Carbon Costs in IRIS

& UKRI NetZero DRI

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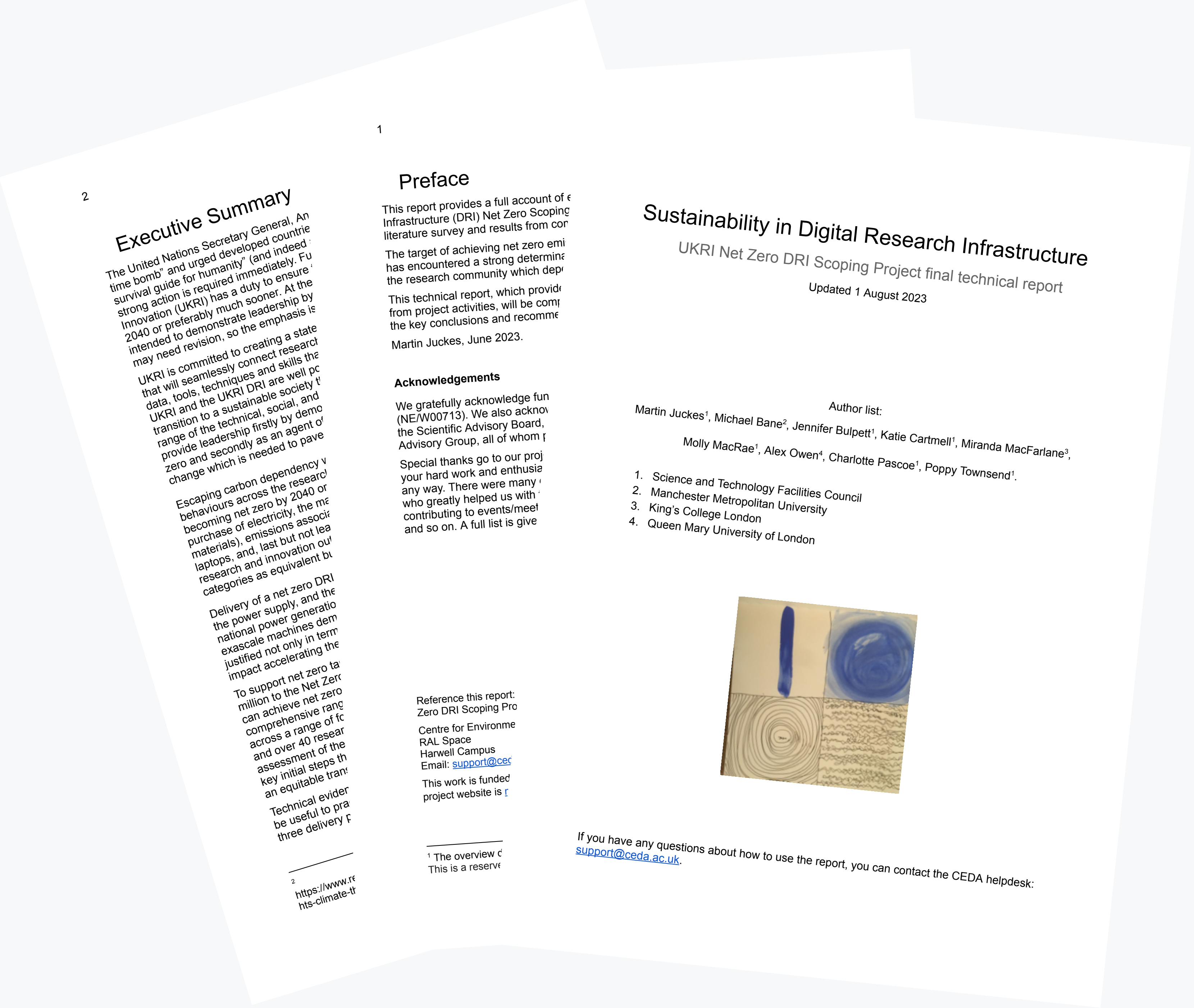
IRISCAST
Audit of Carbon Costs



Executive Summary

Preface

Sustainability in Digital Research Infrastructure

UKRI Net Zero DRI Scoping Project final technical report

Updated 1 August 2023

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iris Carbon Mapping Project

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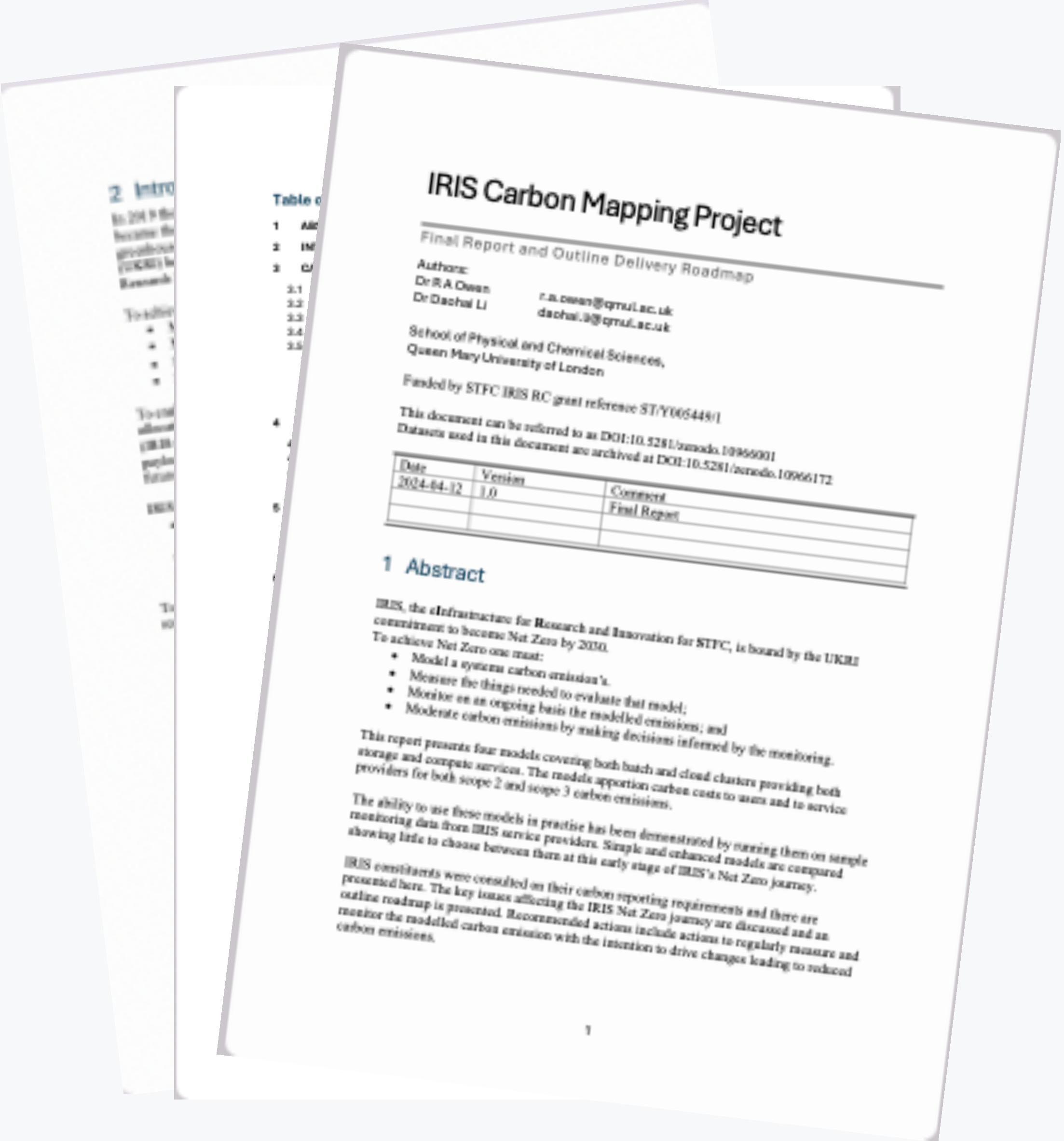

IRIS Carbon Mapping Project

Final Report and Outline Delivery Roadmap

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Date	Version	Comment
2024-04-12	1.0	Final Report

1 Abstract

IRIS, the eInfrastructure for Research and Innovation for STFC, is bound by the UKRI commitment to become Net Zero by 2030.
To achieve Net Zero one must:

- Model a systems carbon emission's.
- Measure the things needed to evaluate that model;
- Monitor on an ongoing basis the modelled emissions; and
- Moderate carbon emissions by making decisions informed by the monitoring.

This report presents four models covering both batch and cloud clusters providing both storage and compute services. The models apportion carbon costs to users and to service providers for both scope 2 and scope 3 carbon emissions.

The ability to use these models in practise has been demonstrated by running them on sample monitoring data from IRIS service providers. Simple and enhanced models are compared showing little to choose between them at this early stage of IRIS's Net Zero journey.

IRIS constituents were consulted on their carbon reporting requirements and there are presented here. The key issues affecting the IRIS Net Zero journey are discussed and an outline roadmap is presented. Recommended actions include actions to regularly measure and monitor the modelled carbon emission with the intention to drive changes leading to reduced carbon emissions.

1

iris

eInfrastructure for Research and Innovation for STFC

https://www.iris.ac.uk/

IRIS is a cooperative community brining together (mainly) STFC computing interests

Formed bottom up by science communities and compute providers

Works closely with STFC but run by the community

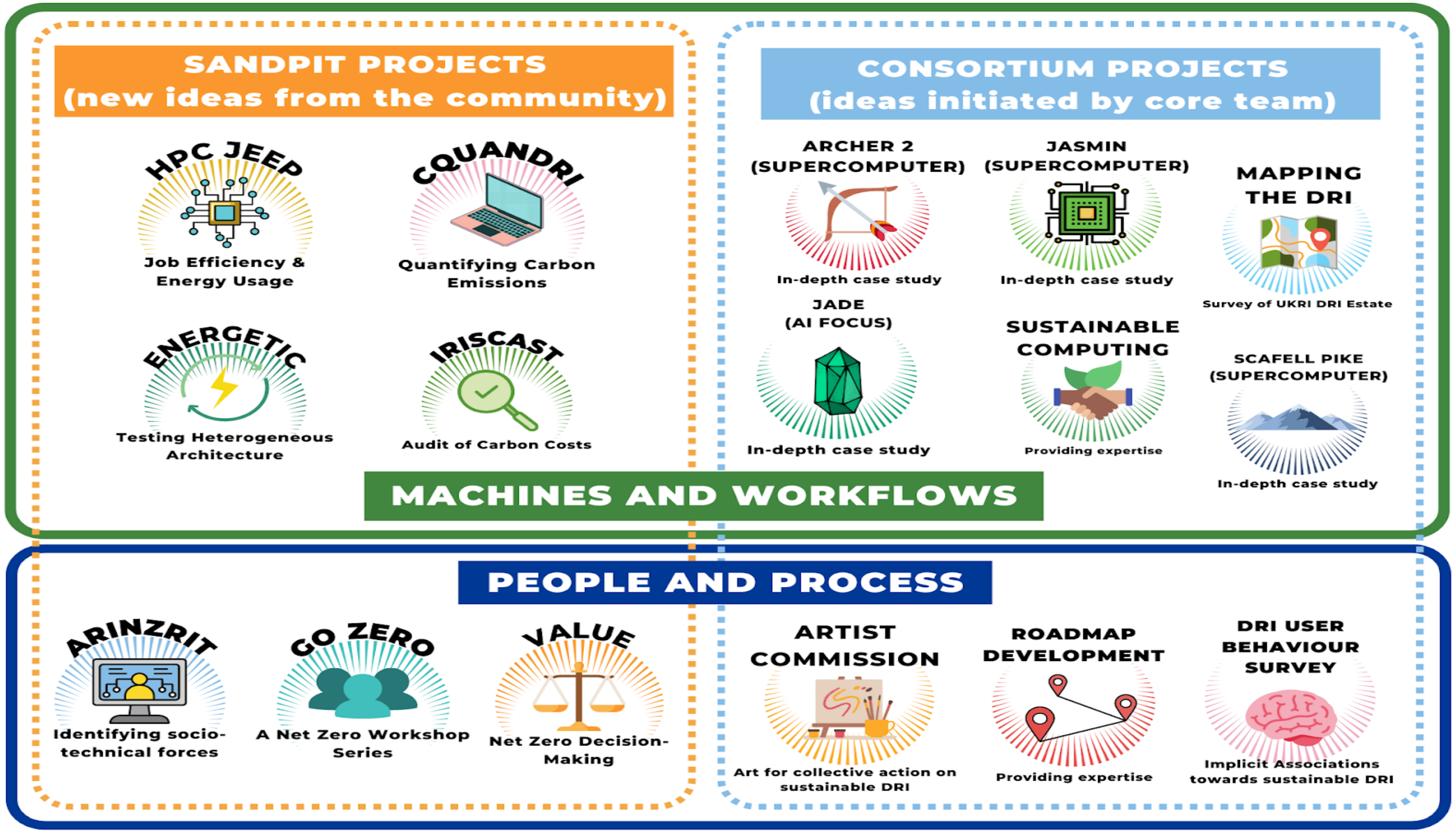
IRIS Science Director is
Prof J Hays
who is also
IRISCAST Project PI
IRIS-CMP Project CI

IRISCAST
Audit of Carbon Costs

iris Carbon Mapping Project

**UKRI DRI
Net Zero
by 2040**

UKRI Net Zero DRI Scoping Project



https://net-zero-dri.ceda.ac.uk/

https://doi.org/10.5281/zenodo.8199984

Measuring Carbon

NetZero and the IRISCAST Project

Audit of Carbon Costs

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6 Month Project Funded within UKRI Net Zero Scoping Project

iris
DiRAC
GridPP
Queen Mary University of London
UNIVERSITY OF CAMBRIDGE
epcc
UKRI Science and Technology Facilities Council | Scientific Computing

What is IRISCAST?

IRISCAST is the IRIS Carbon Audit SnapshoT

Audit of Carbon Costs

24 Hour snapshot across multiple ‘IRIS Facilities’

The Challenge

Estimate carbon costs for scientific computing across a broad heterogeneous landscape

Identifying the key drivers for carbon costs

Identifying the hurdles and barriers

Communicating the carbon costs to drive change

Working coherently across different communities

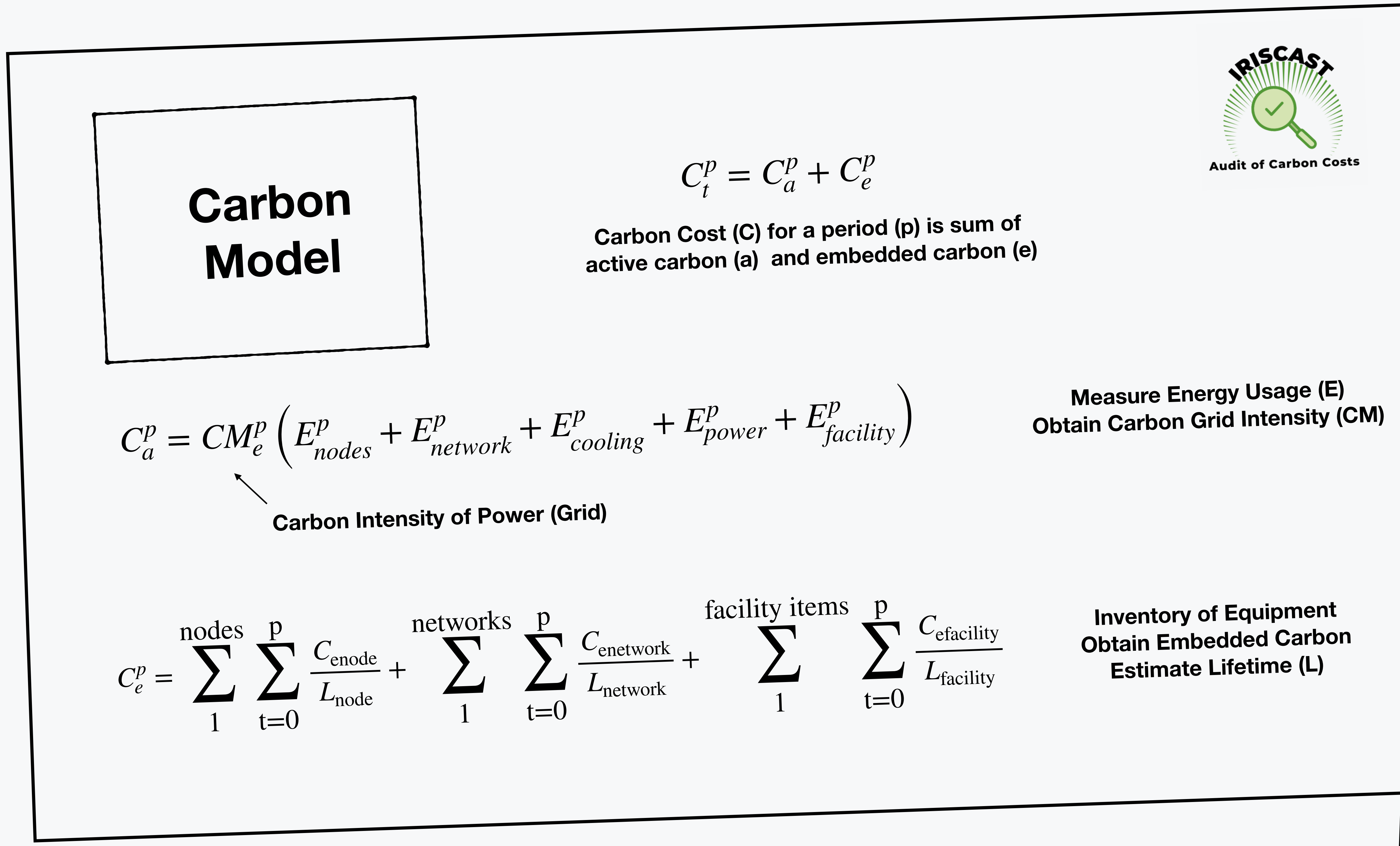
The Project

Work together coherently across different facilities with different remits, tooling, and capabilities.

