Digital Energy Grid Hackathon Design Document For SARTE-AI

1. Team Information

- **Team Name**: SARTE-AI
- **Institution / Organization**: Imperial College London
- **Team Members (2–5):** Hariswar Baburaj: Team Lead/Energy Analyst, Swapnil Kumar: AI-ML Engineer/UX Designer, Oluwasuan Ayanfeoluwa: ML Engineer/Energy Analyst, Imran Matin: AI/ML Engineer, Muhammad Umer Farooq: AI Engineer
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- **Discord User names:** ProfessorPain(hariswar), Ayanfeoluwa (ayanfeoluwa_71848_30224), Swapnil Kumar (swapnilkumar_58677), Imran Matin (imranmatin_08356), and Muhammad Umer Farooq (umer9035).

2. Problem Focus

Problem 2: Compute-Energy Convergence in a DEG World

3. Solution Overview (max 150 words)

The solution is an Agentic Orchestration System designed to co-optimize AI compute workloads and energy resources in a Distributed Energy Generation (DEG) environment. The core is a Grid Co-optimization Agent utilizing a Machine Learning model to predict the optimal action (Run, Defer, or Use Storage) based on real-time compute demand, energy price, and carbon intensity. The system minimizes £/inference while adhering to a carbon cap. All communication between the Compute, Grid, and Storage Agents is handled via the Beckn Protocol, ensuring interoperable, auditable, and traceable transactions (with OBP IDs) for monetizing compute flexibility under schemes like P415. This autonomous approach prevents grid destabilization and transforms flexible compute into a valuable grid asset.

4. Technical Architecture (max 200 words or diagram)

The proposed solution utilizes a Decentralized Agentic Orchestration System built on a microservices architecture, leveraging the Beckn Protocol for secure, interoperable, and auditable communication between independent agents.

Component	Description	Technology Focus

Beckn Gateway	Central communication hub for all agents, handling discovery, request routing, and message validation according to the Beckn Protocol specifications.	Beckn Protocol, Message Queue (e.g., Kafka)
Co-optimization Engine (ML Core)	The central intelligence unit. It ingests real-time data (compute demand, energy price, carbon intensity) and uses a Reinforcement Learning (RL) or Time-Series Forecasting/Classification Model to determine the optimal action (Run, Defer, Storage Discharge) that minimizes cost per inference while adhering to the carbon cap.	Python, Scikit-learn/TensorFlow/PyTorch, Optimization Algorithms
Data Ingestion & Forecasting Service	Collects and processes time-series data from external APIs (Grid Operator, Carbon Intensity Trackers) and internal systems (Compute Cluster Monitor). It forecasts short-term spikes in compute demand and grid signals.	Time-Series Databases (e.g., InfluxDB), Forecasting Models (e.g., ARIMA, Prophet)
Audit & Logging Service	Maintains a tamper-proof, timestamped record of all decisions, data sources, Beckn transactions (OBP IDs), and system outcomes, ensuring full traceability for regulatory review.	Distributed Ledger Technology (DLT) or Immutable Database (e.g., PostgreSQL with audit trails)
Orchestration & Dispatch Layer	Translates the optimal action from the Co-optimization Engine into executable commands for the Compute Cluster and Energy Storage systems.	API Gateway, Command Dispatchers

• **Key Agents and their Roles:**

The system is composed of three primary agents, each fulfilling a distinct role in the Beckn transaction lifecycle (Catalog, Order, Fulfillment).

Agent Name	Primary Role	Beckn Protocol Role	Key Responsibilities
Compute Agent	Manages AI workload scheduling and flexibility.	Provider/Catalog Publisher	1. Publish available compute job slots and their flexibility windows as a Beckn. 2. Receive and process requests (e.g., deferral commands). 3. Report job completion and energy consumption.
Grid Co-optimization Agent	The central decision-maker for energy-aware scheduling.	Buyer/Order Initiator	1. Ingest real-time grid and compute data. 2. Run the ML Co-optimization Model. 3. Initiate Beckn transactions to the Compute Agent (deferral) or Storage Agent (discharge). 4. Ensure the £/inference target and carbon cap are met.
Energy Storage Agent	Manages the local energy storage (e.g., battery) for flexibility.	Provider/Fulfillment Executor	1. Publish the current State of Charge (SoC) and discharge capacity. 2. Receive and execute requests from the Grid Agent to discharge energy to the compute cluster. 3. Report energy flow and updated SoC.

