Towards Zero Carbon

Implementing Sustainable Battery Lifecycle Management in Data Centers

IBM

David Cesarano, Fanjing Meng

David Cesarano
Solutions Architect
IBM Client Engineering
cesarano@ibm.com

Fanjing Meng (Meg)
STSM & CTO
China Systems Lab
mengfj@cn.ibm.com

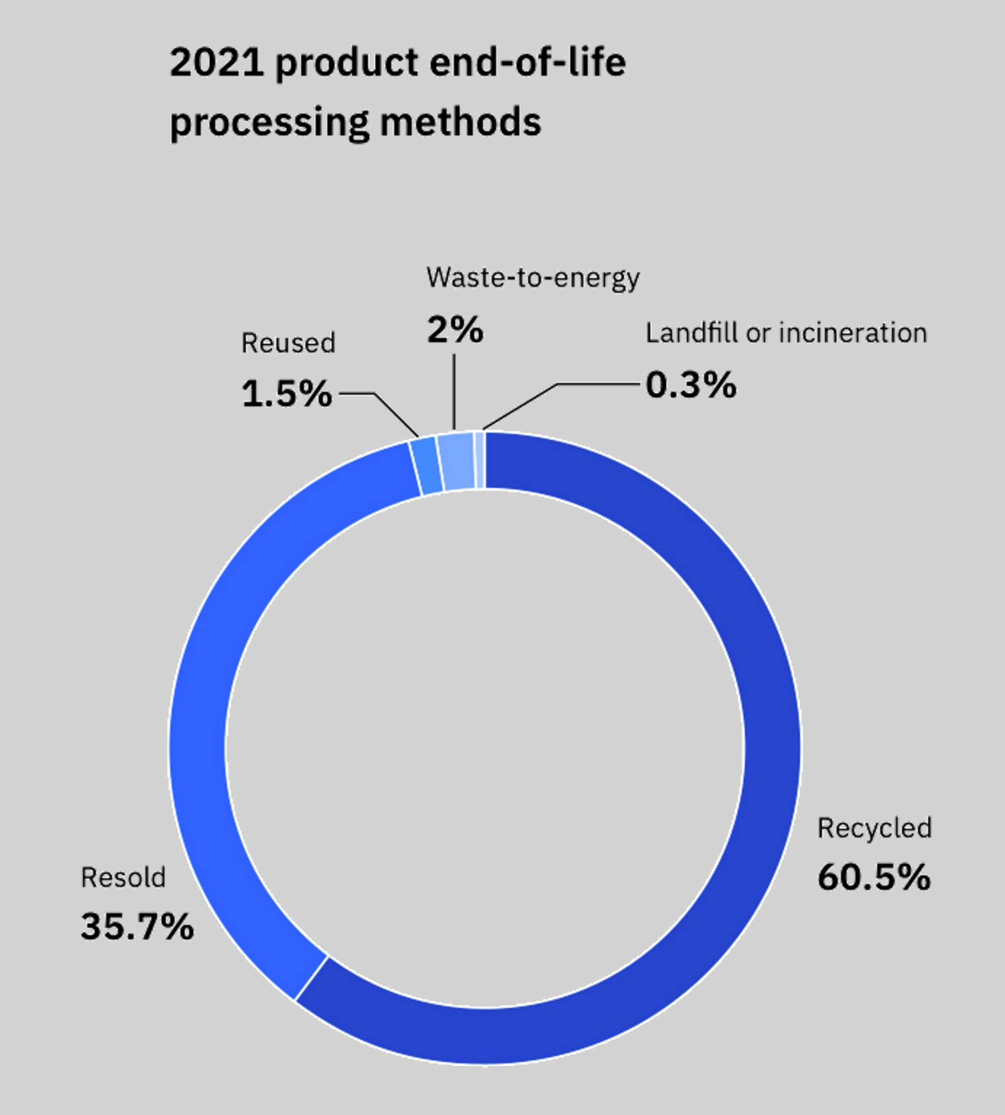
Agenda

- Business and Technical Challenges
- Sustainable Data Center
- Asset and Waste Management
- Proof-of-Concept in IBM Data Center
- Health and Maintenance Demo
- Future Direction and Take-aways

Product end-of-life management

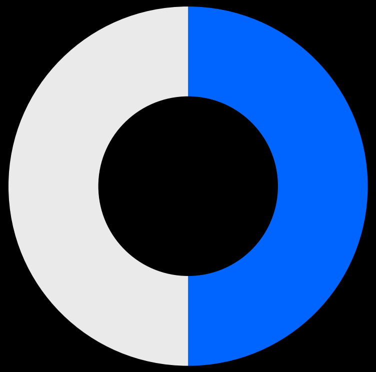
0.3%

Amount (by weight) of the more than 18,000 metric tons of end-of-life products and product waste processed worldwide that was sent to landfill or incineration operations for disposal in 2021, far exceeding IBM's corporate goal of sending 3% or less

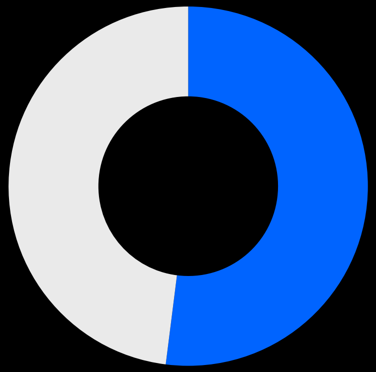


GHG Emissions reduction

Data centers are energy intensive and account for 1-3% of worldwide electricity use - equivalent to the emissions of over 26 million homes[1]



50%
of surveyed organizations seek more energy efficient products and services



52%
of surveyed organizations seek products that use more recyclable and biodegradable materials and packaging

Source: IBM Institute for Business Value (IBV) Research Insights, Sustainability as a transformation catalyst – trailblazers turn aspiration into action, January 2022

Sustainability isn't just about compliance, it's a strategic business imperative

74%

consider Environmental, Social, and Governance (ESG) factors to be very important to the enterprise value of their company[1]

50%

will only partner with or buy from companies that have communicated a commitment to sustainability[2]

73%

of surveyed organizations have set a net-zero goal with an average target date of 2044[3]

Source: IBM Institute for Business Value (IBV) Research Insights, Sustainability as a transformation catalyst – trailblazers turn aspiration into action, January 2022

Data Centre Energy use Singapore

7.0%

Approximately 7% or 3.4 TWh of energy was being consumed in 2020 due to increased digitalization, an increase of 1.7% from 2019 consumption of 2.75 TWh

Terminology

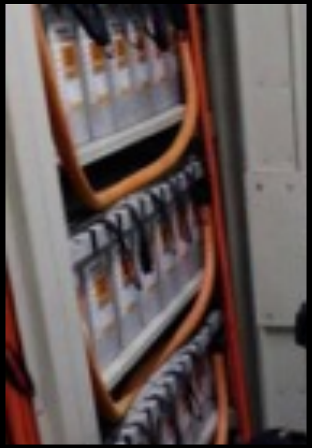
Data Centre

VRLA Battery (Jar)

(Valve Regulated Lead Acid)