Learn by doing!

Document the gaps, the barriers and the issues, drive requirements for future work and decision making

Communicate across our communities and build a foundation for future action



Carbon Model

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Audit of Carbon Costs

$$C_t^p = C_a^p + C_e^p$$

Carbon Cost (C) for a period (p) is sum of active carbon (a) and embedded carbon (e)

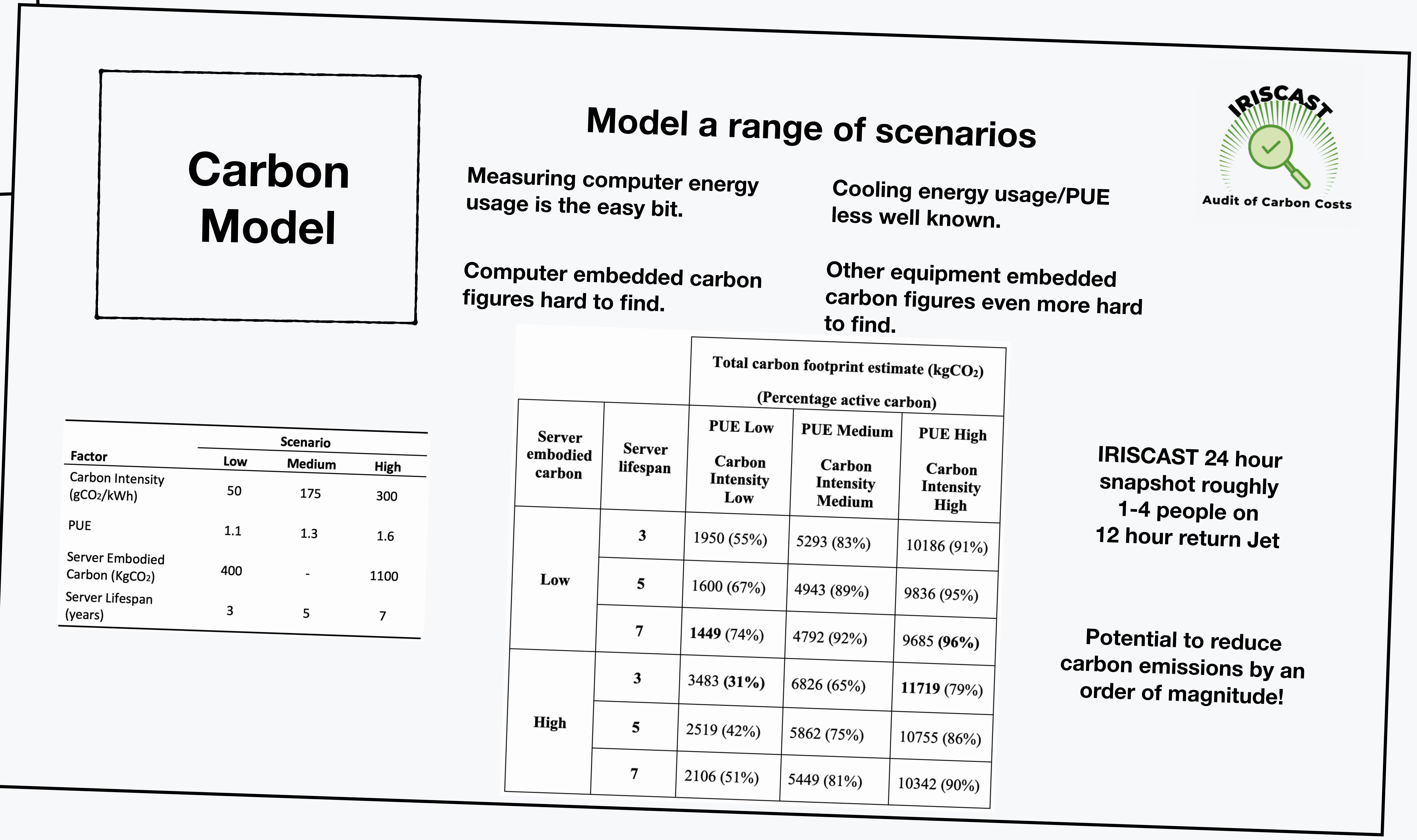
$$C_a^p = CM_e^p \left(E_{nodes}^p + E_{network}^p + E_{cooling}^p + E_{power}^p + E_{facility}^p \right)$$

Carbon Intensity of Power (Grid)

Measure Energy Usage (E)
Obtain Carbon Grid Intensity (CM)

$$C_e^p = \sum_{1}^{\text{nodes}} \sum_{t=0}^{p} \frac{C_{\text{enode}}}{L_{\text{node}}} + \sum_{1}^{\text{networks}} \sum_{t=0}^{p} \frac{C_{\text{enetwork}}}{L_{\text{network}}} + \sum_{1}^{\text{facility items}} \sum_{t=0}^{p} \frac{C_{\text{efacility}}}{L_{\text{facility}}}$$

Inventory of Equipment
Obtain Embedded Carbon
Estimate Lifetime (L)



Carbon Model

Model a range of scenarios

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Measuring computer energy usage is the easy bit.

Cooling energy usage/PUE less well known.

Computer embedded carbon figures hard to find.

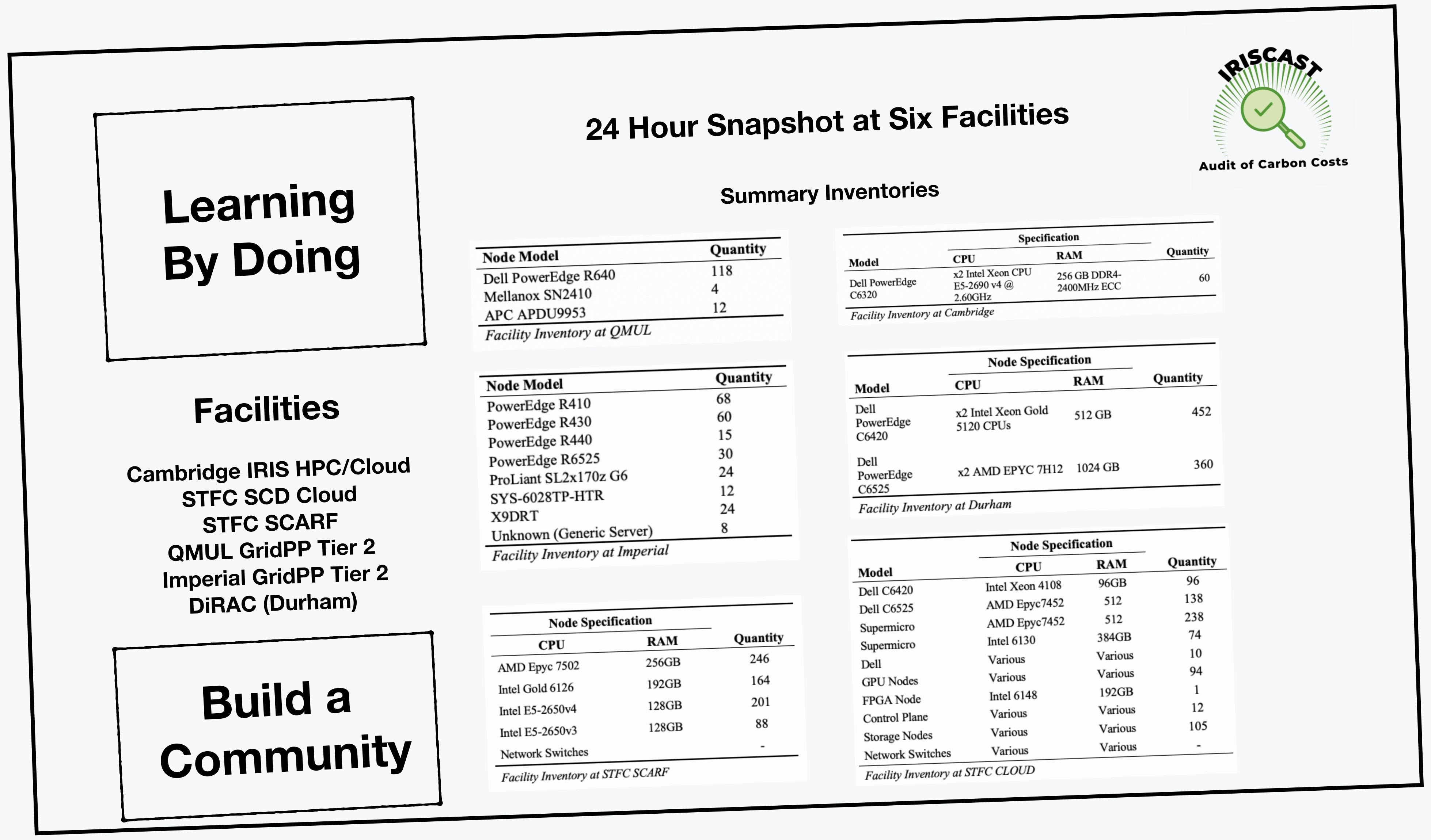
Other equipment embedded carbon figures even more hard to find.

Factor	Scenario Low	Medium	High
Carbon Intensity (gCO_2/kWh)	50	175	300
PUE	1.1	1.3	1.6
Server Embodied Carbon ($KgCO_2$)	400	-	1100
Server Lifespan (years)	3	5	7

		Total carbon footprint estimate ($kgCO_2$) (Percentage active carbon)		
Server embodied carbon	**Server lifespan**	**PUE Low Carbon Intensity Low**	**PUE Medium Carbon Intensity Medium**	**PUE High Carbon Intensity High**
Low	**3**	1950 (55%)	5293 (83%)	10186 (91%)
	5	1600 (67%)	4943 (89%)	9836 (95%)
	7	**1449** (74%)	4792 (92%)	9685 **(96%)**
High	**3**	3483 **(31%)**	6826 (65%)	**11719** (79%)
	5	2519 (42%)	5862 (75%)	10755 (86%)
	7	2106 (51%)	5449 (81%)	10342 (90%)

IRISCAST 24 hour snapshot roughly 1-4 people on 12 hour return Jet

Potential to reduce carbon emissions by an order of magnitude!



Learning By Doing

Facilities

Cambridge IRIS HPC/Cloud
STFC SCD Cloud
STFC SCARF
QMUL GridPP Tier 2
Imperial GridPP Tier 2
DiRAC (Durham)

Build a Community

24 Hour Snapshot at Six Facilities

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Summary Inventories

Node Model	Quantity
Dell PowerEdge R640	118
Mellanox SN2410	4
APC APDU9953	12

Facility Inventory at QMUL

Node Model	Quantity
PowerEdge R410	68
PowerEdge R430	60
PowerEdge R440	15
PowerEdge R6525	30
ProLiant SL2x170z G6	24
SYS-6028TP-HTR	12
X9DRT	24
Unknown (Generic Server)	8

Facility Inventory at Imperial

Node Specification		Quantity
CPU	RAM	
AMD Epyc 7502	256GB	246
Intel Gold 6126	192GB	164
Intel E5-2650v4	128GB	201
Intel E5-2650v3	128GB	88
Network Switches		-

Facility Inventory at STFC SCARF

Model	Specification		Quantity
	CPU	RAM	
Dell PowerEdge C6320	x2 Intel Xeon CPU E5-2690 v4 @ 2.60GHz	256 GB DDR4-2400MHz ECC	60

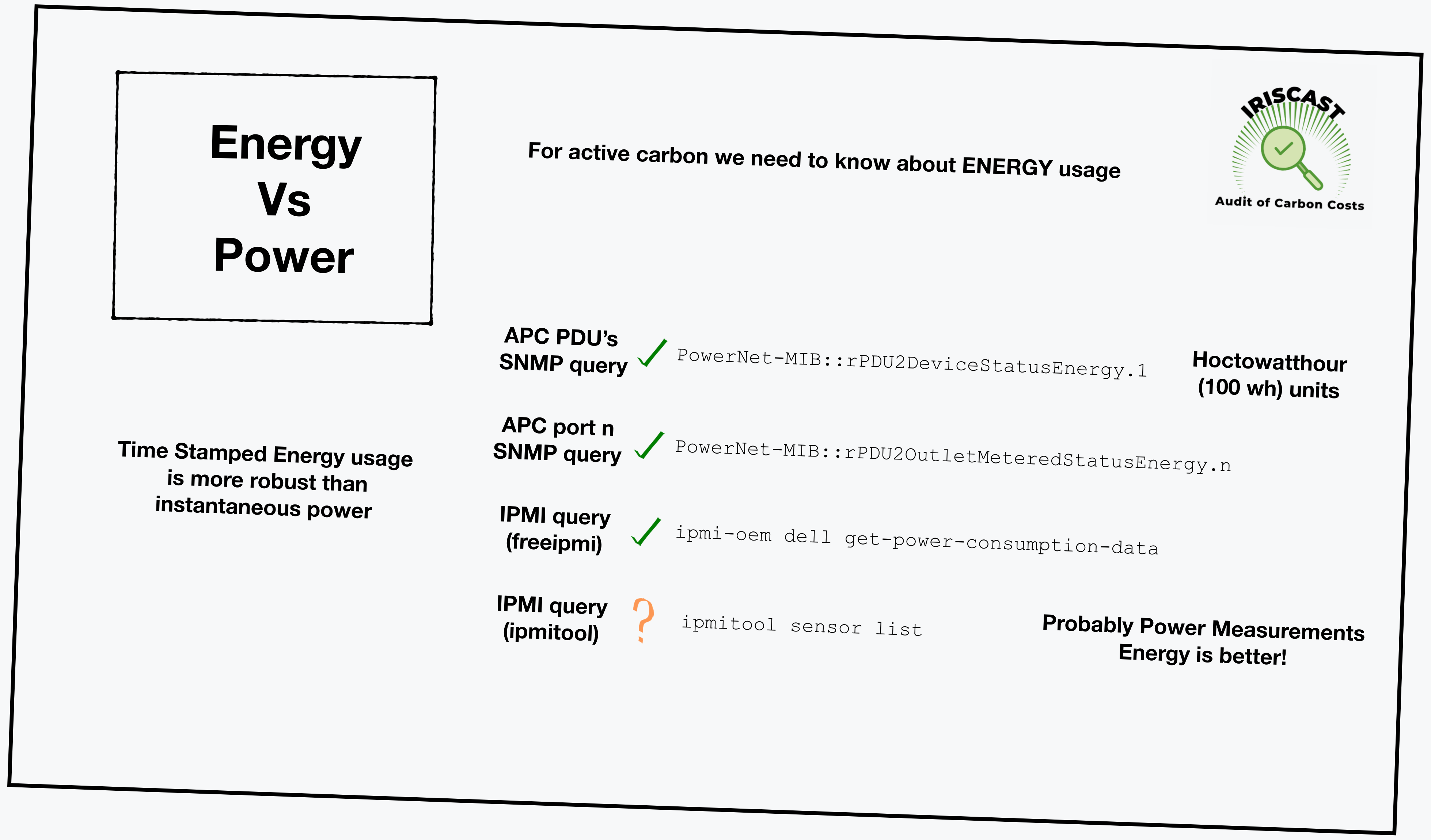
Facility Inventory at Cambridge

Model	Node Specification		Quantity
	CPU	RAM	
Dell PowerEdge C6420	x2 Intel Xeon Gold 5120 CPUs	512 GB	452
Dell PowerEdge C6525	x2 AMD EPYC 7H12	1024 GB	360

Facility Inventory at Durham

Model	Node Specification		Quantity
	CPU	RAM	
Dell C6420	Intel Xeon 4108	96GB	96
Dell C6525	AMD Epyc7452	512	138
Supermicro	AMD Epyc7452	512	238
Supermicro	Intel 6130	384GB	74
Dell	Various	Various	10
GPU Nodes	Various	Various	94
FPGA Node	Intel 6148	192GB	1
Control Plane	Various	Various	12
Storage Nodes	Various	Various	105
Network Switches	Various	Various	-