5. Agent Workflow (max 150 words)

The Compute Agent publishes flexible job slots as a Beckn Catalog. The Grid Co-optimization Agent (GCA) continuously monitors real-time data: compute demand, energy price, and carbon intensity. The GCA's ML model forecasts spikes and determines the optimal action (Run, Defer, or Use Storage) to minimize £/inference under a carbon cap. If deferral is optimal, the GCA initiates a Beckn Order to the Compute Agent. If local energy is needed, it orders the Storage Agent to discharge. All transactions are logged with OBP IDs for auditability, ensuring seamless, autonomous co-optimization of compute and energy resources. This agentic loop enables the monetization of compute flexibility under schemes like P415.

Beckn Workflow Integration: The Compute Agent publishes its flexible job slots as a Catalog item. The Grid Co-optimization Agent acts as the Buyer, querying the Catalog and initiating an Order when the ML model determines it is optimal due to high carbon intensity or price. The Storage Agent acts as a Fulfillment provider, executing a discharge command when the Grid Agent orders it to provide low-carbon, low-cost energy.

6. Business Model & Impact (max 150 words)

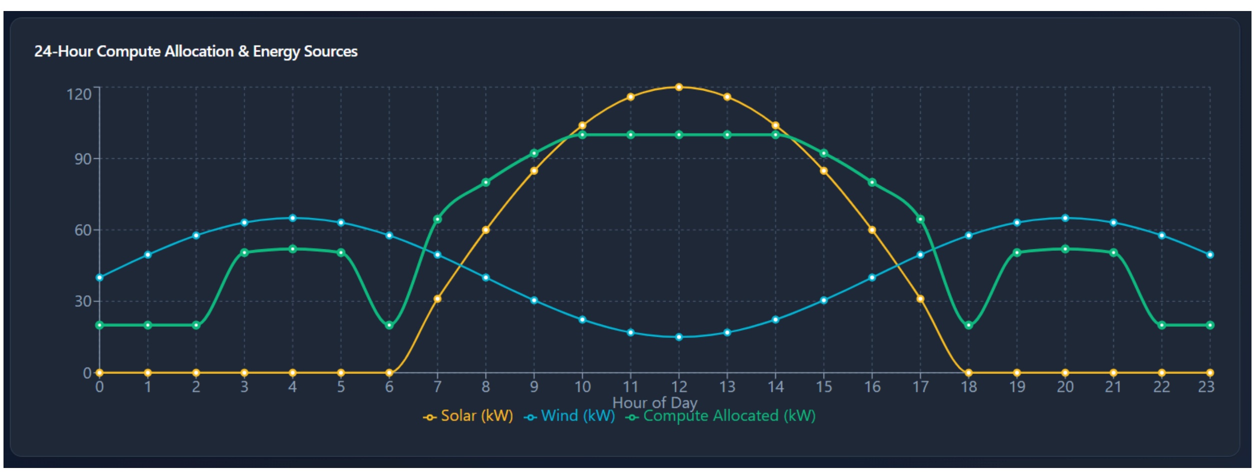
The system operates on a Software-as-a-Service (SaaS) model, charging data centers a percentage of the realized energy cost savings and flexibility market revenue (e.g., P415 payments). A premium tier offers advanced carbon-aware scheduling and multi-agent negotiation features. The model is validated by the verifiable, auditable transaction logs generated via the Beckn Protocol, proving the value delivered.

The system ensures that the surging demand for AI compute does not destabilize the physical grid. It significantly reduces the carbon footprint of digital infrastructure by prioritizing low-carbon energy periods, lowers operational costs for data centers, and transforms compute flexibility into a valuable grid asset, accelerating the transition to a decentralized energy future.

7. References / Inspiration (optional)

• Beckn Protocol Core Specification.
• Unified Energy Interface (UEI) – Beckn-based energy network manifestation.
• Digital Energy Grid (DEG) Vision Paper.

https://claude.ai/public/artifacts/3453491c-bdf9-4d3a-bc1a-e6668cfb98f8



https://github.com/SwapnilMurat/Compute-Energy-Convergence-in-a-DEG-World/tree/main