Product Requirements Document (PRD)

Powercast AI - Multi-Region Grid Forecasting & Decision Support System

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Document Owner: Senior Product Manager
Stakeholders: Grid Operators, Plant Managers, Energy Analysts, Government Agencies

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Executive Summary

Product Vision

Powercast AI is an AI-powered electrical load forecasting and decision support platform designed to optimize power generation scheduling, maintenance planning, and capacity expansion across **India and Switzerland** (with extensibility to other regions). The platform empowers grid operators and plant managers to make data-driven decisions that reduce costs, improve grid stability, and maximize renewable energy utilization.

Business Objectives

1. **Cost Savings**: Reduce over-generation waste and fuel costs through accurate forecasting (Target: 12-18% reduction in operational costs)
2. **Grid Stability**: Prevent blackouts and load shedding via proactive demand-supply balancing
3. **Market Opportunity**: Capture B2B SaaS market targeting utility companies and government grid agencies in India and Switzerland
4. **Research & Innovation**: Establish credibility as a leader in AI-driven grid optimization for emerging markets

Success Metrics (Year 1)

Metric	Target	Measurement
Forecast Accuracy (MAPE)	<8% overall	Thermal/Nuclear: ±5%, Solar/Wind: ±12%
System Uptime	99.5%	Monthly availability tracking
API Latency (P95)	<5 seconds	Forecast generation time
User Adoption	15 utility companies	Active subscriptions (India + Switzerland)

Metric	Target	Measurement
Cost Savings	CHF 2.5M	Documented savings across pilot deployments

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Problem Statement

Current Pain Points

1. **Inaccurate Forecasting**: Traditional methods fail to capture nonlinear temporal patterns in renewable energy sources (solar/wind variability)
2. **Over-Generation Waste**: Excess power generation during low demand periods leads to 15-20% cost inefficiency
3. **Reactive Maintenance**: Unplanned downtime costs utilities 8-12 crore annually per plant
4. **Renewable Integration Challenges**: India's 175 GW renewable target by 2026 requires sophisticated grid balancing
5. **Data Silos**: Plant operators lack unified dashboards combining historical, real-time, and forecast data

Target Users

Persona	Role	Key Needs	Pain Points
Grid Operator (Primary)	Dispatch control, real-time balancing	Intraday (15-min to 6h) forecasts, anomaly alerts	System instability during peak demand
Plant Manager (Primary)	Operations, maintenance scheduling	Day-ahead (24-48h) forecasts, maintenance windows	Unplanned shutdowns, capacity underutilization
Energy Analyst (Primary)	Performance tracking, reporting	Historical accuracy trends, export capabilities	Manual data aggregation from multiple sources
Utility Executive (Secondary)	Strategic planning, investment	Long-term (week/month) forecasts, ROI metrics	Lack of actionable insights for capacity expansion

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Product Scope

In-Scope (MVP + Phase 1)

Core Forecasting - XGBoost-based multi-horizon forecasting (hours, days, weeks) - Support for 5 plant types: Solar, Hydro, Wind, Nuclear, Thermal - Confidence intervals (Q10/Q50/Q90) for uncertainty quantification - Real-time CSV upload + API ingestion (SCADA/POSOCO compatible)

Data Integration - CSV upload with validation (15-minute interval data) - Weather API integration (OpenWeatherMap: irradiance, wind speed, temperature) - Real-time SCADA data connector (OPC UA/IEC 61850 protocols) - Multi-region timezone support (IST for India, CET/CEST for Switzerland)

Decision Support - Generator ON/OFF recommendations based on load forecasts - Maintenance window identification (low-load period detection) - Dynamic optimization suggestions (fuel efficiency, dispatch timing) - Export reports (PDF executive summary + Excel with charts)

User Experience - Modern pill-box UI design with glassmorphism - Multi-horizon graph visualization (scrollable for 8760+ data points) - Auto-refresh forecasts (10-15 min intervals) + manual refresh - AI chat assistant (Gemini 2.0 Flash for Q&A)