Facility Inventory at STFC CLOUD



Energy Vs Power

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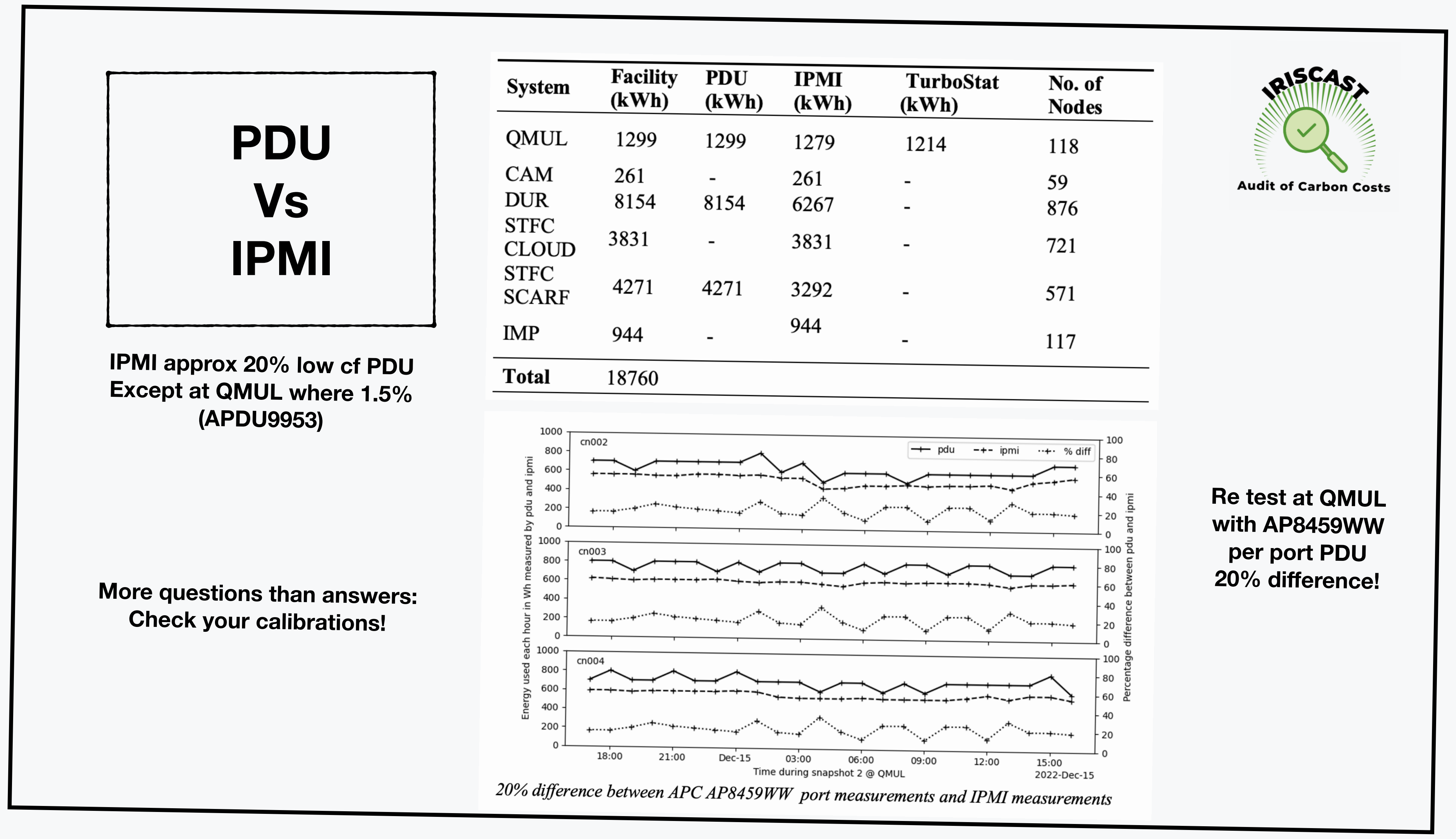
For active carbon we need to know about ENERGY usage

Time Stamped Energy usage is more robust than instantaneous power

APC PDU's SNMP query	✓	`PowerNet-MIB::rPDU2DeviceStatusEnergy.1`	Hoctowatthour (100 wh) units
APC port n SNMP query	✓	`PowerNet-MIB::rPDU2OutletMeteredStatusEnergy.n`	
IPMI query (freeipmi)	✓	`ipmi-oem dell get-power-consumption-data`	
IPMI query (ipmitool)	?	`ipmitool sensor list`	Probably Power Measurements Energy is better!



PDU Vs IPMI

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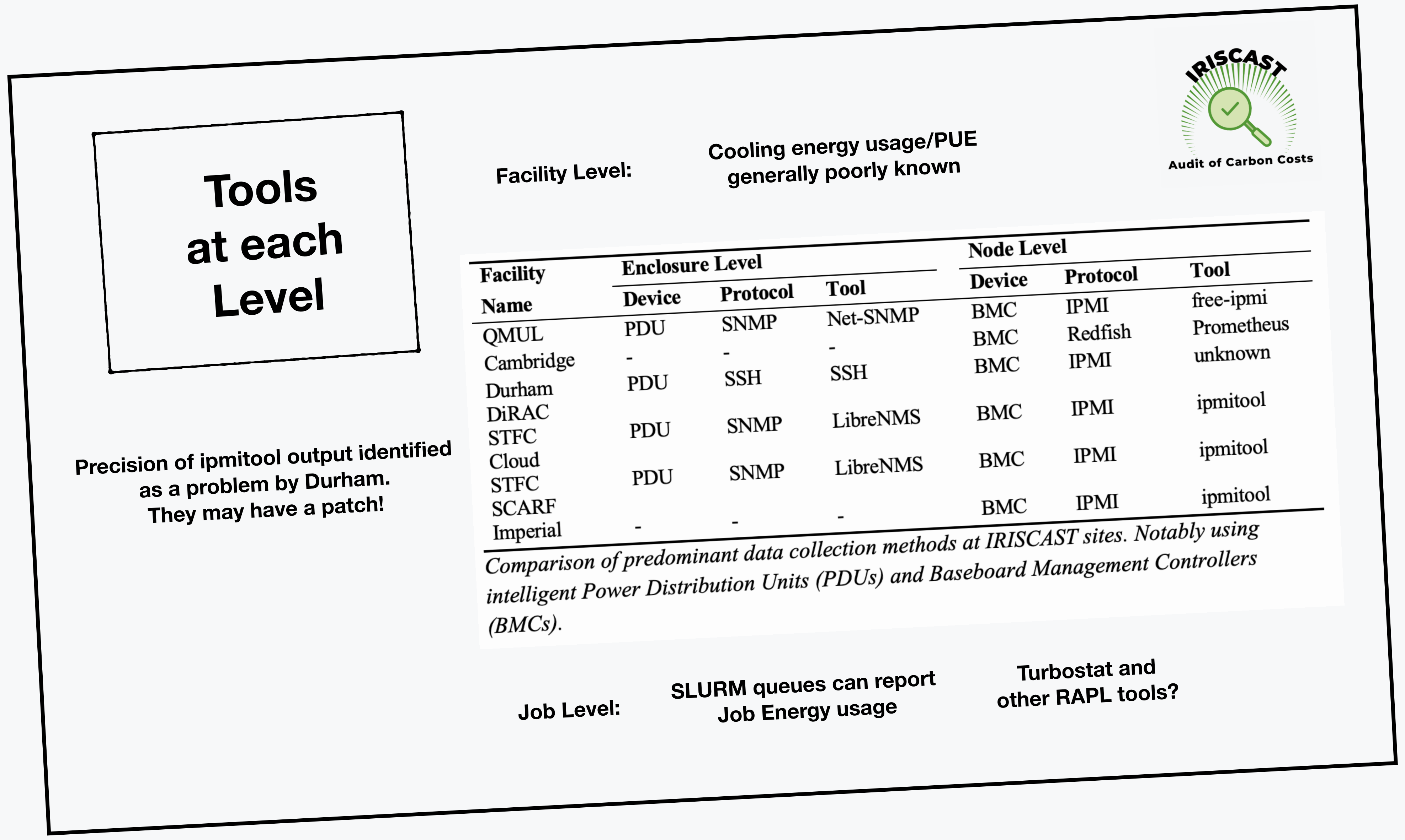
System	Facility (kWh)	PDU (kWh)	IPMI (kWh)	TurboStat (kWh)	No. of Nodes
QMUL	1299	1299	1279	1214	118
CAM	261	-	261	-	59
DUR	8154	8154	6267	-	876
STFC CLOUD	3831	-	3831	-	721
STFC SCARF	4271	4271	3292	-	571
IMP	944	-	944	-	117
Total	18760				

20% difference between APC AP8459WW port measurements and IPMI measurements

IPMI approx 20% low cf PDU
Except at QMUL where 1.5%
(APDU9953)

Re test at QMUL with AP8459WW per port PDU 20% difference!

More questions than answers:
Check your calibrations!



Tools at each Level

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Audit of Carbon Costs

Facility Level: Cooling energy usage/PUE generally poorly known

Facility Name	Enclosure Level			Node Level		
	Device	Protocol	Tool	Device	Protocol	Tool
QMUL	PDU	SNMP	Net-SNMP	BMC	IPMI	free-ipmi
Cambridge	-	-	-	BMC	Redfish	Prometheus
Durham	PDU	SSH	SSH	BMC	IPMI	unknown
DiRAC STFC Cloud	PDU	SNMP	LibreNMS	BMC	IPMI	ipmitool
STFC SCARF	PDU	SNMP	LibreNMS	BMC	IPMI	ipmitool
Imperial	-	-	-	BMC	IPMI	ipmitool

Comparison of predominant data collection methods at IRISCAST sites. Notably using intelligent Power Distribution Units (PDUs) and Baseboard Management Controllers (BMCs).

Precision of ipmitool output identified as a problem by Durham.
They may have a patch!

Job Level: SLURM queues can report Job Energy usage

Turbostat and other RAPL tools?

IRISCAST Proposes

High Level Feedback

Carbon Equivalent per month

1. Future DRI procurement to include a score based on embedded carbon costs and equipment energy usage.
2. New computer hardware to include energy measurement capability such as IPMI (or per port PDUs) and require the supplier to provide best estimates of embedded carbon costs.
3. Measure energy used by cooling infrastructure and the computing infrastructure.
4. Facilities to keep an inventory of equipment including embedded carbon cost and idle power draw.
5. Monthly (or other periodic) reporting of carbon usage by facilities based on 3 and 4 above. Roll into standard grant reporting regime.

Low Level Feedback

Figure of merit per Job → **Carbon Equivalent per Job**

6. Collect per job (or VM) energy usage by using tools like Slurm (correctly configured). Combined this with embedded carbon from inventory and electricity carbon intensity to feedback job carbon cost to the end user to drive improvements in user code and workflow.
7. Identify user communities and the authors of community codebases so that useful feedback can be given to them to drive the development of more efficient code and workflows.

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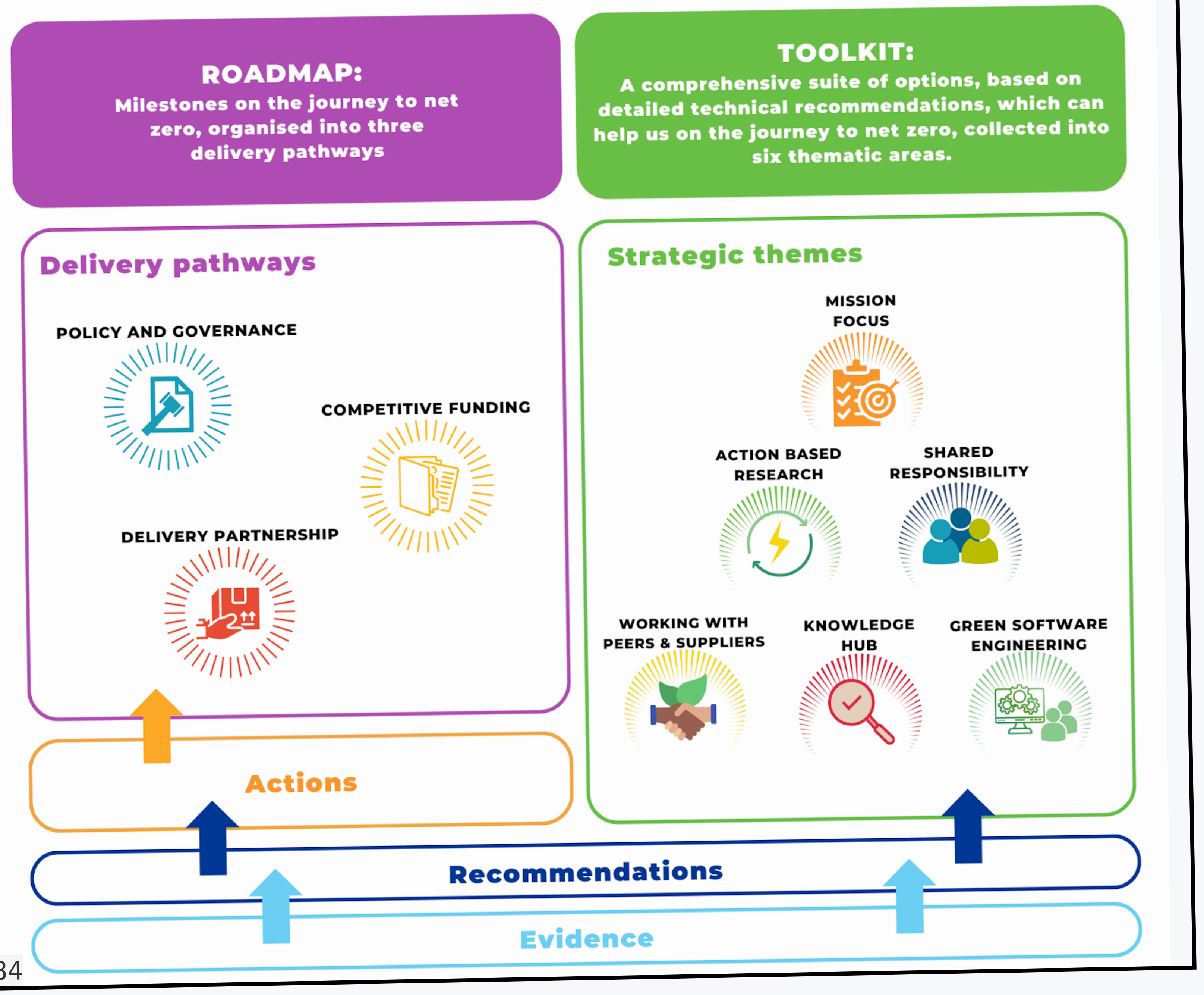
UKRI DRI Net Zero Scoping Outputs



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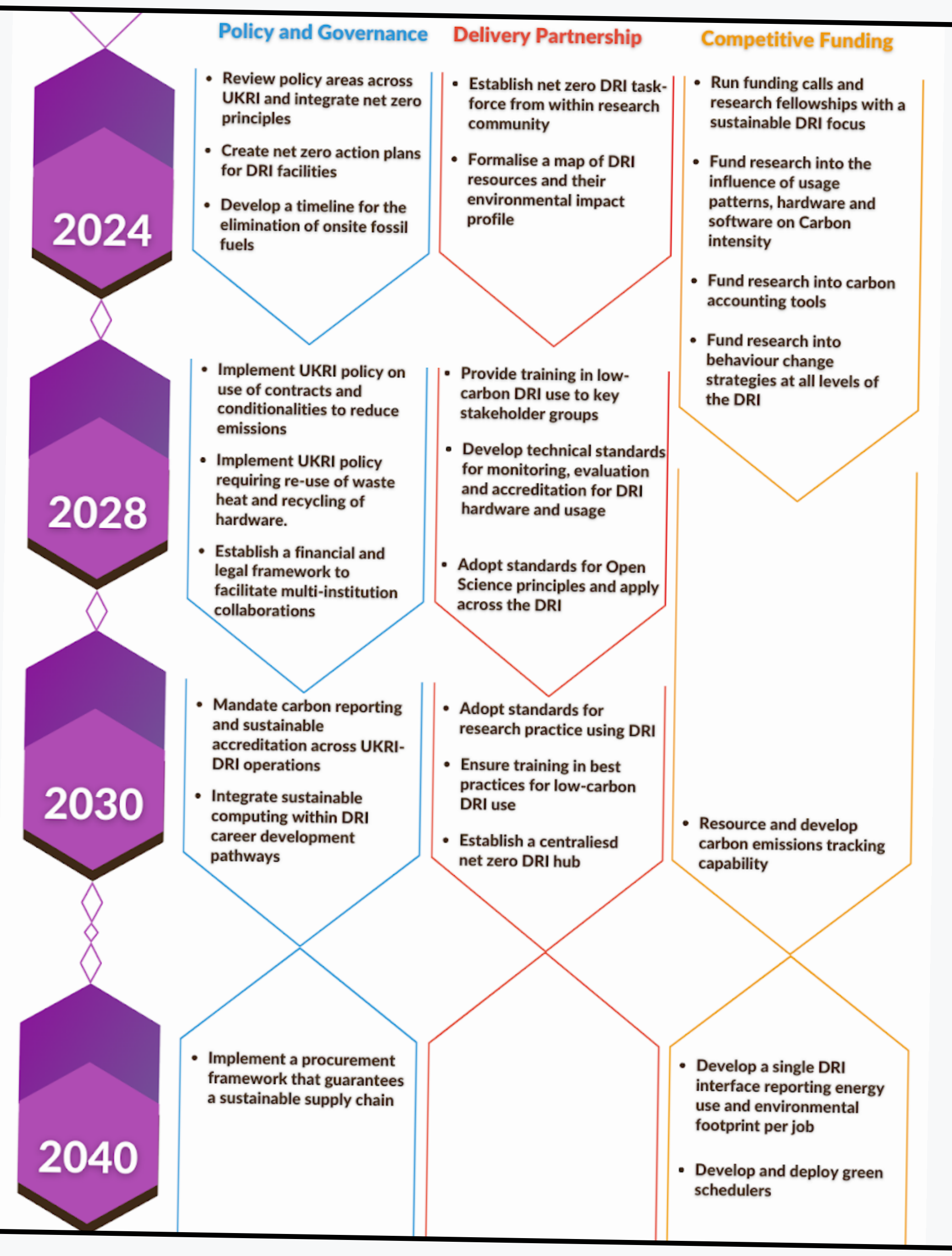
Grant call to lead the follow on implementation activity closed this week