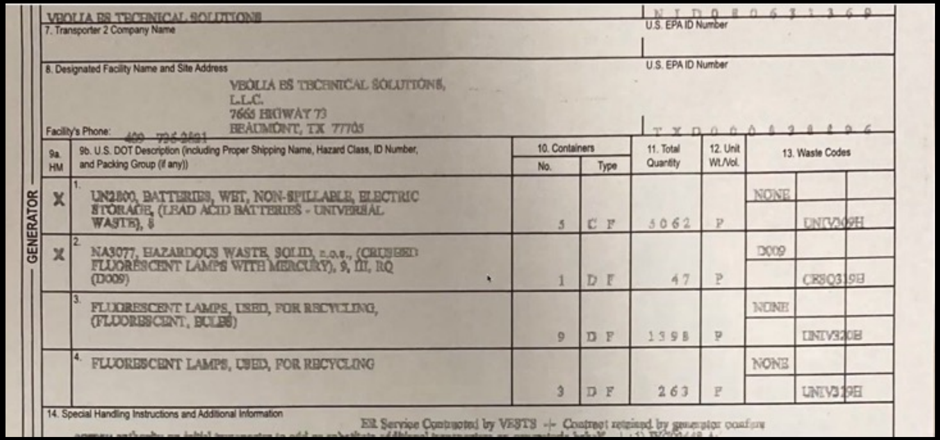
LiIon

(Lithium Ion)



Battery String

Uninterruptable Power Supply (UPS)



VEOLIA ES TECHNICAL SOLUTIONS

7. Transporter 2 Company Name — U.S. EPA ID Number: N J D 0 8 0 6 3 1 3 6 9

U.S. EPA ID Number

8. Designated Facility Name and Site Address — U.S. EPA ID Number: T X D 0 0 0 8 3 8 8 9 6

VEOLIA ES TECHNICAL SOLUTIONS, L.L.C.
7665 HIGHWAY 73
BEAUMONT, TX 77705

Facility's Phone: [illegible]

GENERATOR

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes	
X	1. UN2800, BATTERIES, WET, NON-SPILLABLE, ELECTRIC STORAGE, (LEAD ACID BATTERIES - UNIVERSAL WASTE), 8	5	C F	5062	P	NONE	UNIV[illegible]H
X	2. NA3077, HAZARDOUS WASTE, SOLID, n.o.s., (CRUSHED FLUORESCENT LAMPS WITH MERCURY), 9, III, RQ (D009)	1	D F	47	P	D009	CES[illegible]
	3. FLUORESCENT LAMPS, USED, FOR RECYCLING, (FLUORESCENT, BULBS)	9	D F	1398	P	NONE	UNIV[illegible]H
	4. FLUORESCENT LAMPS, USED, FOR RECYCLING	3	D F	263	P	NONE	UNIV[illegible]H

14. Special Handling Instructions and Additional Information

ER Service Contracted by VESTS -|- Contract retained by generator [illegible]

Certificate of Proper Disposal or Manifest

(Recycle/Grave/Death)

Business and Technical Challenges

General Challenges

Job Scheduling and Prioritization
- When, who and what
- Why

Standardization
- IEEE
- Enterprise

Vendor Management
- Shipping/Hauling
- Support

Asset Management
- Equipment/Comp.
- Supply room

Sustainability Objectives
- GHG, Waste, and others

Business and Technical Challenges

Data Center Redundancy (Power)

Battery Lifecycle Management
- Asset Management
- Waste Management

Proactive Monitoring & Maintenance
- Problem and Change management

Warranty, Support Contracts and Consumables
- Alerted or ad-hoc

Safe handling and storage of hazardous materials
- Processes and Procedures

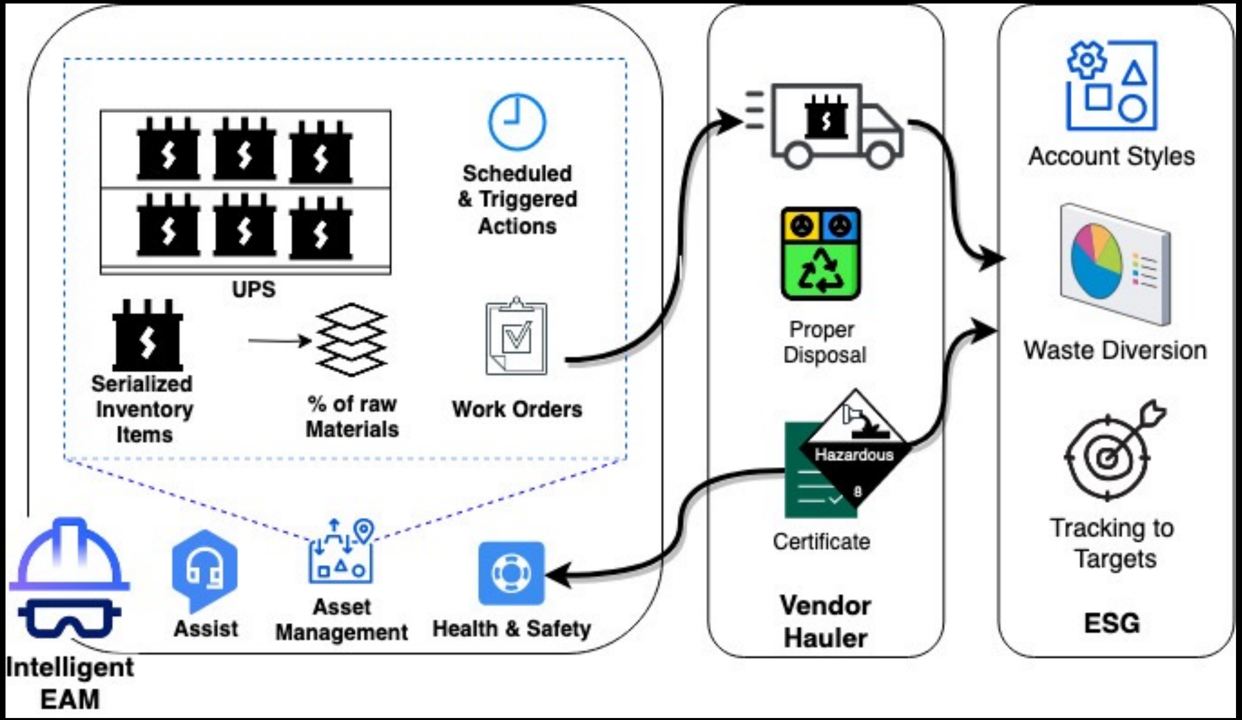
Pressure Points & Imperatives
Sustainable Operations in Data Centers

Pressure Points

- Reliability and Uptime of interconnected and critical Facilities and IT equipment assets
- Sustainability Impact of energy, water, and hazardous waste intensive assets and operations
- Capex and Opex Requirements to handle growing data center workload and demand

Imperatives

- Ensure Critical Asset Availability and Performance
- Increase Operational Efficiency and Productivity
- Reduce Operating Costs and Complexity
- Extend Economic Life of Assets and Equipment
- Contribute to Achieving Sustainability Targets



Lifecycle of Components

Assembly

Raw material extraction and assembly includes the energy consumption and emissions associated with the use of the raw material, the transportation of hardware to manufacturing sites, and the assembly of hardware in manufacturing

Transportation

The energy consumption and emissions associated with transporting equipment from manufacturing to a client's data center

Use

The energy consumption and emissions from the electricity used to run the equipment, as well as providing cooling and power conditioning

End-of-life

The end-of-life energy consumption and carbon emissions associated with landfilling and recycling

Regulations vary per Geo.

