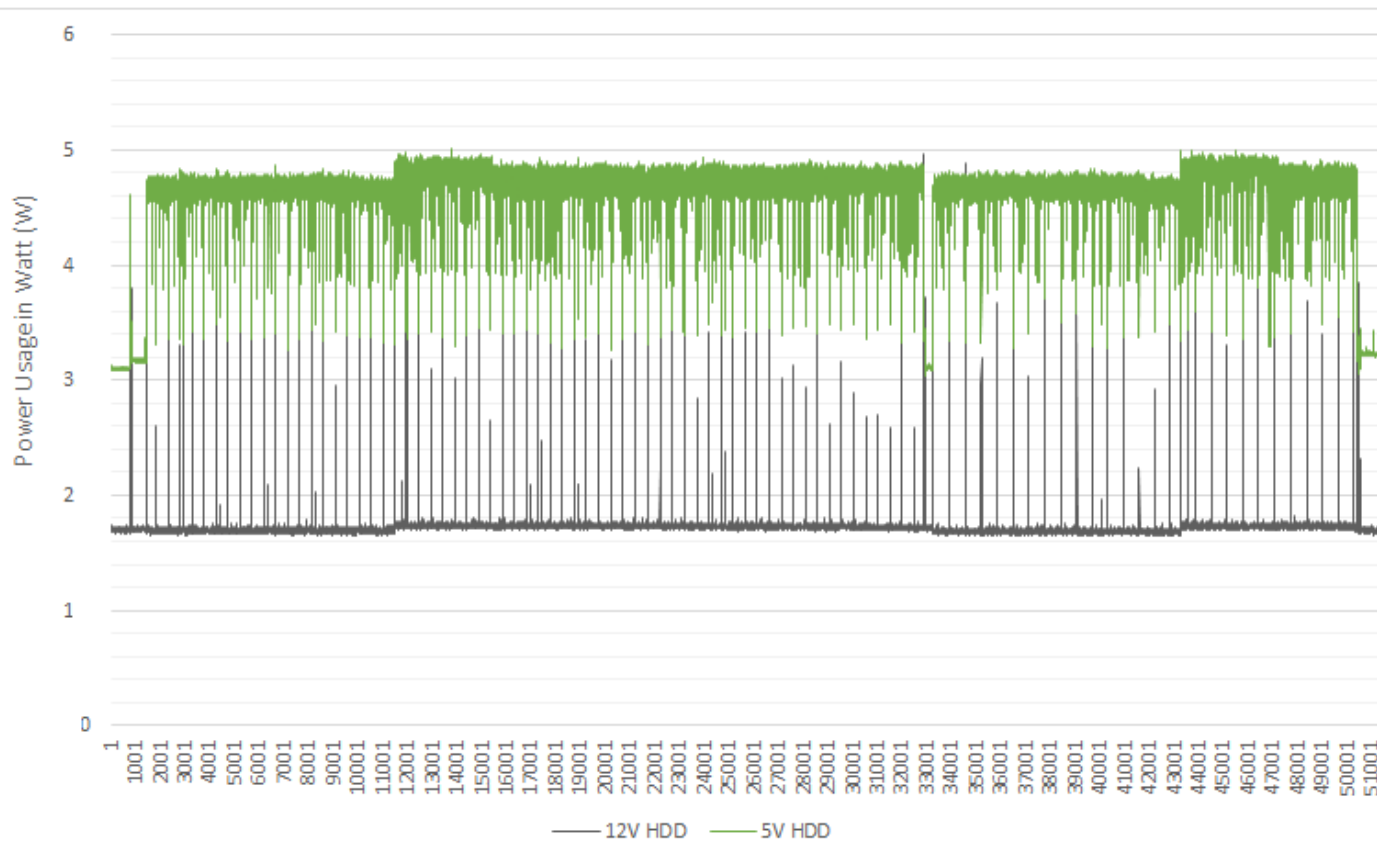


Power Usage of all memory banks (2)