Lets see what happens next…

UKRI DRI Net Zero Scoping Roadmap



	Policy and Governance	Delivery Partnership	Competitive Funding
2024	Review policy areas across UKRI and integrate net zero principles Create net zero action plans for DRI facilities Develop a timeline for the elimination of onsite fossil fuels	Establish net zero DRI task-force from within research community Formalise a map of DRI resources and their environmental impact profile	Run funding calls and research fellowships with a sustainable DRI focus Fund research into the influence of usage patterns, hardware and software on Carbon intensity Fund research into carbon accounting tools Fund research into behaviour change strategies at all levels of the DRI
2028	Implement UKRI policy on use of contracts and conditionalities to reduce emissions Implement UKRI policy requiring re-use of waste heat and recycling of hardware. Establish a financial and legal framework to facilitate multi-institution collaborations	Provide training in low-carbon DRI use to key stakeholder groups Develop technical standards for monitoring, evaluation and accreditation for DRI hardware and usage Adopt standards for Open Science principles and apply across the DRI	
2030	Mandate carbon reporting and sustainable accreditation across UKRI-DRI operations Integrate sustainable computing within DRI career development pathways	Adopt standards for research practice using DRI Ensure training in best practices for low-carbon DRI use Establish a centraliesd net zero DRI hub	Resource and develop carbon emissions tracking capability
2040	Implement a procurement framework that guarantees a sustainable supply chain		Develop a single DRI interface reporting energy use and environmental footprint per job Develop and deploy green schedulers

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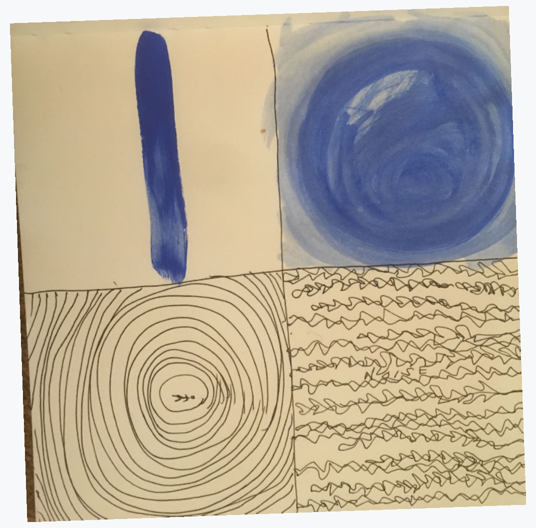
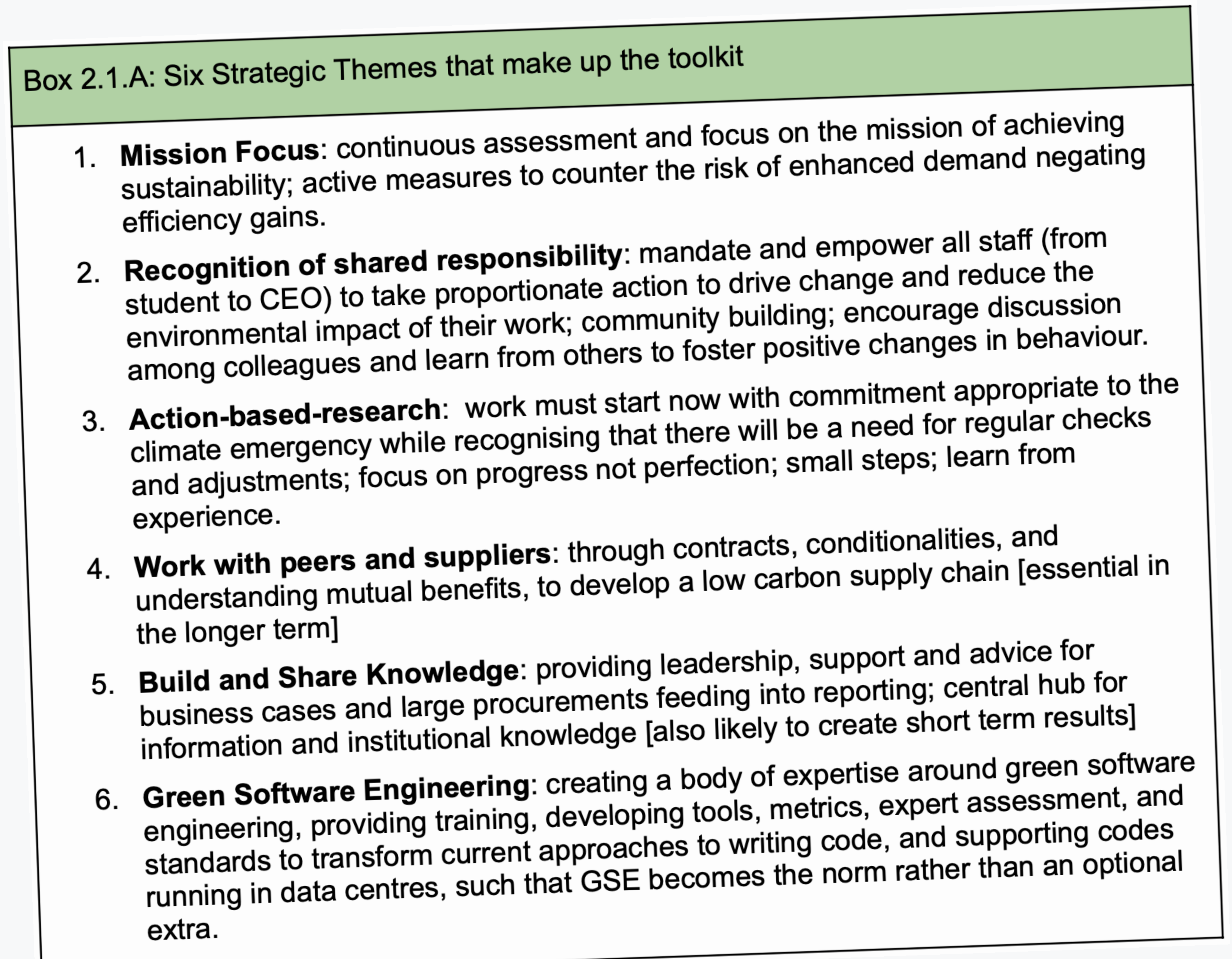
UKRI DRI Net Zero Scoping Toolkit





Box 2.1.A: Six Strategic Themes that make up the toolkit

1. **Mission Focus**: continuous assessment and focus on the mission of achieving sustainability; active measures to counter the risk of enhanced demand negating efficiency gains.
2. **Recognition of shared responsibility**: mandate and empower all staff (from student to CEO) to take proportionate action to drive change and reduce the environmental impact of their work; community building; encourage discussion among colleagues and learn from others to foster positive changes in behaviour.
3. **Action-based-research**: work must start now with commitment appropriate to the climate emergency while recognising that there will be a need for regular checks and adjustments; focus on progress not perfection; small steps; learn from experience.
4. **Work with peers and suppliers**: through contracts, conditionalities, and understanding mutual benefits, to develop a low carbon supply chain [essential in the longer term]
5. **Build and Share Knowledge**: providing leadership, support and advice for business cases and large procurements feeding into reporting; central hub for information and institutional knowledge [also likely to create short term results]
6. **Green Software Engineering**: creating a body of expertise around green software engineering, providing training, developing tools, metrics, expert assessment, and standards to transform current approaches to writing code, and supporting codes running in data centres, such that GSE becomes the norm rather than an optional extra.

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iris Carbon Mapping Project

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Motivation: How should IRIS work towards NetZero DRI?

Models and Tools

Outline Delivery Roadmap

Allocate Carbon Costs to User Payloads

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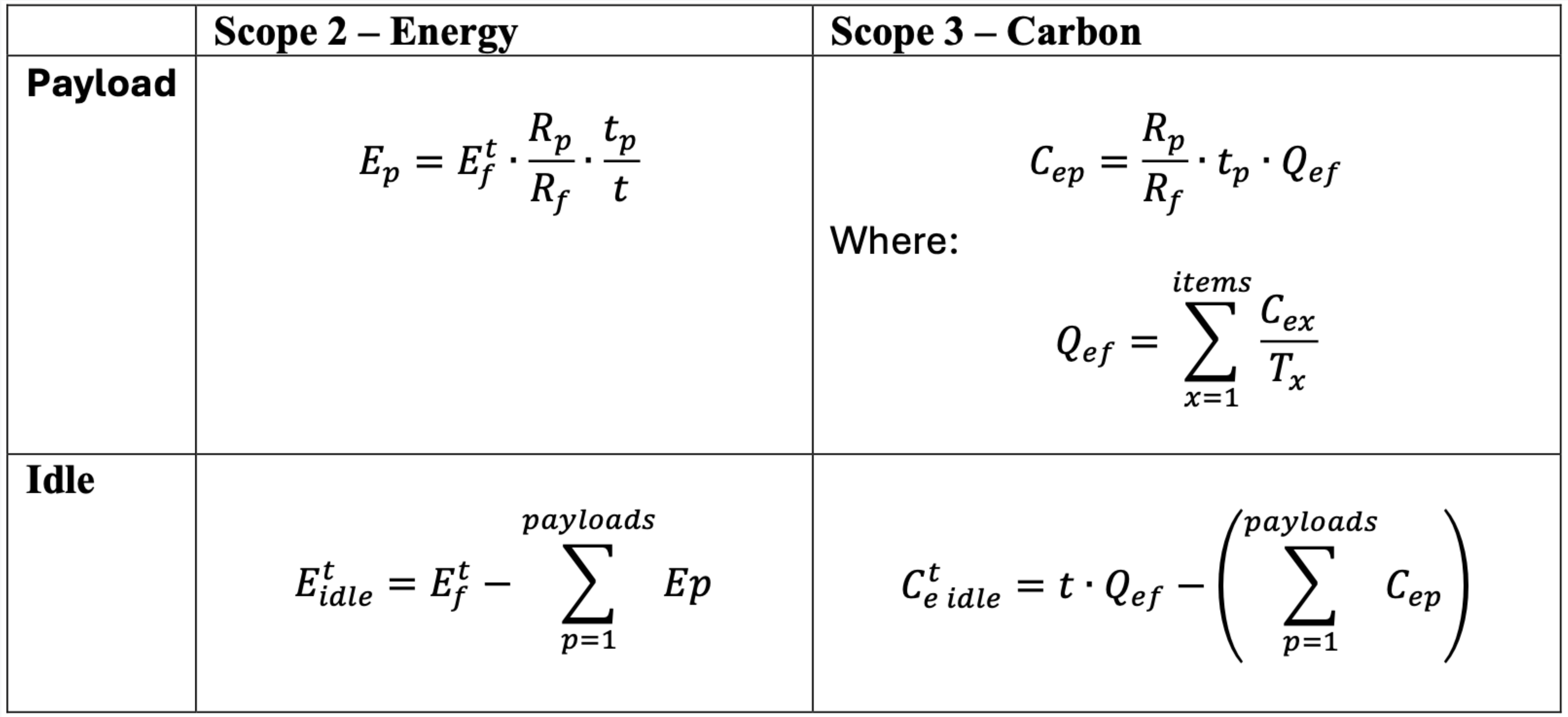
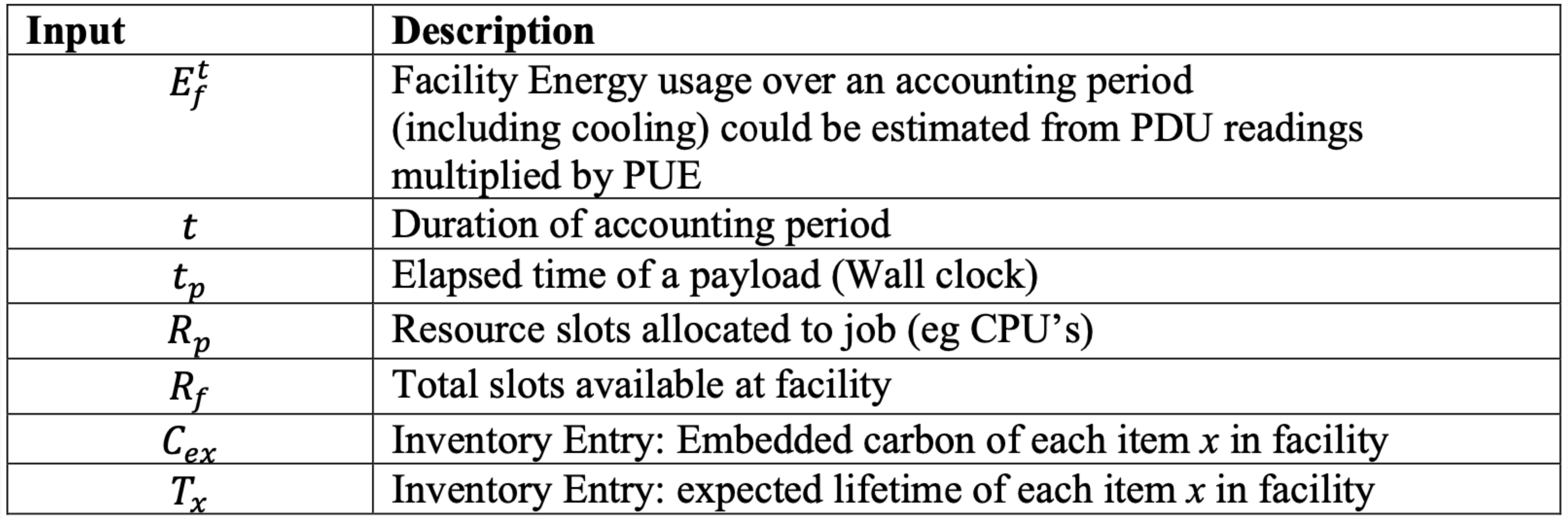
Apportion by Real Time



	Scope 2 – Energy	**Scope 3 – Carbon**
Payload	$E_p = E_f^t \cdot \frac{R_p}{R_f} \cdot \frac{t_p}{t}$	$C_{ep} = \frac{R_p}{R_f} \cdot t_p \cdot Q_{ef}$ Where: $Q_{ef} = \sum_{x=1}^{items} \frac{C_{ex}}{T_x}$
Idle	$E_{idle}^t = E_f^t - \sum_{p=1}^{payloads} Ep$	$C_{e\ idle}^t = t \cdot Q_{ef} - \left(\sum_{p=1}^{payloads} C_{ep} \right)$

Table 1: Summary of the Simple Payload Model showing allocations of Scope 2 energy and Scope 3 carbon to user payloads and the remaining idle allocation to the provider.

Simple Payload Model



Input	**Description**
E_f^t	Facility Energy usage over an accounting period (including cooling) could be estimated from PDU readings multiplied by PUE
t	Duration of accounting period
t_p	Elapsed time of a payload (Wall clock)
R_p	Resource slots allocated to job (eg CPU's)
R_f	Total slots available at facility
C_{ex}	Inventory Entry: Embedded carbon of each item x in facility
T_x	Inventory Entry: expected lifetime of each item x in facility

Table 2: Summary of the inputs needed to evaluate the Simple Payload Model.