Lead Acid: 99%

Lithium-ion: 65-95%

- Sources:
- Lithium Ion Battery Recycling – Review of the current methods and Global Developments.: cas.org CAS Insights (American Chemical Society) September 22, 2022
- Canadian Renewable Energy Association: Sustainable Energy White paper, April 2021

Waste Management

Best Practices

Trackability/Auditability:
Reportable Traceable, and Auditable
Completed Bill of Waste (Certificate of Proper Disposal, Grave, death certificate,…)

Life-cycle Assessment:
ISO 14040 and ISO 14044 - Provide to customers and obtained from vendors

Full Material Disclosure (FMD):
IPC-1752D or IEC 62474, As ways to quantify improvement

How to be Successful

Electrical Distribution (Efficiency)
- 2N UPS config and avg. UPS utilization = 89%
- Software/Hardware to Reduce Redundancy

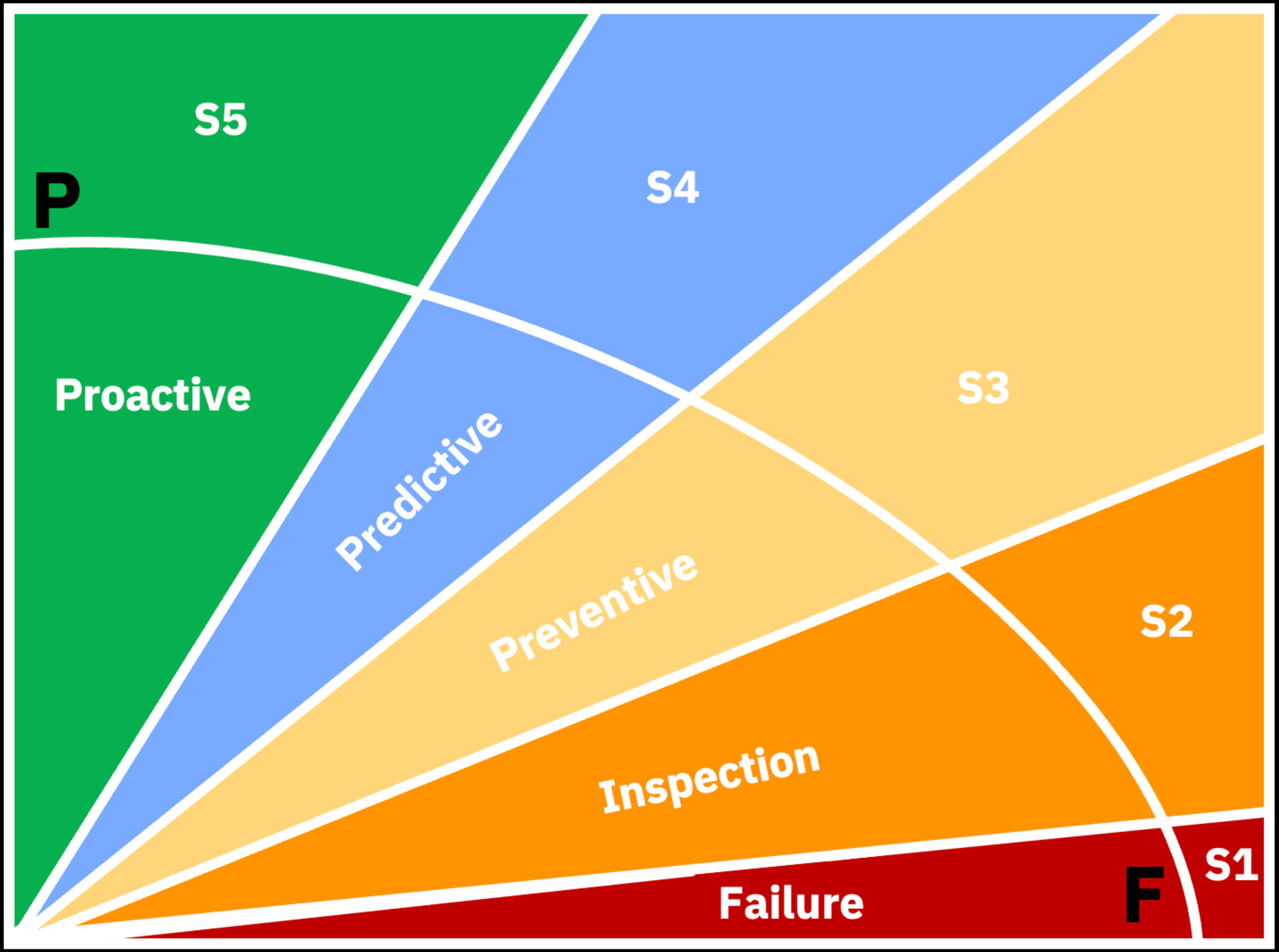
Facilities Management
- Water (if used for battery cooling and not on a closed loop system)
- Standardized processes procedures/vendors

Supply Chain and Vendor Management
- Clear guidance for current and future vendors
- Standards, such as transparency.

Asset Management
- Life-cycle of assets
- Hazardous/Non-Hazardous

P-F Curve
Technical Challenges

P, at the top left represents the point at which component failure or degradation begins. If the degradation goes undetected or uncorrected, it continues to degrade until full system failure occurs,. The period-of-time between P and F, is called the "P-F Interval". This is the window of opportunity during which inspection can detect pending failure and resolution can occur with corrective action.



Technical Challenges

Site Resiliency Challenges (UPS)

UPS batteries are crucial for providing a stable power supply, but due to their widespread deployment, safety incidents are a persistent challenge.

Current battery replacement standards highly rely on internal resistance, which lacks an in-depth analysis of internal resistance changes and intelligent quantification of battery health status.

- Monitor each jar vs system as a whole?
- What is my MTBF?