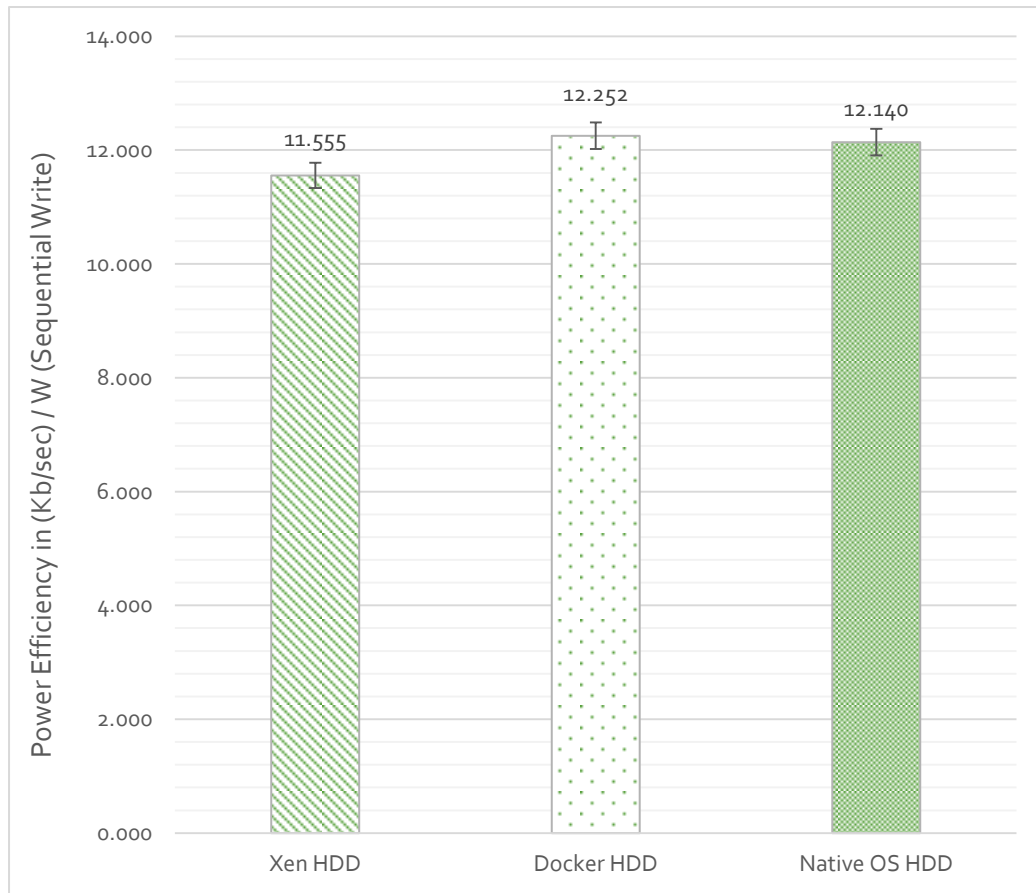
Total Power efficiency during a **sysbench** 350GiB memory transfer



Power Consumption during **Bonnie++** (25GiB)



Total Power efficiency during **Bonnie++** 25GiB (Sequential Writes in Kb/sec)



Conclusion

Research question:

Is there a difference in power efficiency under a traditional hypervisor-based virtualization versus Linux containers?

Performance results match with the Ericsson research

Power Efficiency results:

CPU:

Docker is more efficient in terms of power

Memory, HDD (Writes) and IDLE:

Docker is more efficient but almost negligible

Future Work

- Benchmark **multiple virtual nodes and containers**
- Investigate the **energy footprint** of the **network** component
- Test other applications

Performance evaluation of **real life applications**

- Further investigation of **other platforms** such as **LXC, KVM and VMware**
- Investigate **energy impact** of **(Xen) Paravirtualization**



Thanks for your attention