The **Sustainable "AI-Ready" Cloud Data Center Simulator** is a high-level project that addresses **Environmental Intelligence**. In 2026, IT departments are moving from simple automation to "Carbon-Aware" computing, where software actively seeks to minimize its ecological impact by following the sun or the wind.

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1. Project Overview

This project involves building a **Digital Twin** (a virtual simulation) of a cloud data center. It uses Data Science to model renewable energy availability (Solar/Wind) and AI to intelligently schedule "heavy" computing tasks for times when the carbon footprint is lowest. The goal is to prove that AI can balance high-performance computing with zero-carbon goals.

2. Industrial Application

- **Sector:** Cloud Providers (AWS/Azure/GCP), Green Energy, Enterprise IT.
- **Problem:** Data centers consume massive amounts of electricity. Often, they run heavy batch jobs (like training other AI models or processing logs) using "dirty" grid power when they could have waited a few hours for "clean" renewable energy.
- **Solution:** A **Carbon-Aware Scheduler** that dynamically shifts workloads in time (Temporal Shifting) or location (Spatial Shifting) based on real-time green energy availability.
- **Real-World Example:** Google's **Carbon-Intelligent Computing Platform**, which shifts non-urgent tasks to times when wind and solar power are most plentiful.

3. Architecture & Workflow

The system utilizes a "Predict-Optimize-Execute" pipeline:

- **Data Science (The Environmental Twin):**
  - Ingests historical **Weather Datasets** (Solar radiation, Wind speed) to model how much "Green Power" is available at any given hour.
  - Models **Server PUE (Power Usage Effectiveness)** to calculate how much cooling energy is needed based on ambient temperature.
- **AI Engine (Reinforcement Learning):**
  - Uses a **Deep Q-Network (DQN)** agent.
  - **State:** Current task queue, current solar intensity, current electricity price.
  - **Action:** Execute task now, Delay task, or Hibernate server.
  - **Reward:** The agent receives points for using 100% renewable energy and loses points for using grid power or missing a task deadline.
- **Cloud Orchestration (The "Action" Layer):**
  - **AWS Step Functions:** Manages the logic flow. If the AI says "Wait," the Step Function puts the task in a "Holding State."
  - **AWS Lambda:** Executes the actual "simulated" workload when the AI provides the "Green Signal."

- **Visualization & Analytics:**
  - A dashboard tracks **"Carbon Avoided"** (the amount of CO_2 that *would* have been emitted if not for the AI's scheduling).

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4. Technology Stack

- **Cloud Provider:** AWS or Azure.
- **Data Science:** Python (Pandas, NumPy), OpenWeatherMap API (for historical solar/wind data).
- **AI/ML:** Stable-Baselines3 (for the DQN algorithm) or TensorFlow.
- **Compute/Orchestration:** AWS Step Functions, AWS Lambda, Amazon EventBridge.
- **Database:** Amazon DynamoDB (to store the "Green Status" of different virtual regions).
- **Dashboard:** Streamlit (to visualize energy curves vs. workload spikes).

Key Project Differentiator

To impress your evaluators, highlight the concept of "Temporal Shifting." Explain that your AI understands that a backup job doesn't need to happen at 6:00 PM (peak grid demand); it can wait until 2:00 AM when wind energy is peaking and the grid is "cleaner." This demonstrates a deep understanding of Sustainable IT (GreenOps).