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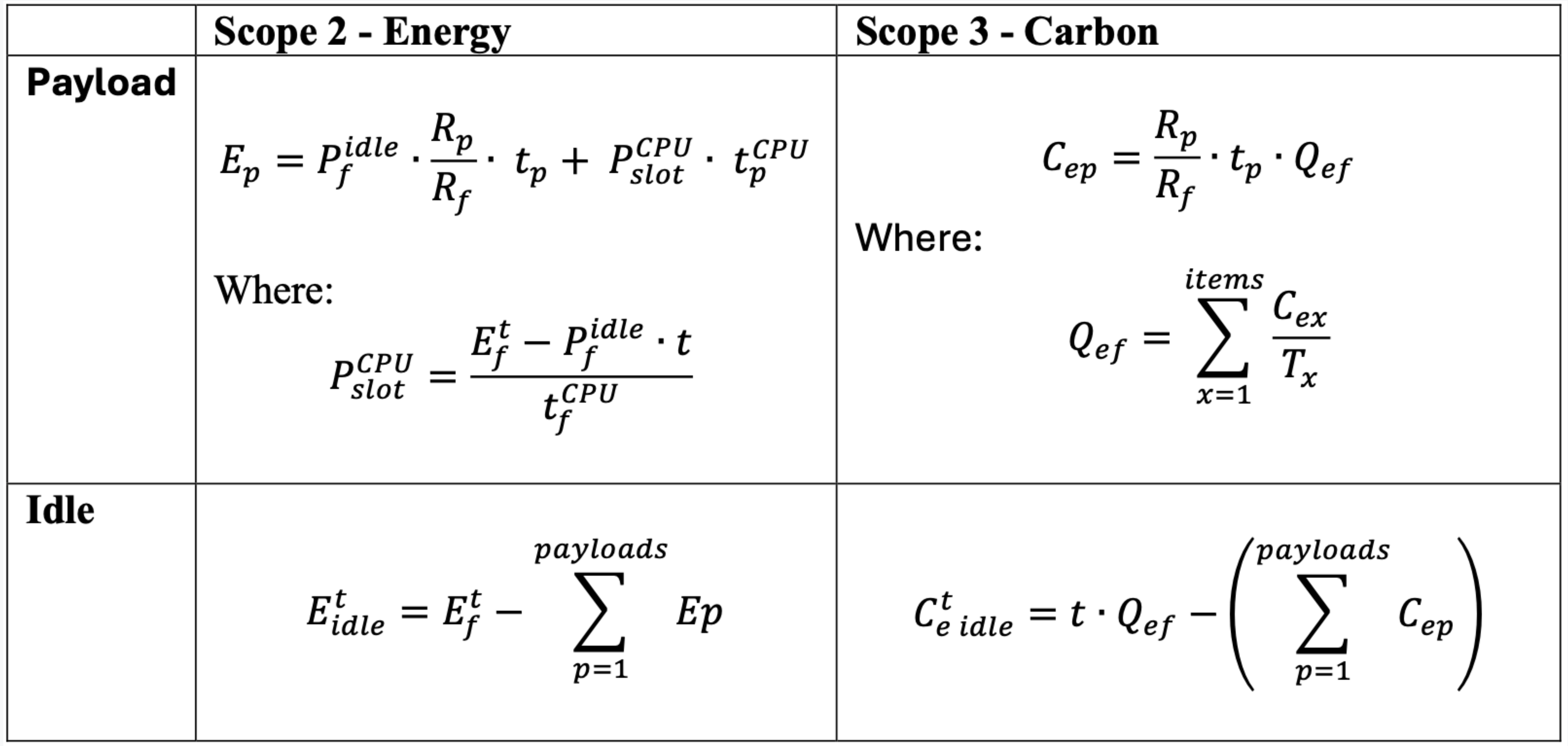
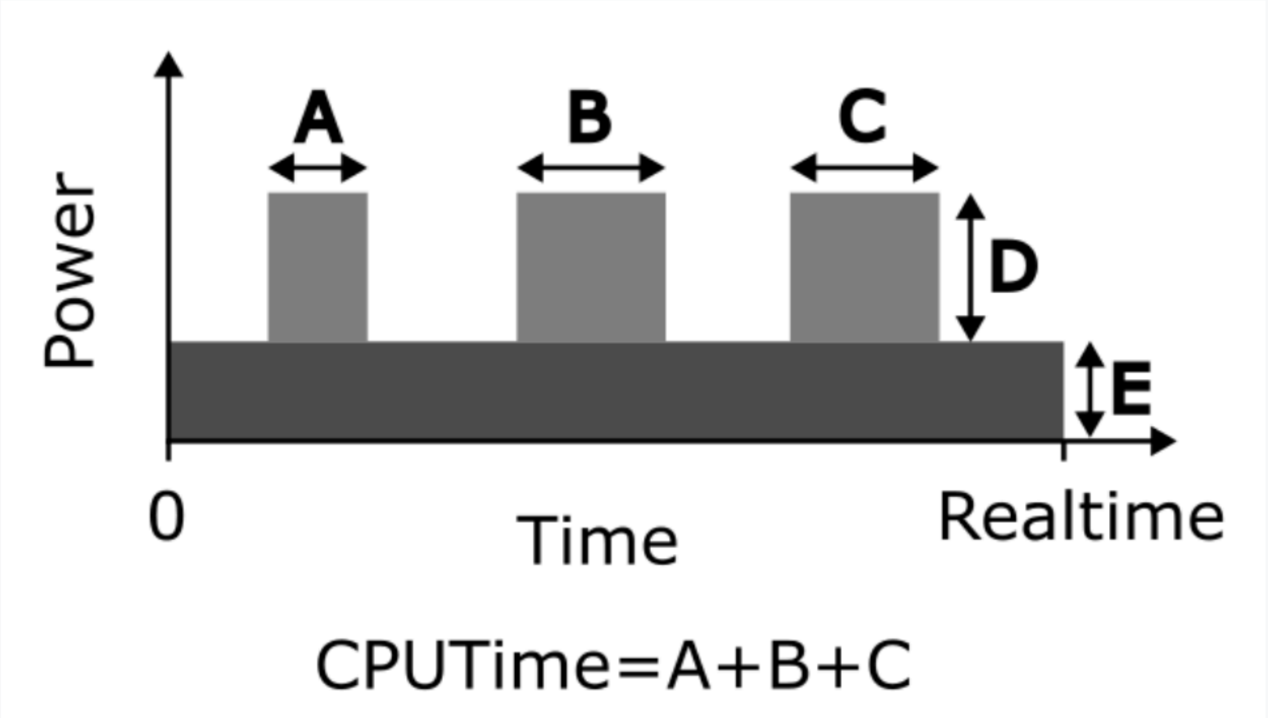
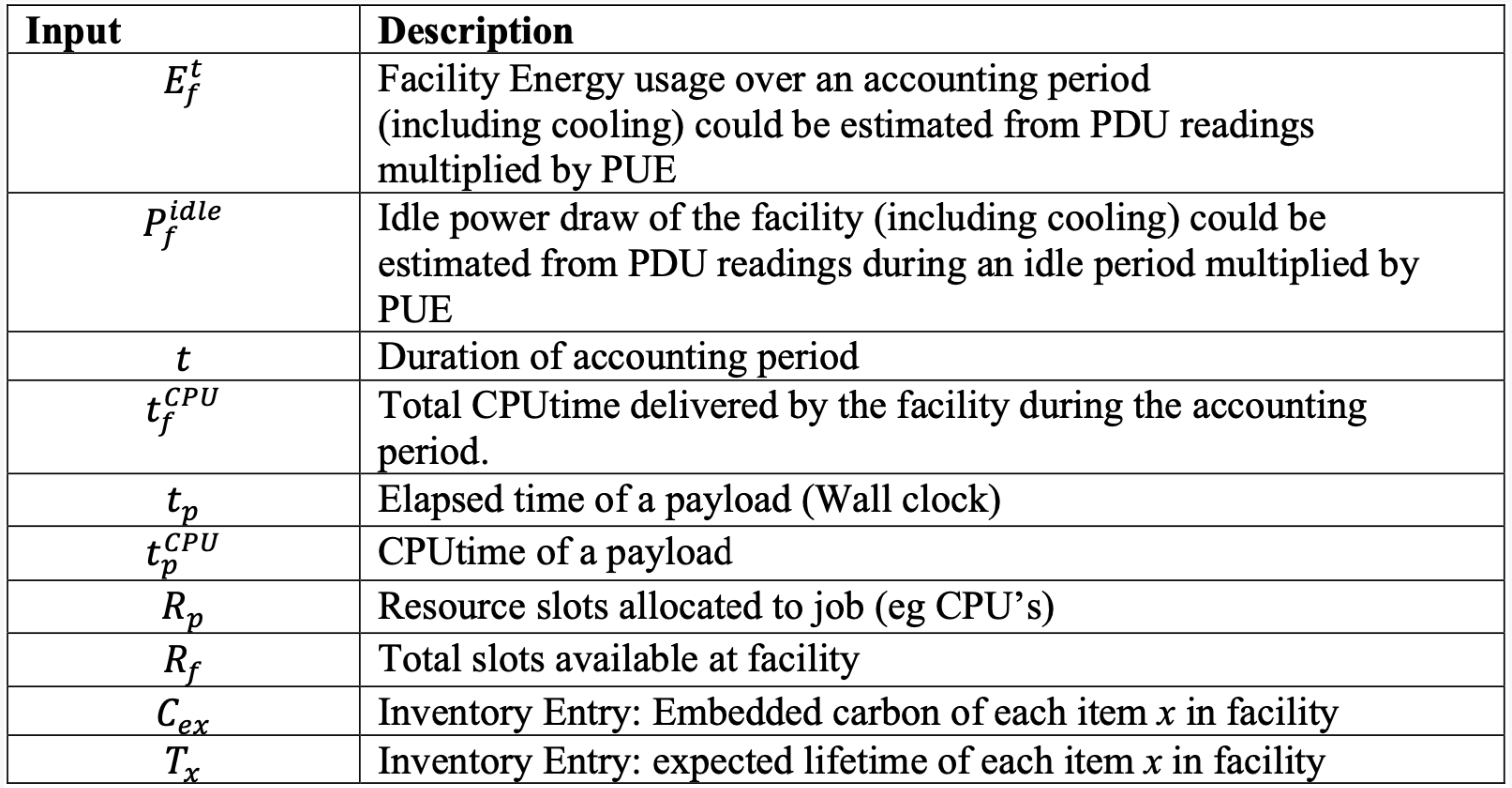


	Scope 2 - Energy	Scope 3 - Carbon
Payload	$E_p = P_f^{idle} \cdot \frac{R_p}{R_f} \cdot t_p + P_{slot}^{CPU} \cdot t_p^{CPU}$ Where: $P_{slot}^{CPU} = \frac{E_f^t - P_f^{idle} \cdot t}{t_f^{CPU}}$	$C_{ep} = \frac{R_p}{R_f} \cdot t_p \cdot Q_{ef}$ Where: $Q_{ef} = \sum_{x=1}^{items} \frac{C_{ex}}{T_x}$
Idle	$E_{idle}^t = E_f^t - \sum_{p=1}^{payloads} Ep$	$C_{e\ idle}^t = t \cdot Q_{ef} - \left(\sum_{p=1}^{payloads} C_{ep} \right)$

Table 3: Summary of the Enhanced Payload Model showing allocations of Scope 2 energy and Scope 3 carbon to user payloads and the remaining idle allocation to the provider





Input	Description
E_f^t	Facility Energy usage over an accounting period (including cooling) could be estimated from PDU readings multiplied by PUE
P_f^{idle}	Idle power draw of the facility (including cooling) could be estimated from PDU readings during an idle period multiplied by PUE
t	Duration of accounting period
t_f^{CPU}	Total CPUtime delivered by the facility during the accounting period.
t_p	Elapsed time of a payload (Wall clock)
t_p^{CPU}	CPUtime of a payload
R_p	Resource slots allocated to job (eg CPU's)
R_f	Total slots available at facility
C_{ex}	Inventory Entry: Embedded carbon of each item x in facility
T_x	Inventory Entry: expected lifetime of each item x in facility

Table 4: Summary of the inputs needed to evaluate the Enhanced Payload Model.

Enhanced Payload Model

Know your idle power?

Know your CPUtime?

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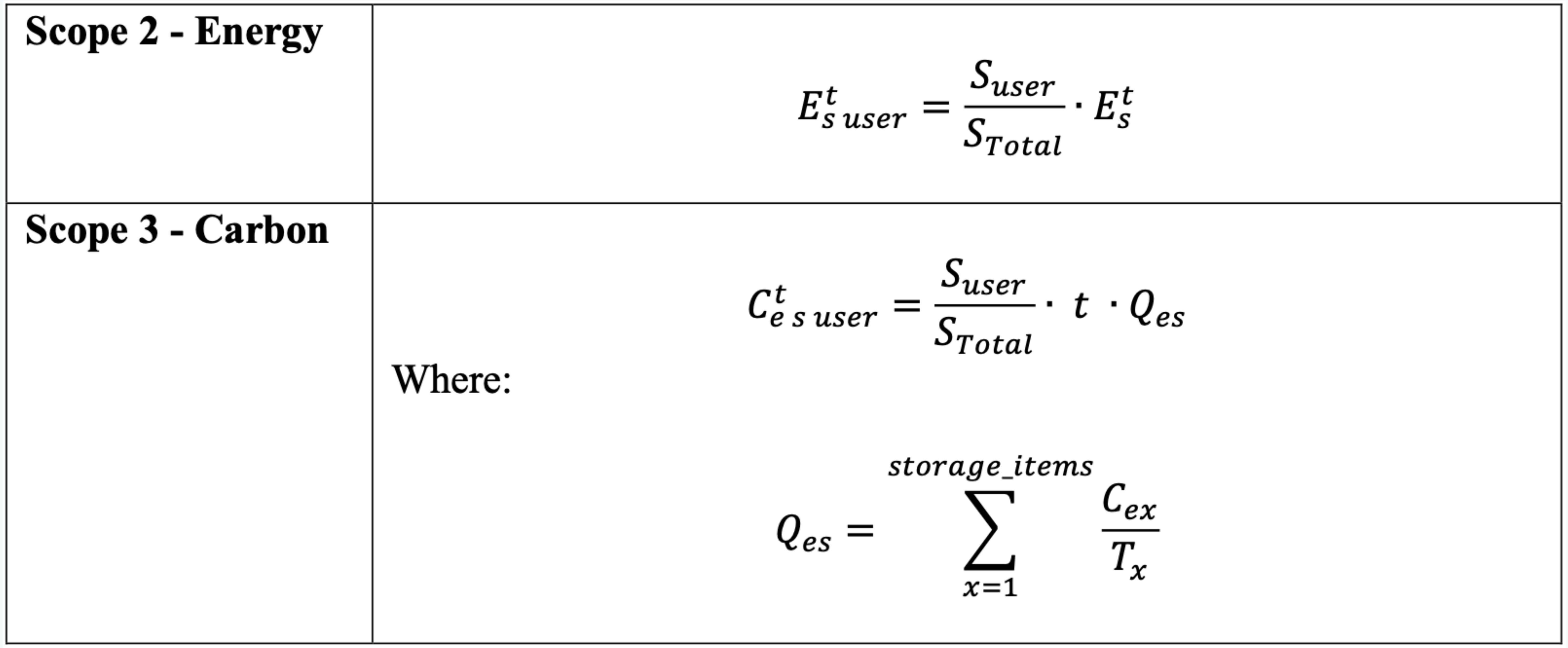
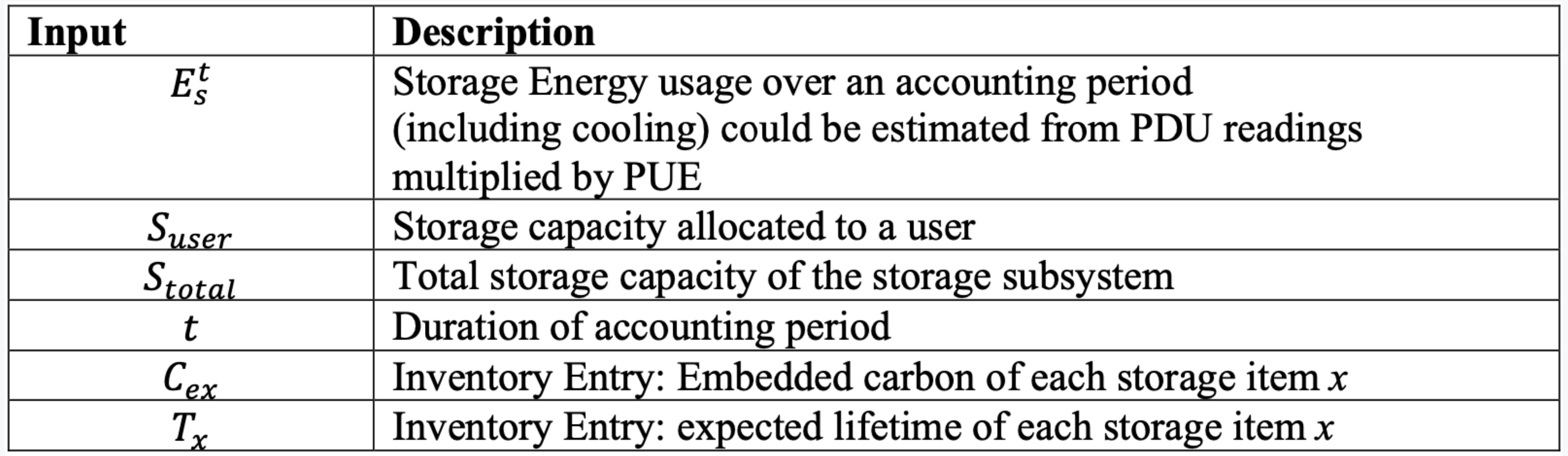


Scope 2 - Energy	$E^t_{s\,user} = \frac{S_{user}}{S_{Total}} \cdot E^t_s$
Scope 3 - Carbon	$C^t_{e\,s\,user} = \frac{S_{user}}{S_{Total}} \cdot t \cdot Q_{es}$ Where: $Q_{es} = \sum_{x=1}^{storage\_items} \frac{C_{ex}}{T_x}$

Table 5: Summary of the Simple Storage Model showing allocations of Scope 2 energy and Scope 3 carbon to user storage use and the remaining allocation to the provider.

Apportion by Quota

Simple Storage Model



Input	**Description**
E^t_s	Storage Energy usage over an accounting period (including cooling) could be estimated from PDU readings multiplied by PUE
S_{user}	Storage capacity allocated to a user
S_{total}	Total storage capacity of the storage subsystem
t	Duration of accounting period
C_{ex}	Inventory Entry: Embedded carbon of each storage item x
T_x	Inventory Entry: expected lifetime of each storage item x

Table 6: Summary of the inputs needed to evaluate the Simple Storage Model.