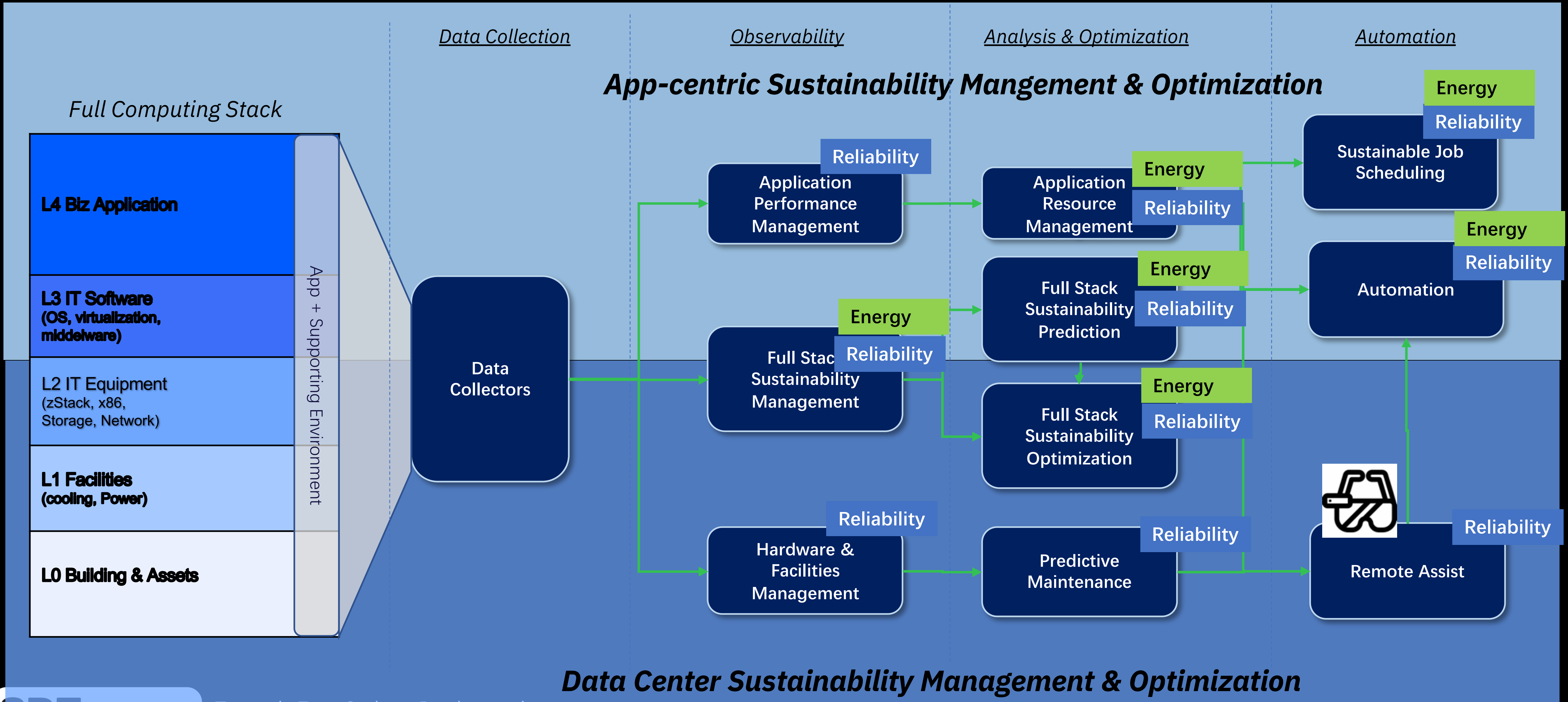
Technical Solutions

Site Resiliency Solutions (UPS)

- A New Hybrid Replacement Criteria based on Internal resistance and charging/discharging cycle count.
- Insight of internal resistance based on analysis of multiple factors such as voltage, temperature, and charge/discharge rates.
- This enables fine-grained battery management, effectively prevents potential issues, and reduces replacement costs.

Energy Reliability

Full-Stack Sustainability Optimization Overview



POC Architecture

Overview of POC

Ingest Data to Asset Monitor	Dashboard	Health and Predict	Assist	Automation
Query	Comparative Analysis	Cooling system, storage and server	Insights for the repairing	Systems Integration
Energy consumption Battery (jar) performance	Comparison battery metrics at different times	Health monitoring	Diagnosis	Process and Procures
	Comparison of battery data for the applications	Predict Maintenance	Remote collaborate	Hands off Keyboard

Key Metrics (KPI) and Modeling

Max Score = 48
Health = Score*100/Max Score

Customize Score = SOC & SOH

Factors	Weight	Maximum Score
Overall Inspection	1	4
Float Voltage	2	4*2 = 8
Inner resistance	4	5*4= 20
Temperature	1	4
Discharge test	3	4*3 = 12

Impact Factors for Battery Health

Impact factor	Influences	Sample value	Collection
temperature	Most batteries have an optimum temperature range beyond which performance degradation, brownout, and even premature failure of the battery's internal structure can result.	Lead acid: 20℃ - 25℃	**meter reading**
cycle number	Each time the battery discharges and re-charges due to utility power failure or some other power loss event, it loses a percentage of its capacity. Once the battery reaches its maximum number of discharge and recharge cycles, the battery will fail and must be replaced. The depth of discharge is also harmful to UPS batteries. If the depth of discharge frequently exceeds more than 80% the number of cycles (discharge-charge) the battery can withstand is greatly reduced.	The manufacturer specifies, i.e. 500	**discharge and recharge recording**
voltage	If the float voltage is too high, it will accelerate the corrosion of the positive side of the battery. If the float voltage is too low, the battery will slowly discharge. When an already fully charged battery is subjected to float voltage for long periods of time, it may result in the steady degradation of the positive which can substantially reduce battery life.	i.e. 10V - 14V	**meter reading**
resistance	The internal resistance increases with the aging of battery, causing battery capacity attenuation, the higher the likelihood that it will need to be replaced.	when its resistance reaches 5mΩ is suggested to be detached from system	**meter reading**
capacity	usually displaying a slow degradation of capacity until they reach 80 percent of their initial rating, followed by a comparatively rapid failure.	80% capacity is the threshold point where the battery is considered to be the End of Life (EOL) and after which the batteries rapidly fails.	**Discharge Testing recording**
battery age	The electrochemical nature of UPS batteries causes them to lose the ability to store and deliver power slowly over time. Even with appropriate storage, usage, and maintenance, batteries still require replacement.	i.e. over battery design life 5 years	**recording**

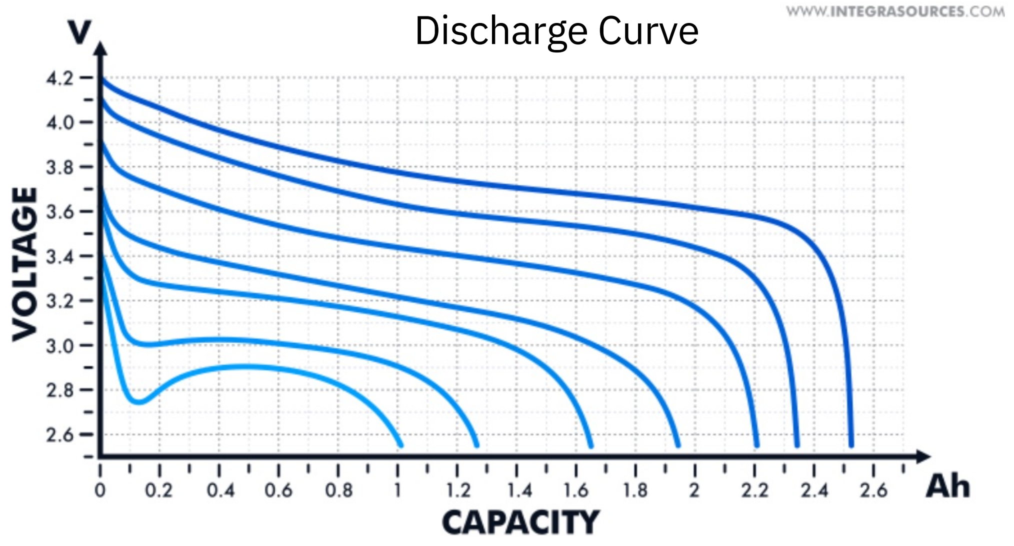
KPIs for Battery Health Prediction

$$SOC = Q/Q_{max}$$

Q - *remaining capacity*
Q_{max} - *rated capacity*

– SOC : State-of-Charge

- To show the amount of electric charge left in the battery
- Impact factors: battery chemistry, voltage, current, capacity, impedance, charging/discharging rate, temperature
- Can be calculated with Open Circuit Voltage (OCV) Method based on Discharge Curve