Out-of-Scope (Future Phases)

Multi-plant comparison dashboard (Phase 2)
Automated SCADA control commands (Phase 3)
Mobile native app (Phase 2)
Carbon footprint tracking (Phase 3)
Anomaly detection with ML alerts (Phase 2)

Technical Architecture

System Overview

```
                    Frontend (Next.js 16)
  - Dashboard, Forecasts, Optimize Tabs
  - Recharts visualization + CSV export
  - Zustand state management + localStorage

                   REST API

                 Backend (FastAPI - Python)
  - XGBoost inference service (96 sub-models)
  - Weather API integration (OpenWeatherMap)
```

```
- SCADA data connector (OPC UA client)
- Report generation (PDF/Excel via ReportLab/openpyxl)



           Database (Supabase PostgreSQL)
- User authentication (email/password, future SSO)
- Forecast data (time-series partitioning)
- Plant configurations (generator metadata)
- Audit logs (GDPR/compliance)
```

Technology Stack

Layer	Technology	Rationale
Frontend	Next.js 16, React 19, TypeScript	Modern SSR framework, excellent DX
Backend	FastAPI (Python 3.11+)	High-performance async, native ML integration
ML Model	XGBoost 2.0.3 (96 sub-models)	Industry-leading accuracy for time-series
Database	Supabase (PostgreSQL 15)	Managed DB with built-in auth, real-time subscriptions
State Management	Zustand + localStorage	Lightweight, persistent session state
Visualization	Recharts	Responsive charts, good performance with large datasets
AI Assistant	Gemini 2.0 Flash API	Conversational Q&A for grid operators
Weather API	OpenWeatherMap (Solar Irradiance API)	15-min intervals, global coverage, affordable

ML Model Specifications

XGBoost Multi-Horizon Architecture: - **96 individual XGBRegressor models** (one per 15-minute interval in 24-hour window) - **Hyperparameters** (from `training_config.json`): - `n_estimators`: 500 - `max_depth`: 7 - `learning_rate`: 0.061156 - `subsample`: 0.822780 - `colsample_bytree`: 0.918789

Performance Metrics (Validation Set): - Test MAPE: **0.9108%** (exceeds industry target of <8%) - MAE: **69.16 MW** - Inference Time: **157.83 ms**

(well under 5s requirement) - Coverage 90%: **91.04%** (high confidence interval accuracy)

Feature Engineering (21 features): 1. **Lag Features**: 1h, 6h, 24h, 168h (7 days) 2. **Rolling Statistics**: 24h mean/std, 168h mean/std 3. **Calendar Features**: Hour (sin/cos), Day of week (sin/cos), Month (sin/cos), Weekend flag, Peak hour flag 4. **Weather Features**: Temperature, humidity, wind speed, irradiance (solar), cloud cover, precipitation

Conformal Prediction: - Provides uncertainty quantification via quantile intervals (Q10, Q50, Q90) - Critical for risk-aware decision making in grid operations

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Data Standards & Integration

CSV Format (Standard Grid API Schema)

Base Schema (All Plant Types):

```
timestamp,output_mw,temperature,humidity,wind_speed,[plant_specific_cols]
2024-01-15T00:00:00Z,680,4.5,72,2.8,142.5,87.2
```

Column	Type	Description	Example
`timestamp`	ISO 8601 (UTC)	15-minute intervals	`2024-01-15T00:15:00Z`
`output_mw`	float	Power output in MW	`680.5`
`temperature`	float	Ambient temp (°C)	`4.5`
`humidity`	int	Relative humidity (%)	`72`
`wind_speed`	float	Wind speed (m/s)	`2.8`

Plant-Specific Extensions: - **Solar**: `cloud_cover` (%), `irradiance` (W/m²) - **Hydro**: `water_flow_rate` (m³/s), `reservoir_level` (%) - **Wind**: `wind_direction` (degrees), `turbulence` (%) - **Thermal**: `fuel_consumption` (tons/h), `efficiency` (%) - **Nuclear**: `reactor_temp` (°C), `capacity_factor` (%)