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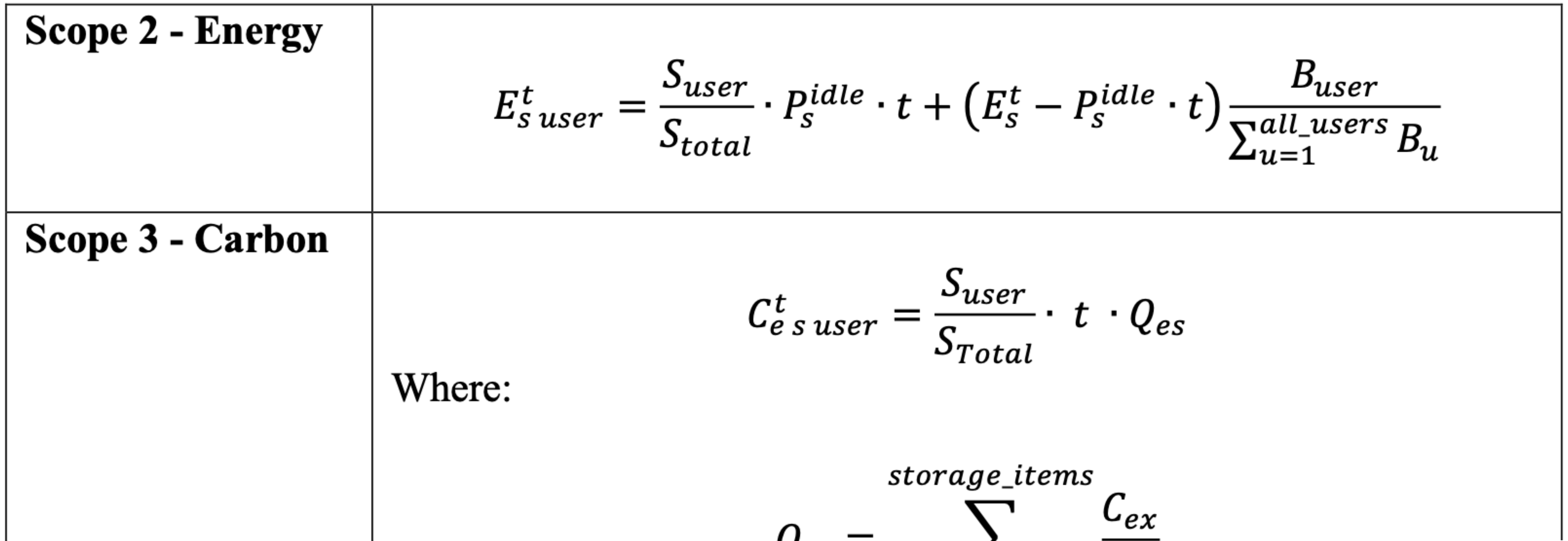
Enhanced Storage Model

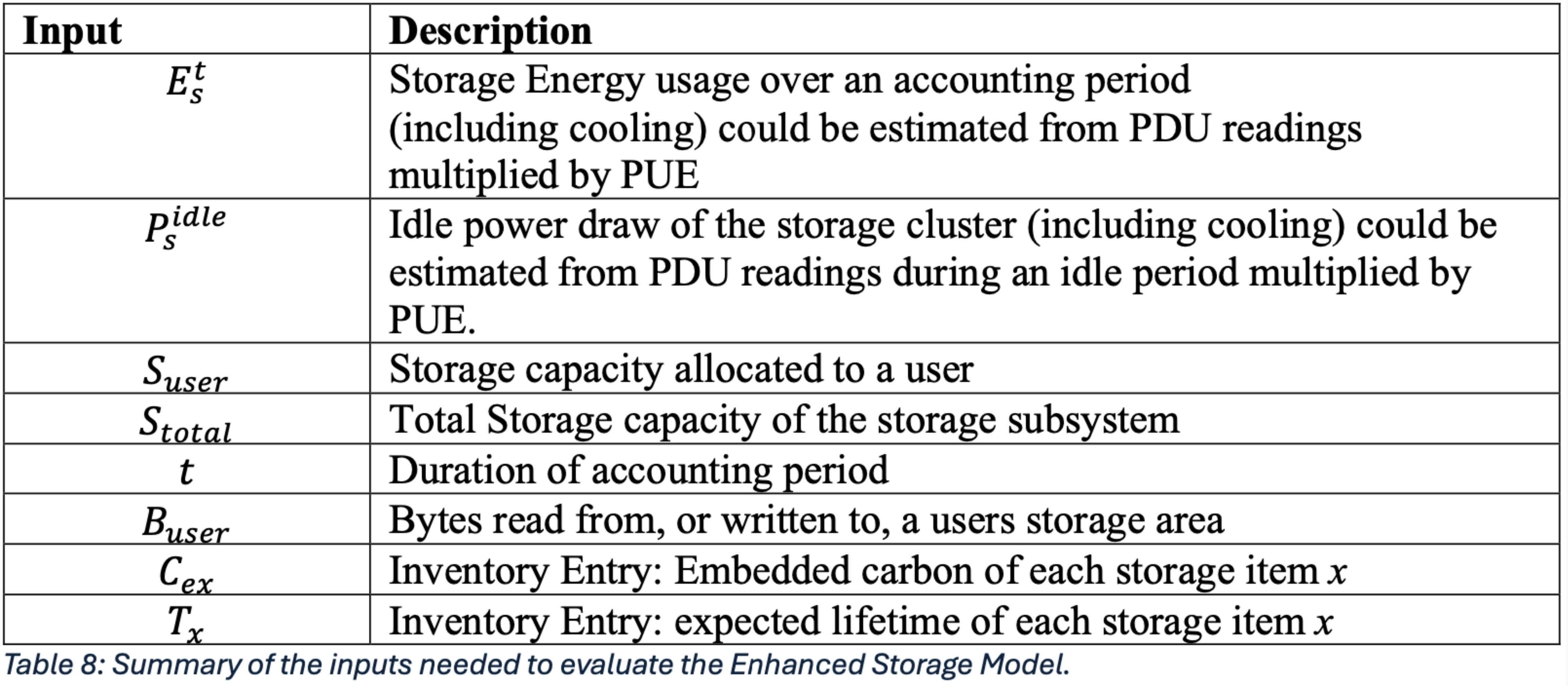


Scope 2 - Energy	$E^t_{s\,user} = \frac{S_{user}}{S_{total}} \cdot P_s^{idle} \cdot t + \left(E_s^t - P_s^{idle} \cdot t\right)\frac{B_{user}}{\sum_{u=1}^{all\_users} B_u}$
Scope 3 - Carbon	$C^t_{e\,s\,user} = \frac{S_{user}}{S_{Total}} \cdot t \cdot Q_{es}$ Where: $Q_{es} = \sum_{x=1}^{storage\_items} \frac{C_{ex}}{T_x}$

Table 7: Summary of the Enhanced Storage Model showing allocations of Scope 2 energy and Scop storage use and the remaining allocation to the provider.

Know your idle power?

Know your bytes?



Input	Description
E_s^t	Storage Energy usage over an accounting period (including cooling) could be estimated from PDU readings multiplied by PUE
P_s^{idle}	Idle power draw of the storage cluster (including cooling) could be estimated from PDU readings during an idle period multiplied by PUE.
S_{user}	Storage capacity allocated to a user
S_{total}	Total Storage capacity of the storage subsystem
t	Duration of accounting period
B_{user}	Bytes read from, or written to, a users storage area
C_{ex}	Inventory Entry: Embedded carbon of each storage item x
T_x	Inventory Entry: expected lifetime of each storage item x

Table 8: Summary of the inputs needed to evaluate the Enhanced Storage Model.

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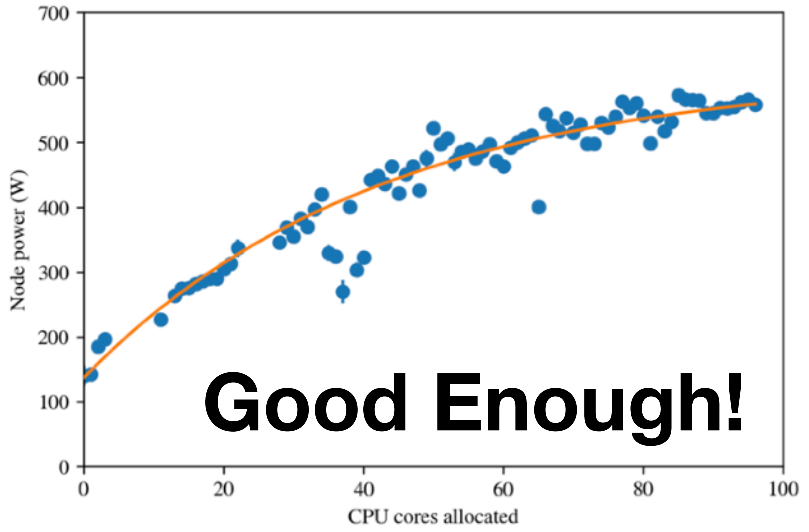
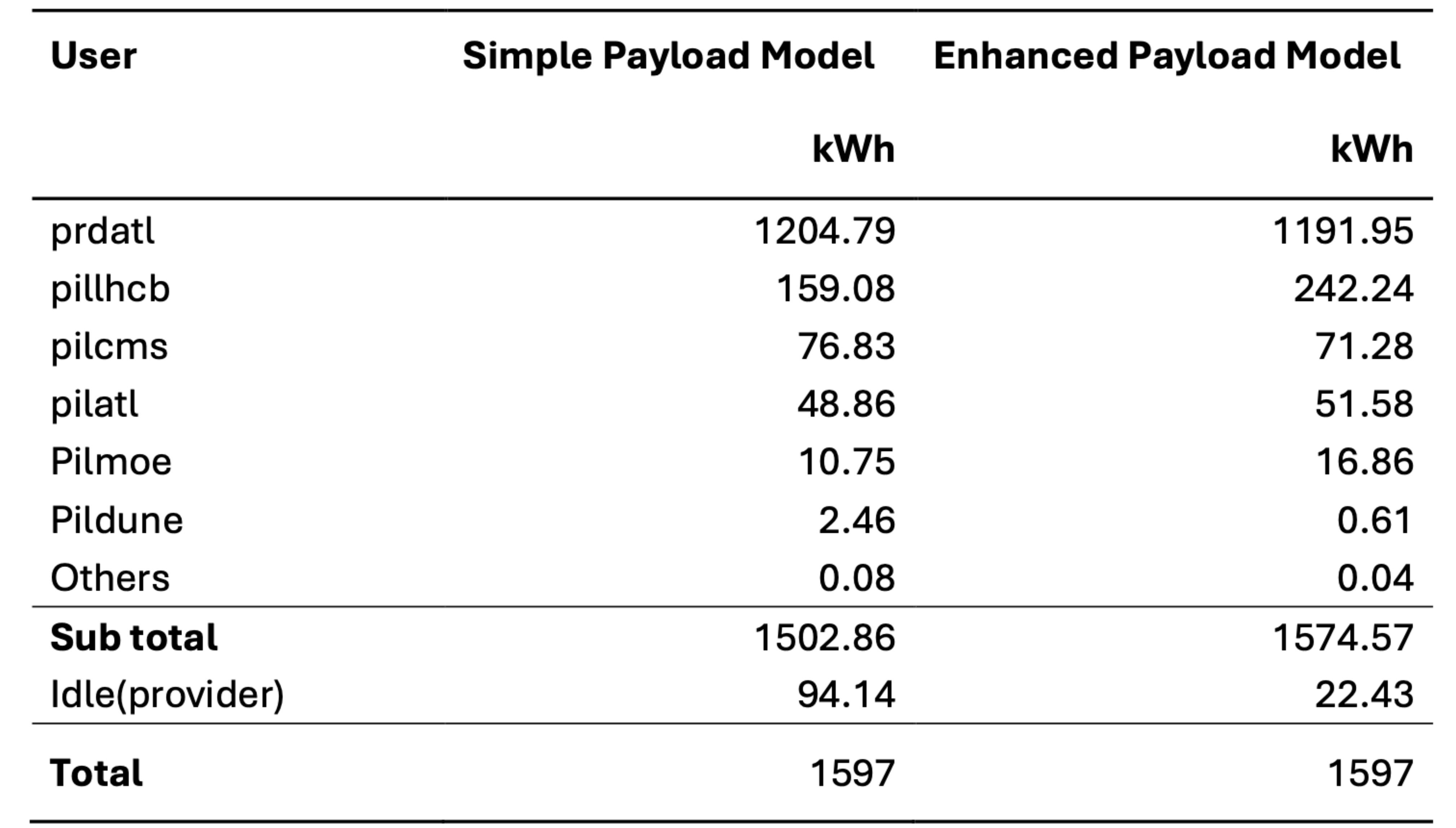
Nice model but is it practical?

Idle Power →



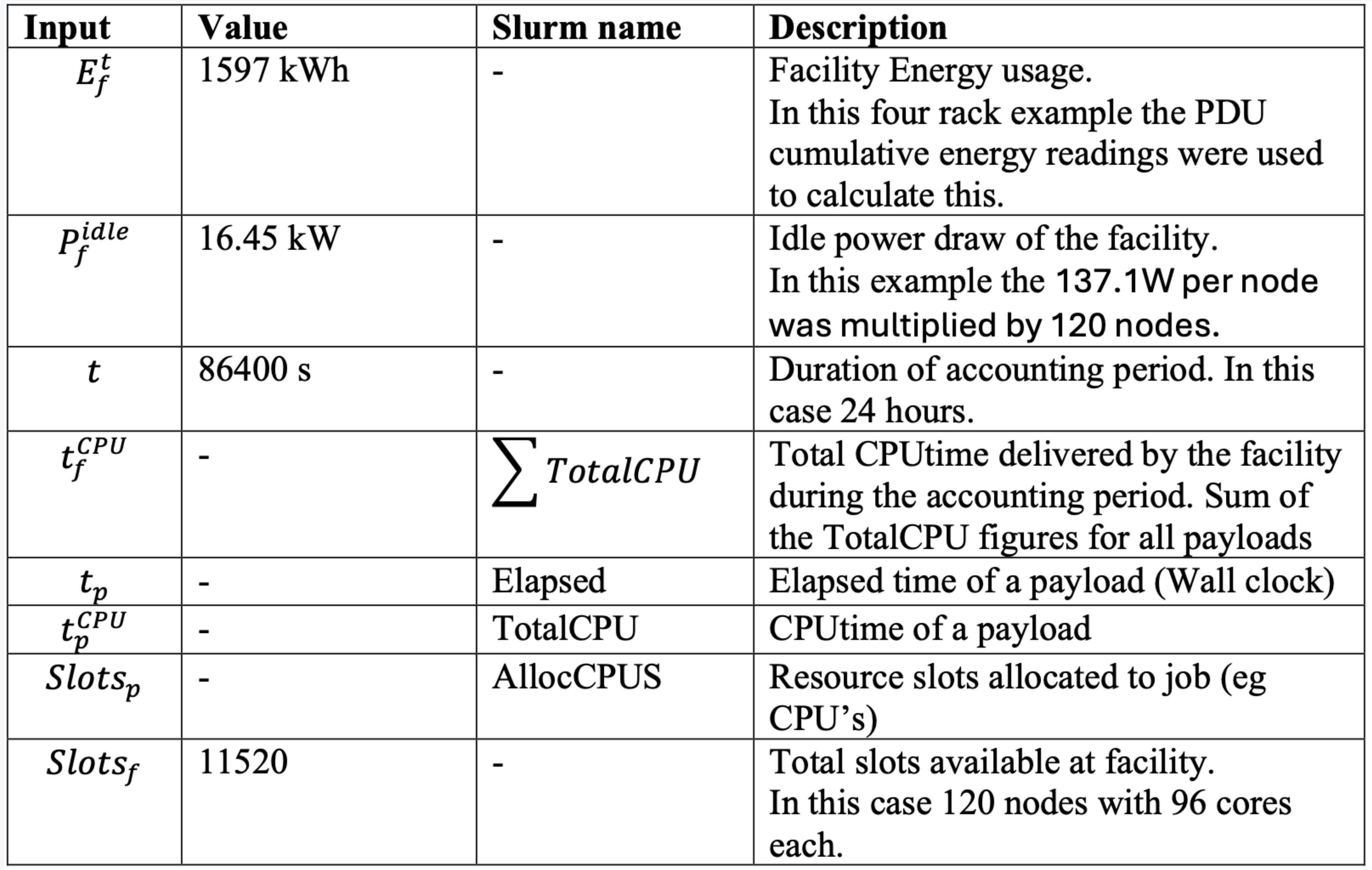
Good Enough!

Figure 2: Node power P_N as a function of allocated CPU cores in a node N_{CA}. The Blue dots and error bars show the mean power and std-deviation for each discrete N_{CA}. Regression line y-intercept gives the idle power of a node $P_{idle} \approx 137.1W$.



User	Simple Payload Model kWh	Enhanced Payload Model kWh
prdatl	1204.79	1191.95
pillhcb	159.08	242.24
pilcms	76.83	71.28
pilatl	48.86	51.58
Pilmoe	10.75	16.86
Pildune	2.46	0.61
Others	0.08	0.04
Sub total	1502.86	1574.57
Idle(provider)	94.14	22.43
Total	1597	1597

Table 10: Results of evaluating the Simple and Enhanced Payload models on QMUL batch payloads the 24 hour period of 2024-03-07.