Discharge curves or variations in the remaining capacity to the open-circuit voltage of a Li-ion battery

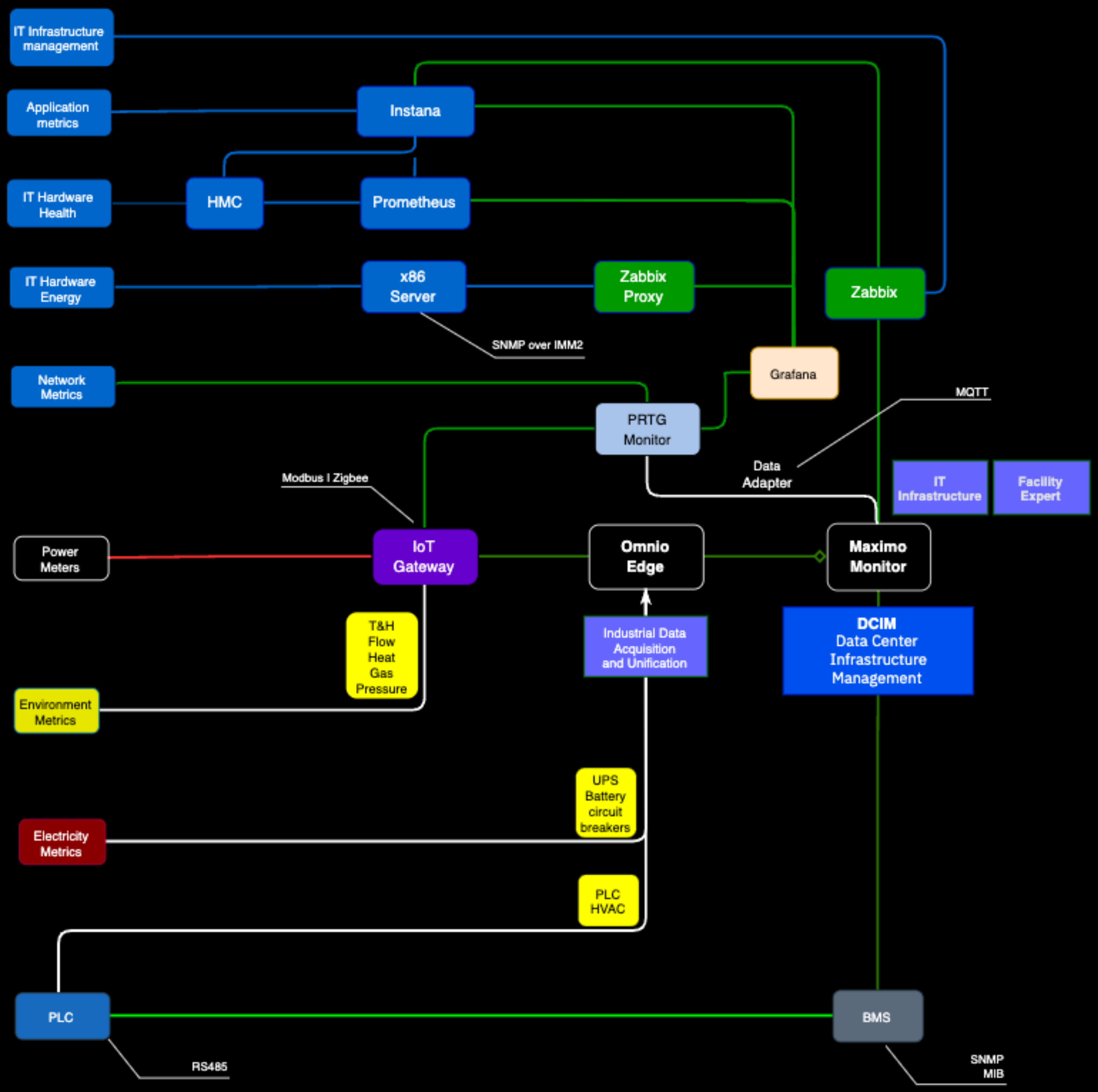
– SOH : State-of-Health

- To show the health of the battery
- Impact factors: battery age, cycle number, capacity, internal resistance, energy throughput, temperature, self-discharge rate, voltage

Source: Andrey Solovev and Anna Petrova, Battery Management System (BMS): Effective Ways to Measure State-of-Charge and State-of-Health, https://www.integrasources.com/blog/battery-management-system-bms-state-charge-and-state-health/

