# Product Requirements & Specification Document

## Project Name

**GridInsightPro - Smart Energy Demand Forecaster**

## Overview

GridInsightPro is a web application enabling energy providers to forecast demand using big data and AI. The platform allows users to upload consumption data, visualize regional trends, and receive predictive insights for grid management. Key features include real-time analytics, anomaly detection, and collaborative planning tools.

---

## 1. Objectives

| Objective | Description |
|---|---|
| Accurate Demand Forecasting | Provide AI-driven, high-accuracy demand forecasts for energy providers. |
| Real-Time Analytics | Enable live monitoring and analysis of energy consumption data. |
| Anomaly Detection | Identify and alert on unusual consumption patterns. |
| Collaborative Planning | Facilitate team-based scenario planning and decision-making. |

---

## 2. Target Users

| User Type | Description |
|---|---|
| Grid Operators | Monitor, forecast, and manage grid demand. |
| Data Analysts | Analyze trends and anomalies in consumption. |
| Planners/Managers | Collaborate on grid management strategies. |

---

## 3. Core Features

| Feature | Description |
|---|---|
| Data Upload | Secure upload of CSV/Excel consumption data. |
| Data Visualization | Interactive dashboards for regional and temporal trends. |
| Predictive Insights | AI/ML-based demand forecasts (short/long-term). |
| Real-Time Analytics | Live data streaming and instant metric updates. |
| Anomaly Detection | Automated detection and alerting of outliers. |
| Collaborative Tools | Shared workspaces, comments, and scenario planning. |

| | |
|---|---|
| User Management | Role-based access control and audit logs. |

---

## 4. Functional Requirements

| ID | Requirement |
|---|---|
| FR1 | Users can upload and validate large datasets (up to 10GB) in CSV/Excel formats. |
| FR2 | System processes and stores data using distributed Spark jobs on GCP. |
| FR3 | Users can view interactive charts (line, bar, heatmap) of consumption by region/time. |
| FR4 | AI/ML models (Python) generate demand forecasts; results are visualized and downloadable. |
| FR5 | Real-time analytics dashboard updates with live data streams. |
| FR6 | Anomaly detection flags and notifies users of irregular patterns. |
| FR7 | Users can create, share, and comment on planning scenarios. |
| FR8 | Role-based permissions: Admin, Analyst, Viewer. |
| FR9 | Audit logs track data uploads, changes, and user actions. |

---

## 5. Non-Functional Requirements

| ID | Requirement |
|---|---|
| NFR1 | System uptime ≥ 99.5%. |
| NFR2 | Data upload and processing latency < 2 minutes for 10GB files. |
| NFR3 | Forecast accuracy ≥ 95% (measured by MAPE on test data). |
| NFR4 | Secure data storage and encrypted transmission (TLS 1.2+). |
| NFR5 | Scalable to 100 concurrent users and 1TB data. |
| NFR6 | Responsive UI (load time < 2s on modern browsers). |

---

## 6. Technical Architecture

| Layer | Technology/Tooling |
|---|---|
| Frontend | Next.js, React, D3.js/Chart.js |
| Backend API | Python (FastAPI/Flask), REST |
| Data Processing | Apache Spark (GCP Dataproc) |
| ML/AI | Python (scikit-learn, TensorFlow) |
| Storage | GCP BigQuery, Cloud Storage |
| Auth/Security | GCP IAM, OAuth2 |
| Deployment | GCP Cloud Run, CI/CD (GitHub Actions) |

## 7. User Flows

```
flowchart TD
    A[Login] --> B[Upload Data]
    B --> C[Data Validation]
    C --> D[Processing & Storage]
    D --> E[Visualization Dashboard]
    E --> F[Forecast & Anomaly Detection]
    F --> G[Collaborative Planning]
```

## 8. API Endpoints (Sample)

| Endpoint | Method | Description |
|---|---|---|
| /api/upload | POST | Upload consumption data |
| /api/forecast | GET | Retrieve demand forecasts |
| /api/anomalies | GET | Get detected anomalies |
| /api/scenarios | POST | Create new planning scenario |
| /api/users | GET | List users and roles |

## 9. UI/UX Guidelines

- **Theme:** Futuristic, clean, and intuitive.
- **Navigation:** Sidebar with quick access to core modules.
- **Visualization:** Interactive, real-time, and exportable.
- **Accessibility:** WCAG 2.1 AA compliance.

## 10. Milestones & Timeline

| Milestone | Target Date |
|---|---|
| Requirements Finalized | Week 1 |
| MVP Development Start | Week 2 |
| Core Features Complete | Week 8 |
| Internal Testing | Week 10 |
| Beta Release | Week 12 |
| Production Launch | Week 16 |

## 11. Risks & Mitigations

| Risk | Mitigation |
| --- | --- |
| Data privacy breaches | End-to-end encryption, strict IAM policies |
| Model accuracy shortfall | Continuous retraining, model monitoring |
| Scalability bottlenecks | Use of GCP managed services, auto-scaling |

---

## 12. Success Metrics

| Metric | Target Value |
| --- | --- |
| Forecast Accuracy | ≥ 95% MAPE |
| User Adoption (3 months) | ≥ 50 active users |
| System Uptime | ≥ 99.5% |
| Data Processing Latency | < 2 minutes |

---

**End of Document**