Input	Value	Slurm name	Description
E_f^t	1597 kWh	-	Facility Energy usage. In this four rack example the PDU cumulative energy readings were used to calculate this.
P_f^{idle}	16.45 kW	-	Idle power draw of the facility. In this example the 137.1W per node was multiplied by 120 nodes.
t	86400 s	-	Duration of accounting period. In this case 24 hours.
t_f^{CPU}	-	$\sum TotalCPU$	Total CPUtime delivered by the facility during the accounting period. Sum of the TotalCPU figures for all payloads
t_p	-	Elapsed	Elapsed time of a payload (Wall clock)
t_p^{CPU}	-	TotalCPU	CPUtime of a payload
$Slots_p$	-	AllocCPUS	Resource slots allocated to job (eg CPU's)
$Slots_f$	11520	-	Total slots available at facility. In this case 120 nodes with 96 cores each.

Table 9: Measured and derived constants and Slurm accounting data names used to evaluate the payload models for QMUL batch payloads.

Works for Batch!

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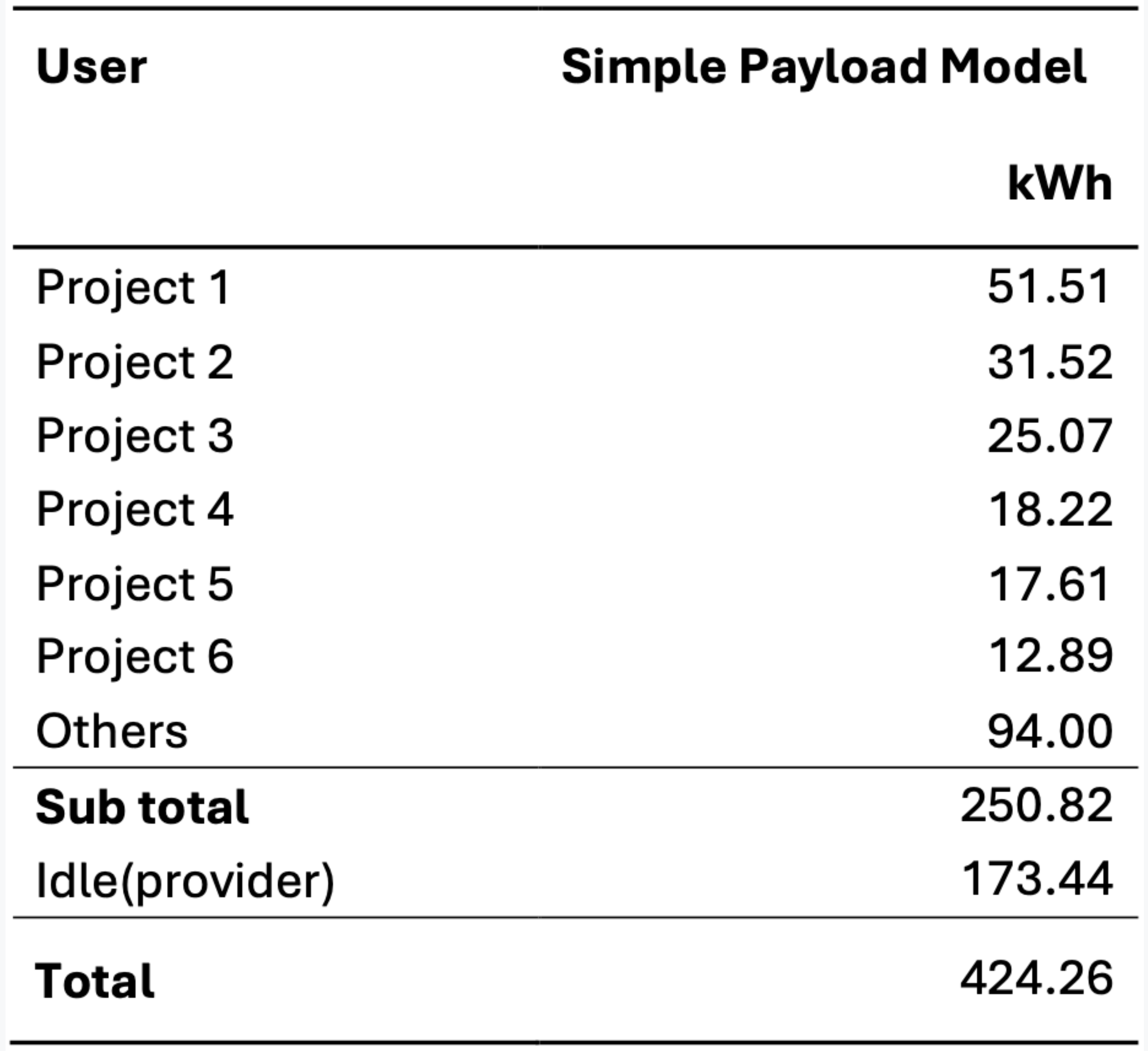
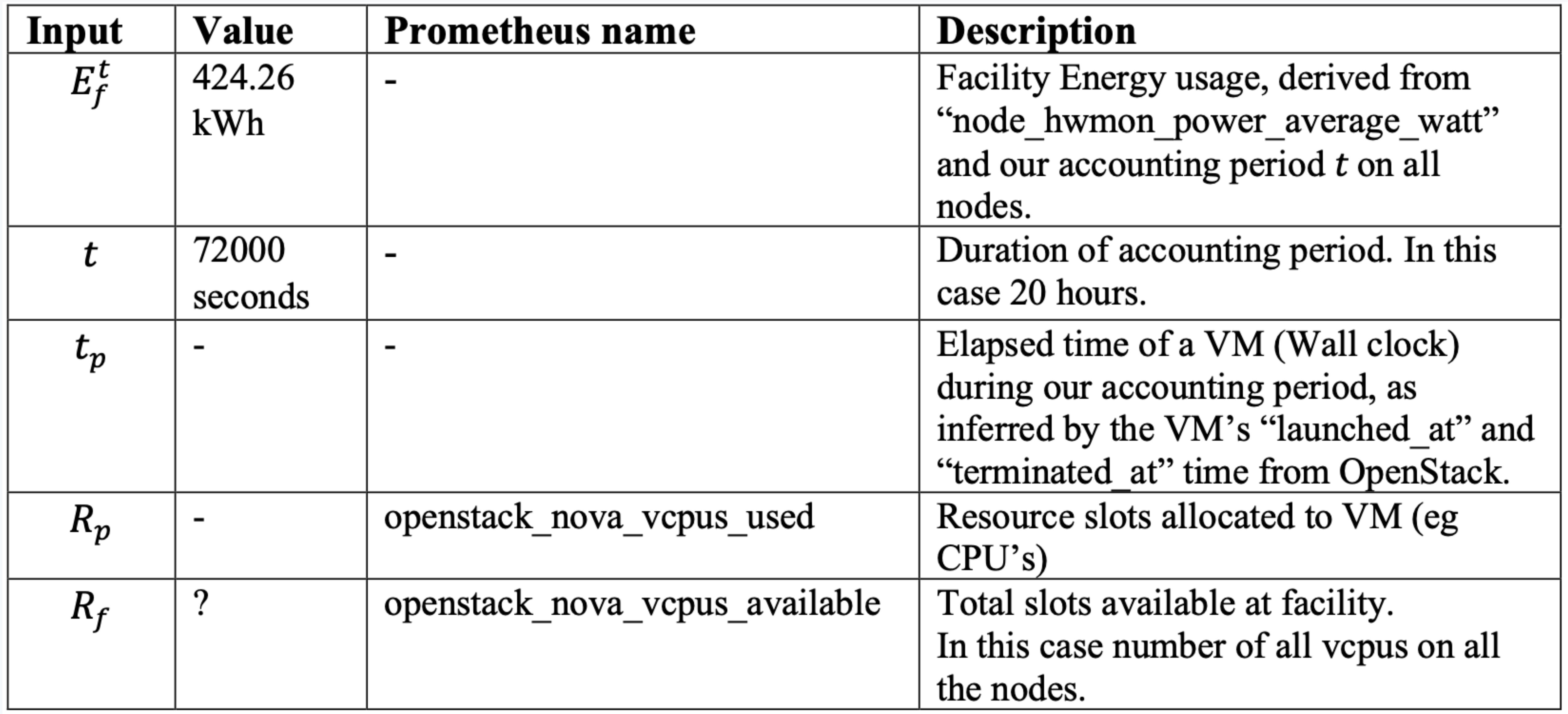
Nice model but is it practical?

Works for Cloud too!
(Simple does at least)



User	Simple Payload Model kWh
Project 1	51.51
Project 2	31.52
Project 3	25.07
Project 4	18.22
Project 5	17.61
Project 6	12.89
Others	94.00
Sub total	250.82
Idle(provider)	173.44
Total	424.26



Input	**Value**	**Prometheus name**	**Description**
E_f^t	424.26 kWh	-	Facility Energy usage, derived from “node_hwmon_power_average_watt” and our accounting period t on all nodes.
t	72000 seconds	-	Duration of accounting period. In this case 20 hours.
t_p	-	-	Elapsed time of a VM (Wall clock) during our accounting period, as inferred by the VM’s “launched_at” and “terminated_at” time from OpenStack.
R_p	-	openstack_nova_vcpus_used	Resource slots allocated to VM (eg CPU’s)
R_f	?	openstack_nova_vcpus_available	Total slots available at facility. In this case number of all vcpus on all the nodes.

Table 13: Measured and derived constants and Prometheus accounting data names used to evaluate the simple payload model for STFC Cloud payloads.

Enhanced should too…

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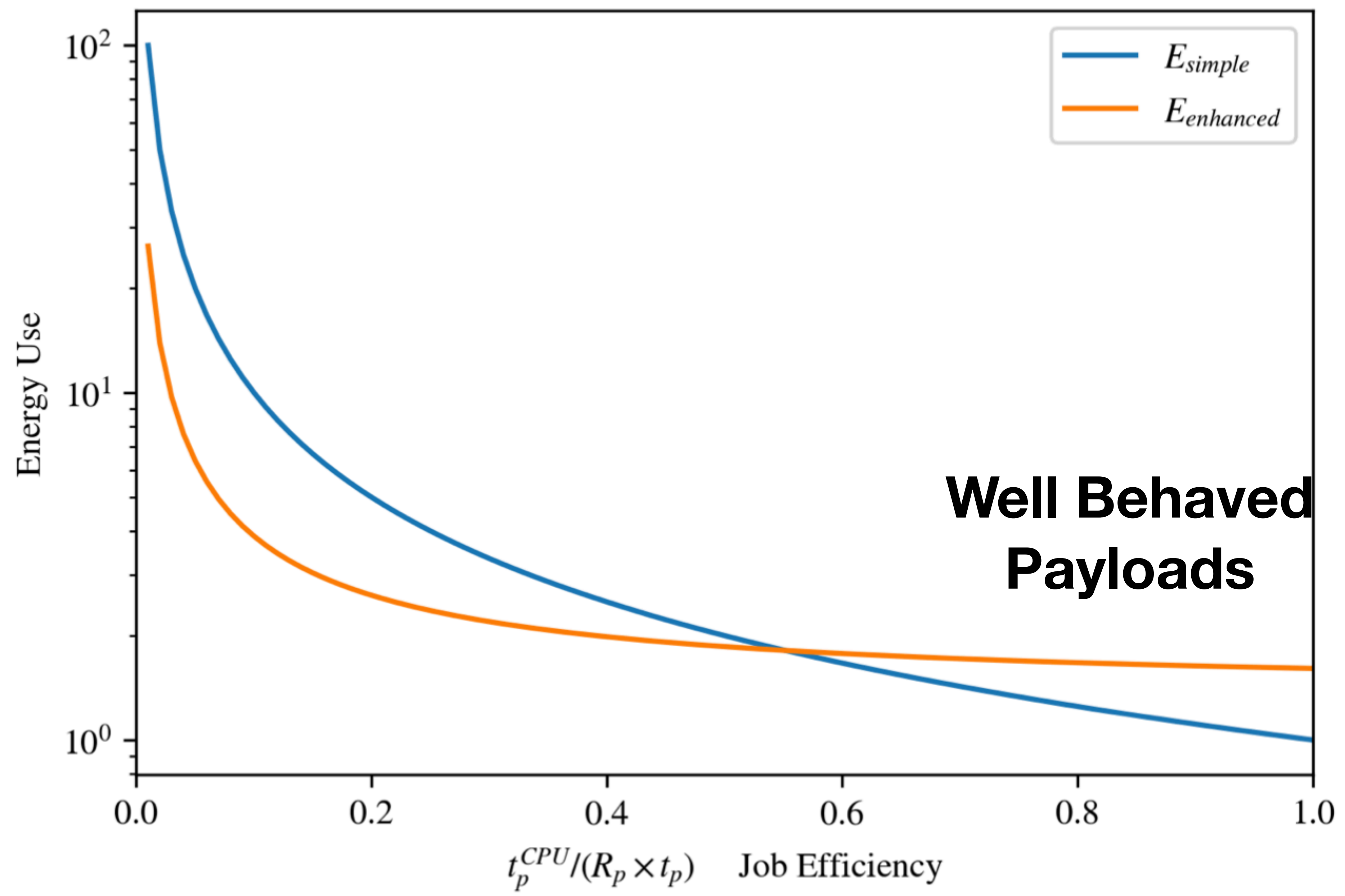
Which Payload Mode is Best?



Log Scale

Well Behaved Payloads

← **Small Delta**

Figure 3: Behaviour of the Simple and Enhanced payload models for a fixed amount of work (constant CPUtime) varying with Job Efficiency. Plotted on a log scale.

Not much to choose between them.

Both encourage more efficient code

Enhanced reduces Allocation to Providers

Which Storage Mode is Best? -> Can we get bytes read/written?

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Reporting Requirements / Concerns

Federation

Carbon costs of IRIS activity/providers broken down into scope 2 and scope 3.

Carbon costs of IRIS supported projects broken down into scope 2 and scope 3.

Carbon saved by being a federation

Reporting upwards:
- Benefit realisation, infrastructure efficiency
- Demonstrate right mix of platforms/tech
- Value of heterogeneity in the federation

Present success while using more?
- Power used per hepspec
- Fossil power used per hepspc

Try to lead the narrative

Providers

Carbon costs of a provider’s service broken down by scope.

Allocate service carbon cost to users and idle/provider

Ease of implementation

Allocate maximum to users (minimum to idle/provider)

Users

Energy per job

Average IRIS Carbon Intensity

Average Embedded carbon factor

Try to avoid motivating behaviour that increase federation carbon costs.

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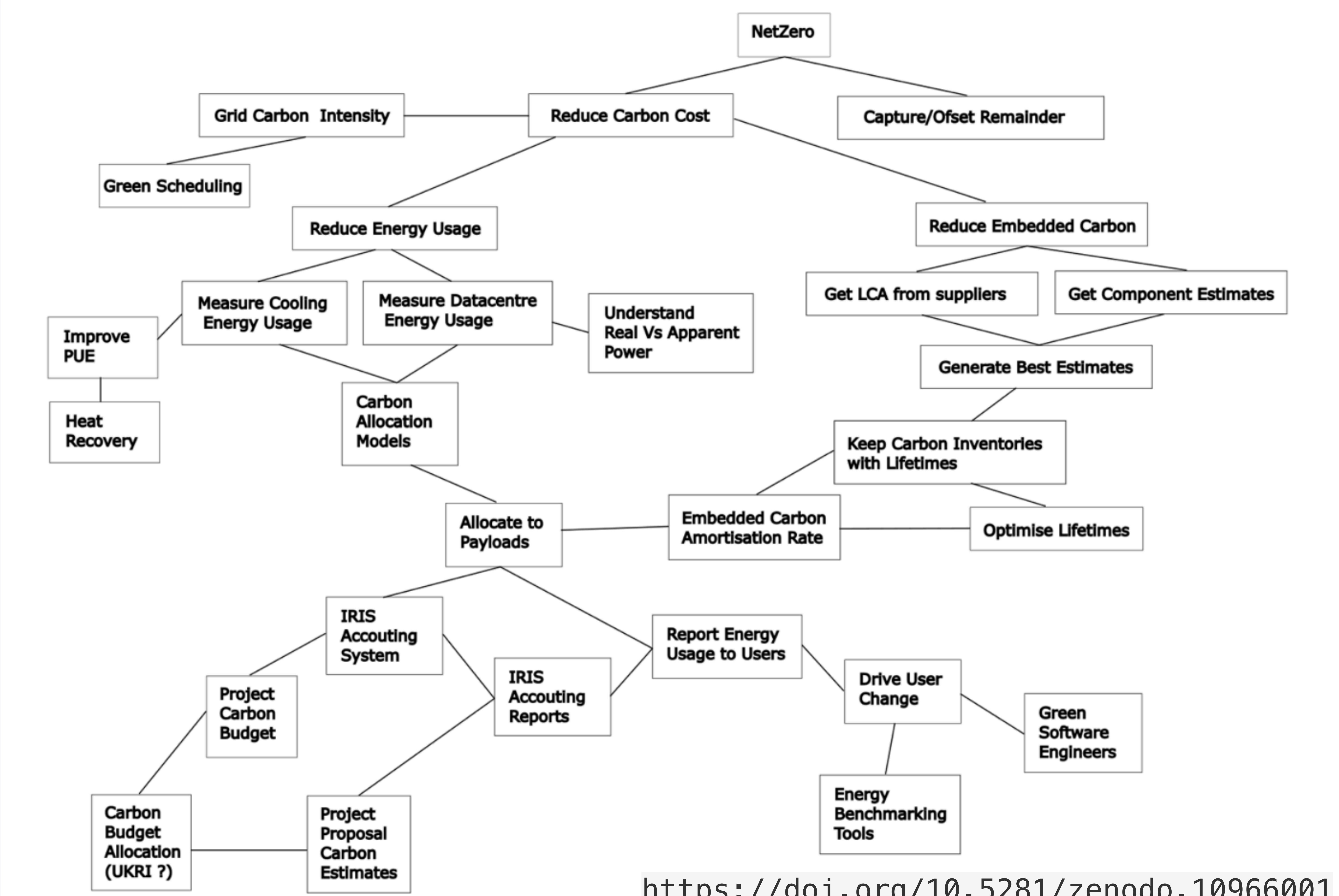
Carbon Mapping Project

What’s the Problem?