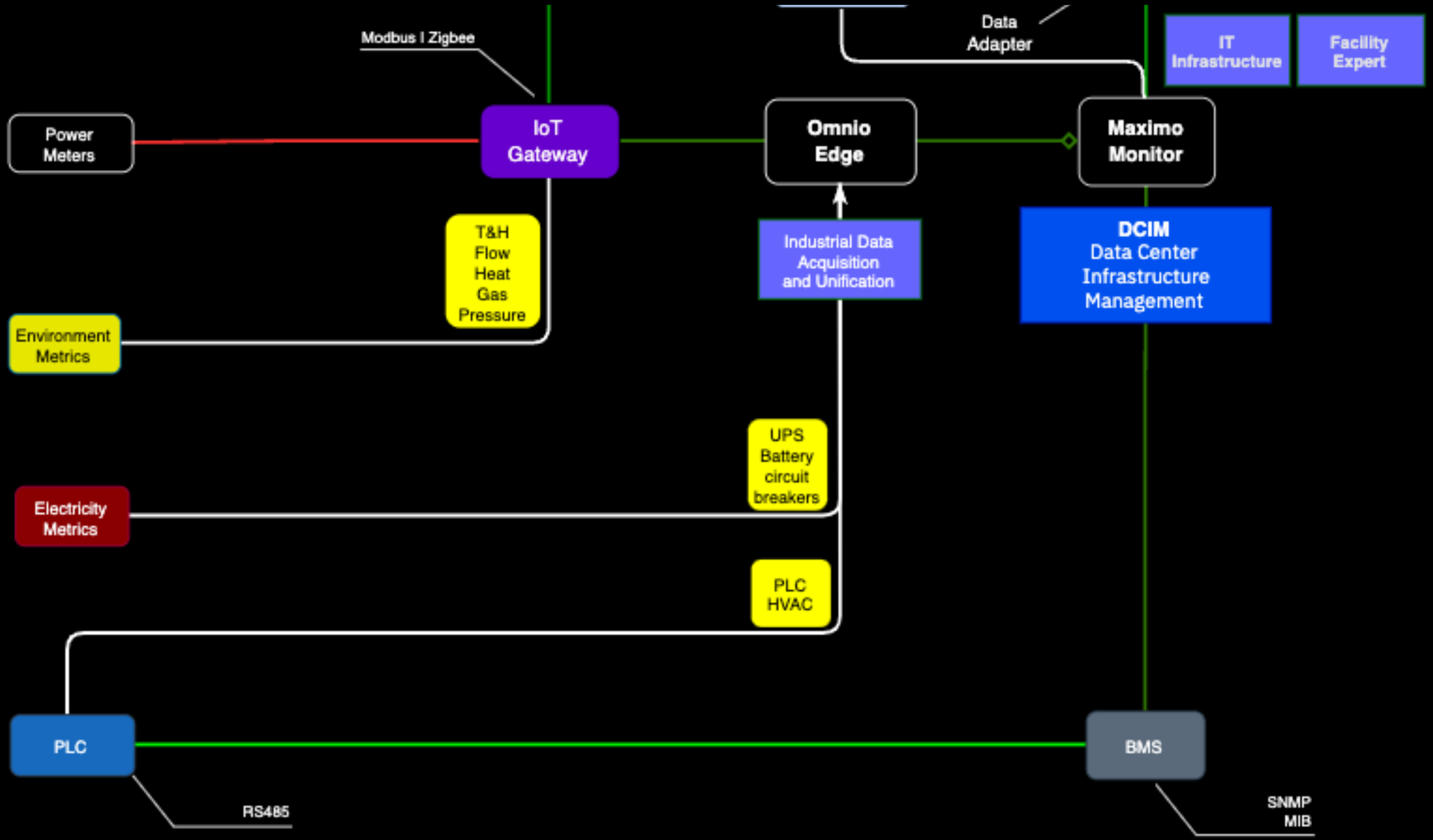
Architecture

Flow Diagram



Architecture

Flow Diagram



Demo

UPS loading
26.4%
UPS estimated minutes ...
142 minutes
TotalVoltage
DCIM_zhuoyou: Voltage - UPS Battery Group...
544.97 V
DCIM_zhuoyou: Voltage - UPS Battery Group...
544.88 V
DCIM_zhuoyou: Voltage - UPS Battery Group...
544.84 V
DCIM_zhuoyou: Voltage - UPS Battery Group...
544.80 V
Temperature
DCIM_zhuoyou: T...
22.39 °C
DCIM_zhuoyou: T...
14.50 °C
DCIM_zhuoyou: T...
24.37 °C
DCIM_zhuoyou: T...
21.33 °C
Electricity Current - Group01
0 A
Electricity Current - Group03
0 A
Electricity Current - Group02
0 A
Electricity Current - Group04
0 A
SOC - Group 01-04
100%
Group 01
100%
Group 02
100%
Group 03
100%
Group 04
Voltage - Group 01
Temperature - Group 01
IR - Group 01

Demo

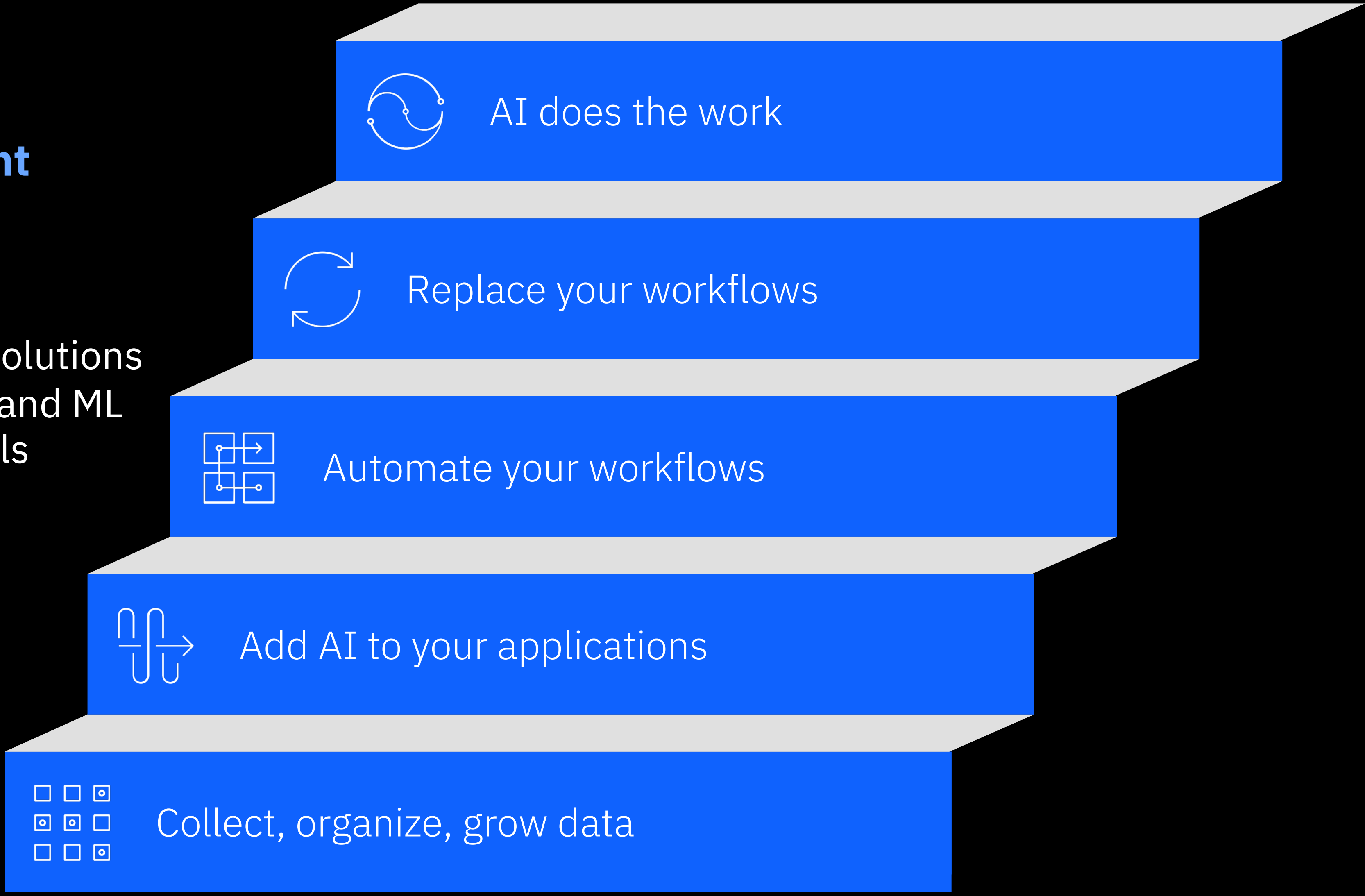
Voltage - Group 03
14.300 V
14.200 V
14.100 V
14.000 V
13.900 V
13.800 V
13.700 V
13.600 V
13.500 V
03/02 03/12 03/22 04/01 04/11 04/21 05/01 05/11 05/21
Temperature - Group 03
21.000 °C
20.000 °C
19.000 °C
18.000 °C
17.000 °C
16.000 °C
03/02 03/12 03/22 04/01 04/11 04/21 05/01 05/11 05/21
IR - Group 03
2.400 Ω
2.300 Ω
2.200 Ω
2.100 Ω
2.000 Ω
1.900 Ω
03/02 03/12 03/22 04/01 04/11 04/21 05/01 05/11 05/21
Voltage - Group 04
14.400 V
14.200 V
14.000 V
13.800 V
13.600 V
03/02 03/12 03/22 04/01 04/11 04/21 05/01 05/11 05/21
Temperature - Group 04
21.000 °C
20.000 °C
19.000 °C
18.000 °C
17.000 °C
03/02 03/12 03/22 04/01 04/11 04/21 05/01 05/11 05/21
IR - Group 04
2.400 Ω
2.300 Ω
2.200 Ω
2.100 Ω
2.000 Ω
1.900 Ω
03/02 03/12 03/22 04/01 04/11 04/21 05/01 05/11 05/21

