Digital Energy Grid Algorithm Design

1. Team Information

Team Name: SynapseFlex
Team Members:
• Andy Chen — AI Engineer & Systems Architect
• Rad Dris — Beckn / Backend Engineer
• Saaheb Kohli — UX & Simulation Designer

2. Problem Focus

☑ **Problem 2: Compute–Energy Convergence in a DEG World**

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3. Solution Overview (max 150 words)

SynapseFlex is an agentic orchestration system that unifies compute workloads and energy resources within the **Digital Energy Grid (DEG)** ecosystem. Inspired by the DEG Vision Paper, we treat compute clusters, storage, and grid nodes as **digitally addressable assets**—each with a DEG-compliant identity and machine-readable operational metadata. SynapseFlex forecasts compute demand, grid conditions, and carbon intensity, then dynamically aligns AI workload execution with periods of low cost, low carbon, or high renewable availability. Using the Beckn protocol, compute agents publish job slots as catalog items while grid and storage agents respond via interoperable order lifecycles. The system minimises **£ per inference** under a carbon-intensity cap and monetises workload deferral via **P415 flexibility participation**. Our approach reflects the “Great Transformation” and “Age of Freedom” principles: an abundant, clean, interoperable compute-energy fabric that avoids centralised, extractive energy-compute dystopias.

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4. Technical Architecture (max 200 words)

Key Agents
• **Compute Operator Agent (COA):** Represents GPU clusters and server farms. Publishes workloads as Beckn catalog items annotated with DEG asset IDs, energy needs, carbon caps, and flexibility windows.
• **Grid Operator Agent (GOA):** Provides price, carbon intensity, renewable forecast, and capacity availability using DEG APIs. Validates and confirms workload orders.
• **Storage Agent (SA):** Represents behind-the-meter or grid-scale batteries that can discharge strategically to support compute windows.
• **Forecasting Agent (FA):** Predicts compute spikes (based on queue metrics, user demand, model deployment schedules) and grid conditions (short-term supply, price, carbon intensity).

Data Sources / APIs / Models
• **DEG identity registry**, machine-readable asset metadata
• **Beckn Sandbox APIs** for discovery, catalog, and order flows
• Real-time grid signals (simulated): carbon intensity, price, renewable fraction
• Predictive models: temporal sequence models (LSTM/TFT) for workload and grid forecasting

Orchestration Logic
A multi-objective optimiser evaluates cost, carbon caps, P415 value streams, and asset constraints.

COA issues order requests to GOA/SA; GOA confirms when conditions meet carbon/capacity thresholds. Logs capture decisions, sources, and trade-offs for auditability and flexibility settlement.

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5. Agent Workflow (max 150 words)

1. **Asset Registration:** All agents register through a DEG-aligned identity layer, creating interoperable digital twins of compute nodes, storage assets, and grid services.
2. **Forecasting:** FA predicts compute and grid conditions, generating recommended windows for low-carbon or low-cost execution.
3. **Publication:** COA publishes job slots via Beckn catalog, including energy demand, carbon cap, and allowable deferral window.
4. **Discovery & Negotiation:** GOA and SA discover job slots through Beckn search/select, offering capacity, renewable availability, or discharge schedules.
5. **Order Lifecycle:** COA confirms optimal offers; GOA allocates energy capacity and SA commits storage discharge if needed.
6. **Execution & Monitoring:** Workloads run only when conditions match the optimiser's targets. Logs are stored for carbon auditing and P415 flexibility claims.

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6. Business Model & Impact (max 150 words)

Stakeholders: Data centres, hyperscalers, cloud providers, DSOs/TSOs, flexibility aggregators, storage operators, and sustainability-focused enterprises.

Business Model:

• SaaS orchestration layer for compute-energy optimisation
• Transaction-based fees on flexibility market participation
• Optional premium modules: carbon-aware SLA engine, regional compute-shifting, renewable-only workload guarantees

Impact:

• Reduces cost per inference by aligning compute with low-price or renewable-rich grid periods.
• Unlocks new revenue streams for data centres by participating in **P415 flexibility markets**.
• Strengthens the grid by smoothing load, increasing renewable utilisation, and reducing peak demand.
• Supports the RethinkX "Age of Freedom" vision by democratizing access to clean, abundant compute and avoiding centralised, opaque compute-energy systems.

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7. References / Inspiration (optional)

• **Digital Energy Grid (DEG) Vision Paper**, FIDE, 2025
• Beckn Protocol Specification
• RethinkX — *The Great Transformation*, *The Age of Freedom*, *Two Dystopias*
• Google Carbon-Intelligent Computing
• UK Carbon Intensity & P415 Flexibility Framework
• National Grid ESO / LF Energy interoperability frameworks