NetZero

Grid Carbon Intensity

Reduce Carbon Cost

Capture/Ofset Remainder

Green Scheduling

Reduce Energy Usage

Reduce Embedded Carbon

Measure Cooling Energy Usage

Measure Datacentre Energy Usage

Understand Real Vs Apparent Power

Get LCA from suppliers

Get Component Estimates

Improve PUE

Heat Recovery

Carbon Allocation Models

Generate Best Estimates

Keep Carbon Inventories with Lifetimes

Allocate to Payloads

Embedded Carbon Amortisation Rate

Optimise Lifetimes

IRIS Accouting System

Report Energy Usage to Users

IRIS Accouting Reports

Project Carbon Budget

Drive User Change

Green Software Engineers

Energy Benchmarking Tools

Carbon Budget Allocation (UKRI ?)

Project Proposal Carbon Estimates

https://doi.org/10.5281/zenodo.10966001

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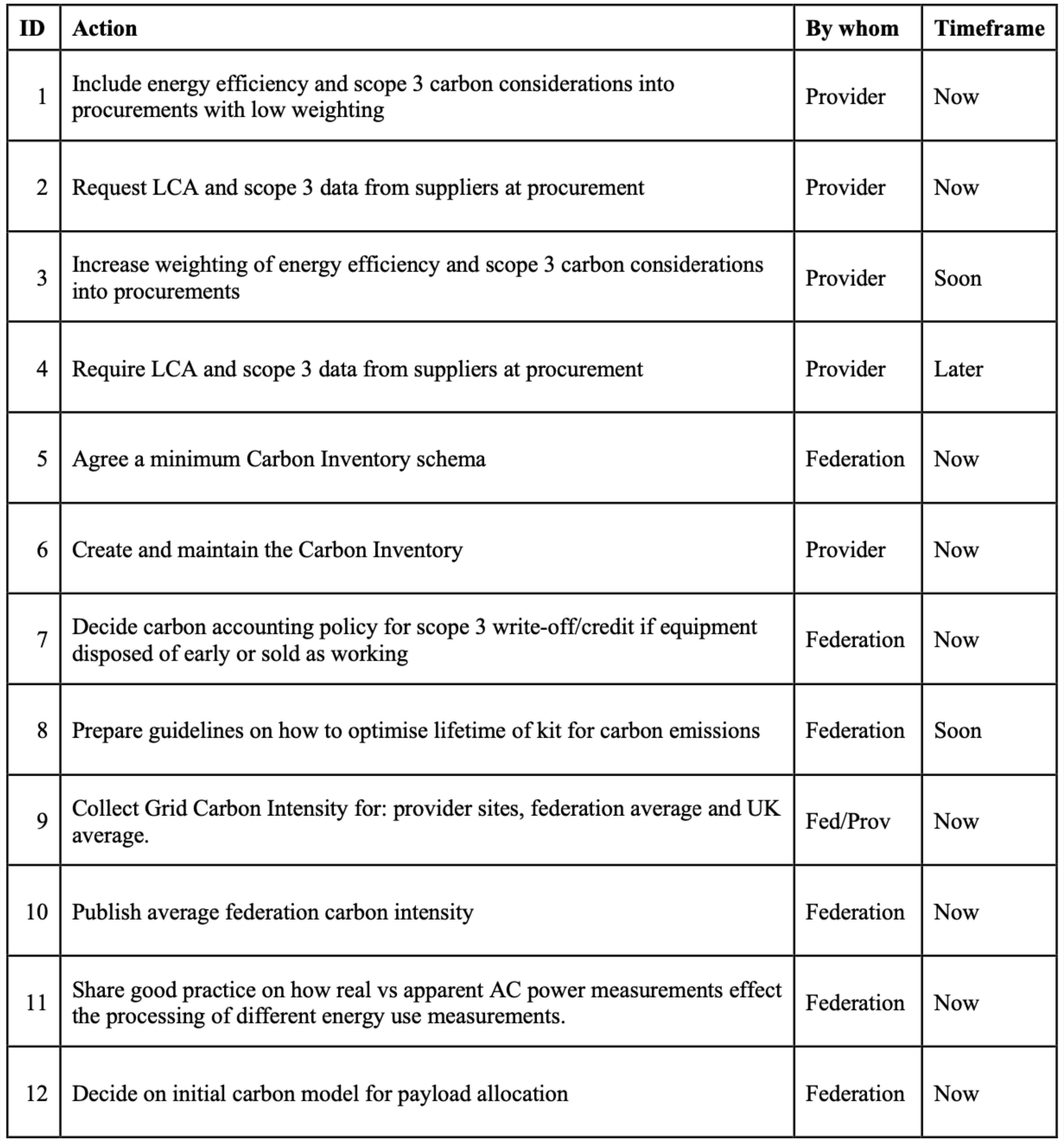
What we will do…



ID	Action	By whom	Timeframe
1	Include energy efficiency and scope 3 carbon considerations into procurements with low weighting	Provider	Now
2	Request LCA and scope 3 data from suppliers at procurement	Provider	Now
3	Increase weighting of energy efficiency and scope 3 carbon considerations into procurements	Provider	Soon
4	Require LCA and scope 3 data from suppliers at procurement	Provider	Later
5	Agree a minimum Carbon Inventory schema	Federation	Now
6	Create and maintain the Carbon Inventory	Provider	Now
7	Decide carbon accounting policy for scope 3 write-off/credit if equipment disposed of early or sold as working	Federation	Now
8	Prepare guidelines on how to optimise lifetime of kit for carbon emissions	Federation	Soon
9	Collect Grid Carbon Intensity for: provider sites, federation average and UK average.	Fed/Prov	Now
10	Publish average federation carbon intensity	Federation	Now
11	Share good practice on how real vs apparent AC power measurements effect the processing of different energy use measurements.	Federation	Now
12	Decide on initial carbon model for payload allocation	Federation	Now

ID	Action	By whom	Timeframe
13	Commission an IRIS Carbon Accounting Data Repository: planning and implementation, including data model and data transfer.	Federation	Now
14	Evaluate selected model on payloads daily to give user energy feedback	Provider	Now
15	Evaluate selected model on payloads monthly to report sum of payload energies and idle energy and apportioned embedded carbon costs	Prov/Fed	Now
16	Collect monthly returns of data from providers to IRIS Carbon Accounting Data Repository	Federation	Now
17	Commission reporting portal to provide the identified reports to federation, providers, and users.	Federation	Now
18	Commission reporting to users of payload energy usage and average federation carbon intensity.	Federation	Now
19	Additional tools for user code optimisation such as energy benchmark tools and the addition of profiling queues to services run by providers.	Fed/Prov	Soon
20	Find or commission an energy benchmark for providers to run on compute nodes and keep results in inventory	Federation	Soon
21	Survey GPU energy monitoring frameworks and plan how to add accelerators into carbon monitoring models.	Federation	Soon
22	Review evidence from under-clocking of accelerators and the effect on carbon emissions.	Federation	Soon
23	Collect additional user carbon reporting needs.	Users	Soon
24	Plan how to record and report the impact of Green RSE's.	Federation	Now
25	Regular review of developments in 'Green Scheduling'.	Federation	Now
26	Regular review of UKRU DRI NetZero projects and policy	Federation	Now
27	Bid for UKRI DRI NetZero funds	ALL	Now
28	Prepare IRIS Carbon Costing Framework for grant proposals	Federation	Now

https://doi.org/10.5281/zenodo.10966001

Energy
Vs
Power

For active carbon we need to know about ENERGY usage

IRISCAST
Audit of Carbon Costs

APC PDU's SNMP query ✓ `PowerNet-MIB::rPDU2DeviceStatusEnergy.1` **Hoctowatthour (100 wh) units**

APC port n SNMP query ✓ `PowerNet-MIB::rPDU2OutletMeteredStatusEnergy.n`

IPMI query (freeipmi) ✓ `ipmi-oem dell get-power-consumption-data`

freeipmi precision improved: https://savannah.gnu.org/bugs/index.php?65449

ipmitool bug submission + 1 line patch pending

IPMI query (ipmitool) ? `ipmitool sensor list` **Probably Power Measurements Energy is better!**

Time Stamped Energy usage is more robust than instantaneous power

Do you know your PUE? (Cooling kWh)

Don't use IPMI for serious power measurements!

IRISCAST
Audit of Carbon Costs

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We can measure Carbon Costs of a computer service ✓

We can allocate Carbon Costs to Payloads ✓

Next Steps

Establish Embedded Carbon Inventories

Measure model inputs regularly

Establish Carbon Accounting/Reporting System

Run Model Regularly

Monitor the model trends

Make informed decisions to recuse Carbon costs

Stay aware of UKRI NetZero DRI work

Carbon Costs in IRIS

& UKRI NetZero DRI

Speaker: Dr Alex Owen

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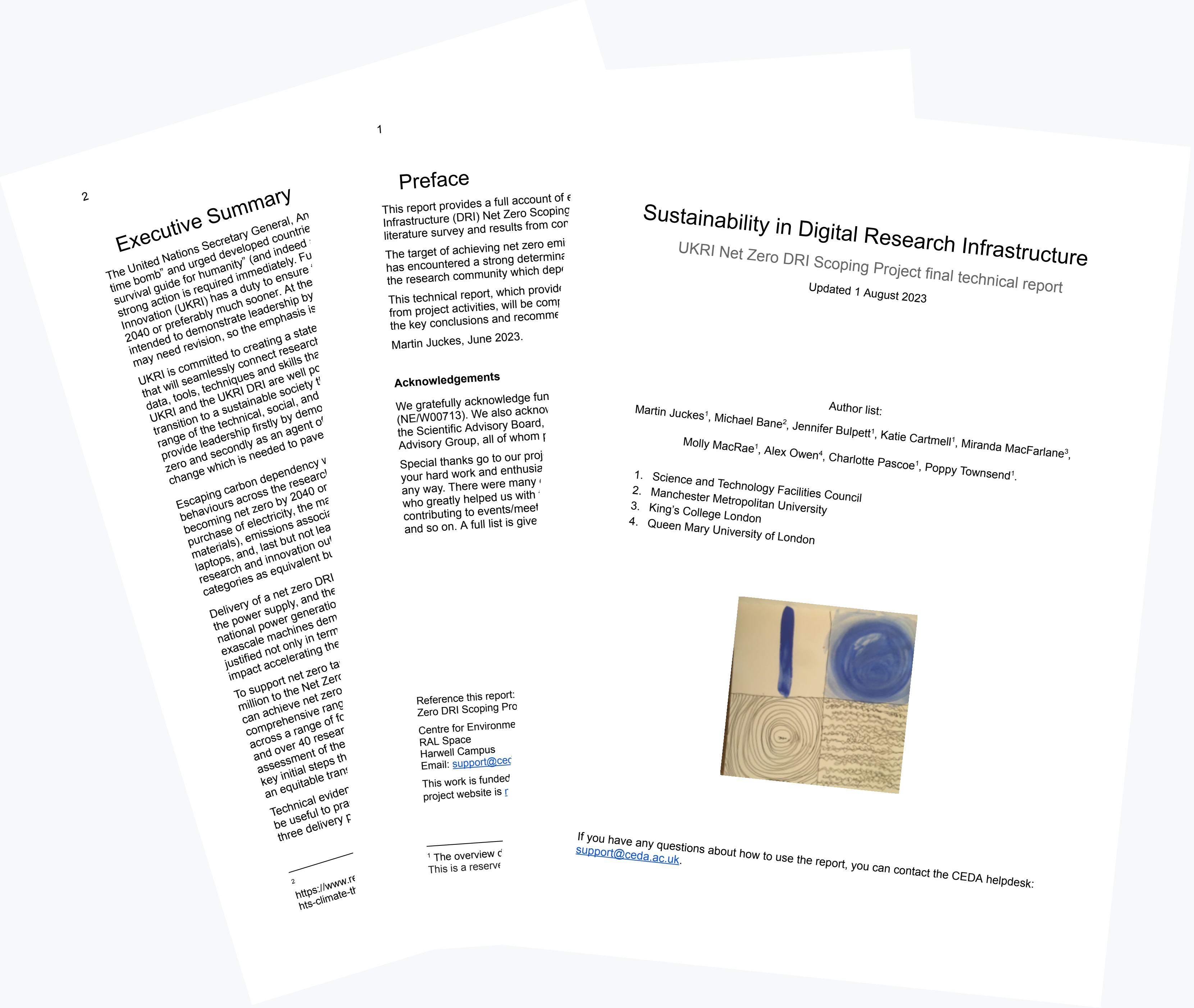
https://doi.org/10.5281/zenodo.7692451

IRISCAST
Audit of Carbon Costs



Executive Summary

Preface

Acknowledgements

Sustainability in Digital Research Infrastructure
UKRI Net Zero DRI Scoping Project final technical report
Updated 1 August 2023

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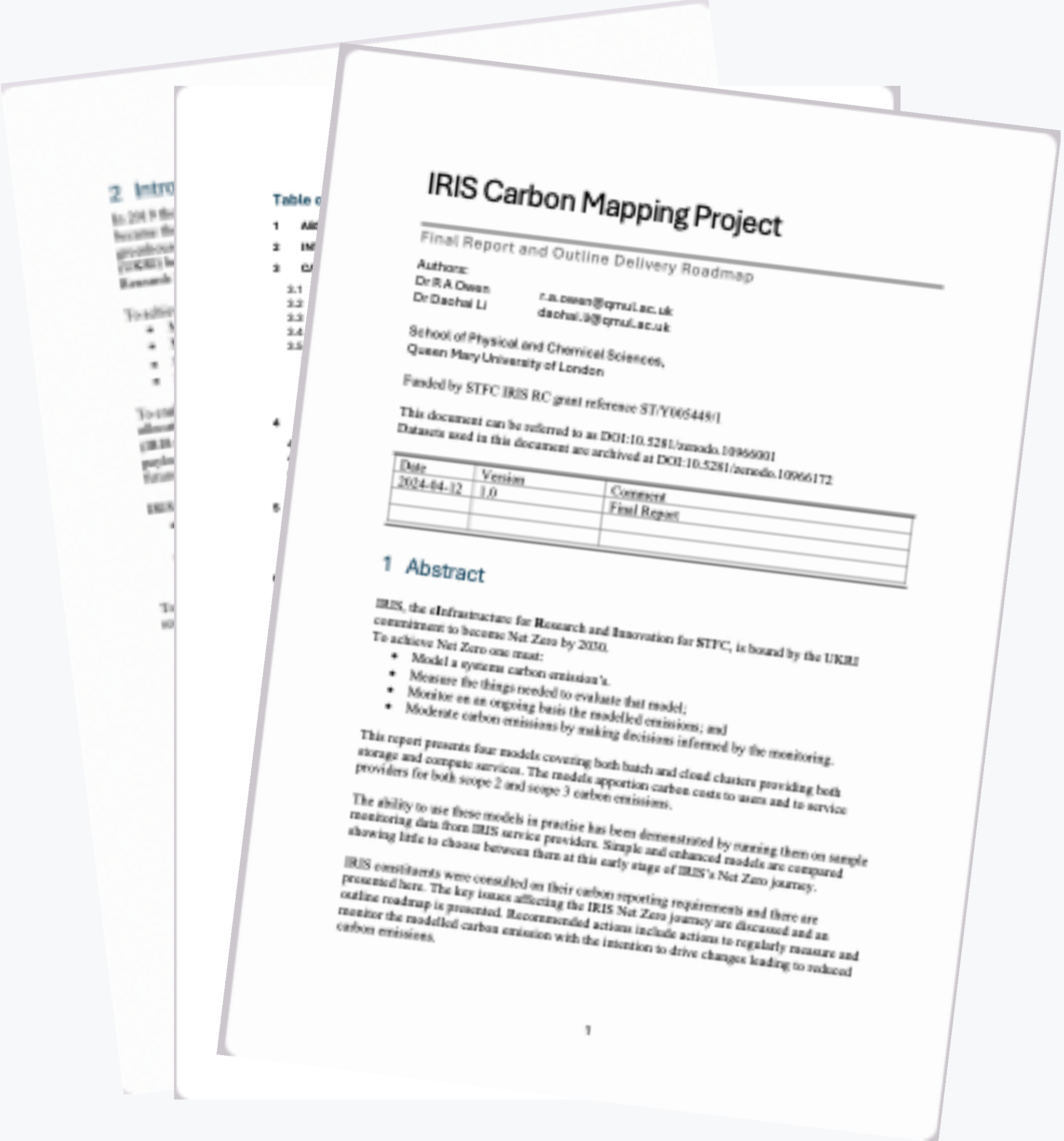

IRIS Carbon Mapping Project
Final Report and Outline Delivery Roadmap

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Date	Version	Comment
2024-04-12	1.0	Final Report

1 Abstract

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