Emerging Technologies

Waste and Asset Management

The path to maturity and beyond:

- Improved Sensors and Monitoring Solutions
- Asset failure predictability using AI and ML
- Generative AI and foundation models
- Automation and Integration
- Self-Healing
- Break down the silos

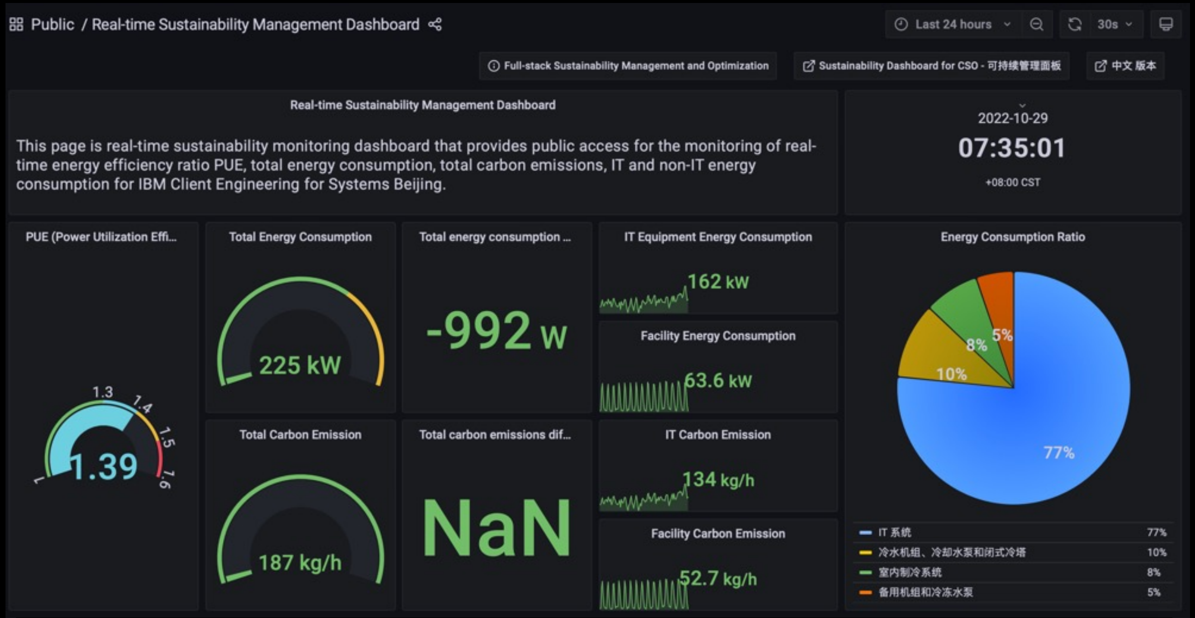


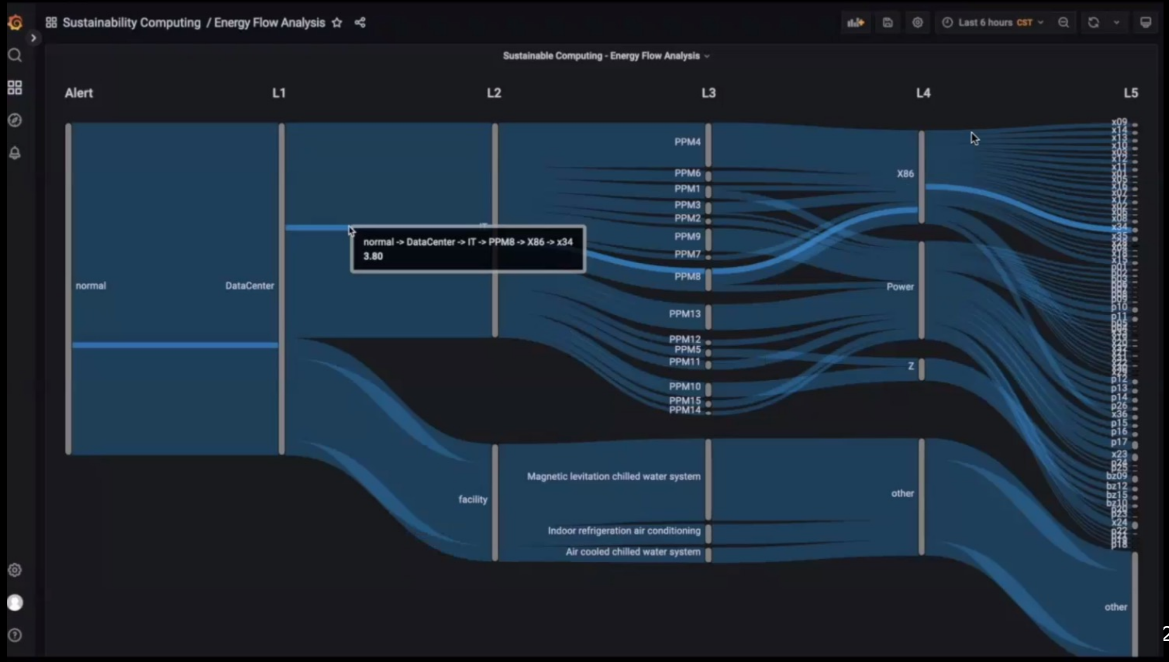
Emerging Technologies

GHG Tracking

Carbon Tracking and Dashboards:
https://www.opencompute.org/projects/sustainability
https://github.com/Green-Software-Foundation/sci
https://www.cloudcarbonfootprint.org/docs/embodied-emissions

https://ibm.biz/fsso-en or https://ibm.biz/fsso-cn
https://github.com/ambitus/sustainability-grafana-dashboard





Towards Zero Carbon: Implementing Sustainable Battery Lifecycle Management in Data Centers

SRECON ASIA PACIFIC

Thank You !

Any questions or comments, please contact Meg (mengfj@cn.ibm.com) and David (cesarano@ibm.com) !

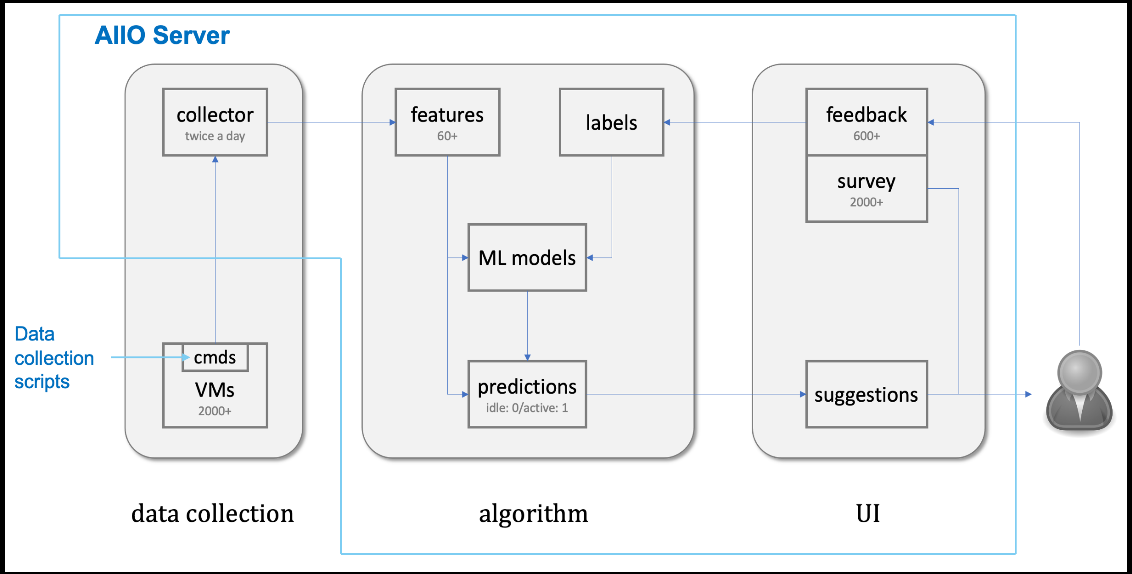
IBM

Emerging Technologies

Waste and Asset Management

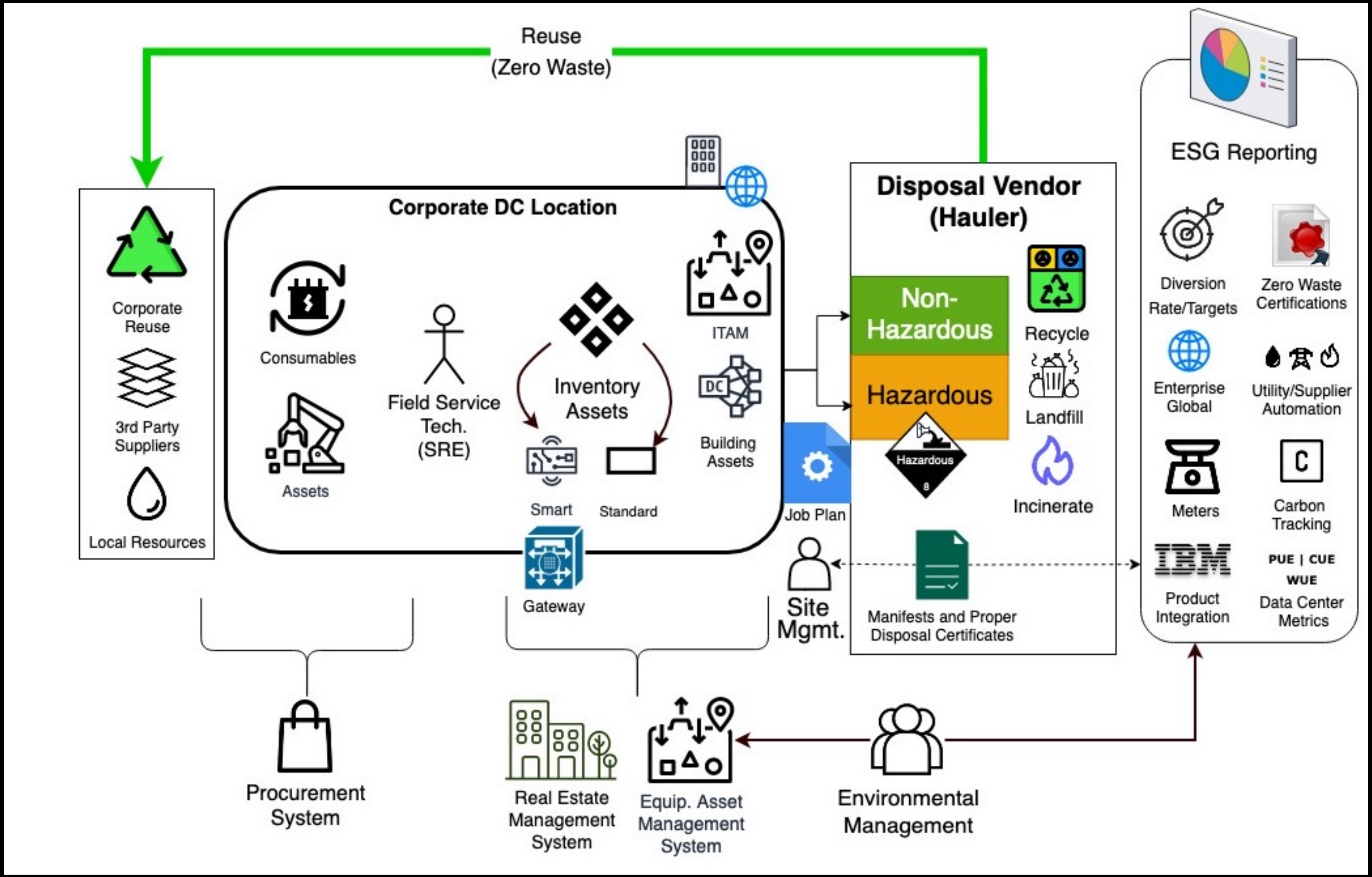
The path to maturity and beyond:

- Improved Sensors and Monitoring Solutions
- Asset failure predictability using AI and ML
- Use of Foundational Models and Training
- Automation and Integration
- Self-Healing
- <u>Break down the silos</u>



Data Center Asset Management

Content & Patterns



GHG Managing and Reporting

Scope 1, 2, 3 for Data Centers

Scope 1: Direct Emissions

- Operations, such as heating, cooling and power generation. This includes combustion of fossil fuels

Scope 2: Indirect Emissions

- Purchased GHG such as Utilities

Scope 3: Indirect Emissions

- Upstream and Downstream Activates

Net-Zero Guidance and Policy (Over 3k)

- EU Fit for 55, Australia's LTERP, 14th Five-Year Plan, COP26, Singapore Green Plan 2030

Strategies to decrease Scope 1 and 2:

- Reduce consumption and energy conservation (STAR, GPP, SmartWay
- Power Purchase Agreements (PPA)
- Carbon Offsets
- Optimize Transportation: Ocean, Rail, Ground, Air

	Create Materials & Transportation	**Use** Consumption	**Dispose** EOL Disposition
Equipment Manufactures	Scope 1 Scope 2	Scope 3 ↓	Scope 3 ↓
Data Center (Owned)	Scope 3 ↑	Scope 1 Scope 2	Scope 3 ↓
Data Center (Leased)	Scope 3 ↑	Scope 3 ↑	Scope 3 ↑
Cloud (Corp. & Users)	Scope 3 ↑	Scope 3 ↑	Scope 3 ↑

← **Consumption** | **Disposal** →