Regional Compliance

India (POSOCO/SLDC Standards): - Follows **Forum of Regulators (FOR)** 5-minute scheduling guidelines - Data interval: 15-minute blocks (compatible with POSOCO reporting) - Timezone: IST (UTC+5:30) - Regulatory: CEA reporting formats, MNRE renewable integration norms

Switzerland (Swissgrid/ENTSO-E Standards): - Aligns with **ENTSO-E Transparency Platform** schemas - Data interval: 15-minute (EU standard) -

Timezone: CET/CEST (UTC+1/+2 with DST handling) - Regulatory: Swiss Federal Electricity Act compliance

API Integration Points

SCADA Connector (Real-time Data): - **Protocol**: OPC UA (IEC 62541) - industry standard for industrial automation - **Fallback**: IEC 61850 for legacy systems - **Polling Interval**: 5 minutes (aggregated to 15-min for forecasting) - **Data Points**: Active power (MW), reactive power (MVAR), frequency, voltage

Weather API (OpenWeatherMap): - **Endpoint**: `https://api.openweathermap.org/energy/2.0/solar/ir` - **Parameters**: `lat`, `lon`, `date`, `interval=15m` - **Data**: GHI (Global Horizontal Irradiance), DNI, DHI, cloud cover, wind speed - **Cost**: ~$500/month for 100,000 calls (suitable for 50 plants with hourly updates)

Functional Requirements

FR1: Dashboard - Plant Configuration

User Story: As a plant manager, I want to configure my plant's parameters so the system can generate accurate forecasts.

Acceptance Criteria: - [ ] User selects plant type from 5 options (Solar, Hydro, Wind, Nuclear, Thermal) - [ ] User inputs plant name (max 100 characters) and total capacity (MW, integer 1-10,000) - [ ] **Generator Configuration** (NEW): - User adds 1-10 generator units with individual capacities - Each unit has ON/OFF status, minimum turndown level (%), ramp rate (MW/min) - Example: Solar Plant (500 MW) = Inverter 1 (200 MW) + Inverter 2 (300 MW) - [ ] CSV upload validates against plant type schema (shows errors if columns missing) - [ ] System displays data summary: row count, avg output, max output, date range - [ ] "Initialize Forecast" button is disabled until plant name + CSV + valid capacity

Technical Notes: - Store generator configs in `plant_generators` table (FK to `plants`) - Validation logic in `lib/utils/csv-parser.ts` (add generator-level checks)

FR2: Forecasts - Multi-Horizon Visualization

User Story: As a grid operator, I want to view forecasts for different time horizons (hours, days, weeks) to plan dispatch schedules.

Acceptance Criteria: - [ ] Horizon selector: **Hours** (6h, 12h, 24h, 48h) | **Days** (3d, 7d, 14d) | **Weeks** (4w, 12w) - [ ] Graph adjusts X-axis dynamically: - Hours: 15-min ticks - Days: Hourly ticks - Weeks: Daily ticks - [ ] Chart is horizontally

scrollable for >200 data points (no UI glitches) - [ ] Confidence bands (Q10-Q90) shown as shaded area - [ ] Metrics update to match selected horizon: Peak Output, Avg Output, Total Energy - [ ] Export button downloads CSV with filtered data (only selected horizon) - [ ] Auto-refresh every 10-15 minutes (user sees countdown timer) - [ ] Manual refresh button (spins on click, shows "Last updated: 2m ago")

Performance Requirements: - Graph renders 8,760 data points (1 year hourly) in <3 seconds - Smooth scrolling (60 FPS) with 1000+ points visible - Use virtualization for large datasets (react-window or similar)

Technical Notes: - XGBoost model supports up to 96 intervals (24h). For longer horizons: - 7 days = 7 separate 24h forecasts (chained) - 12 weeks = Weekly aggregates from daily forecasts - Store forecast cache in Supabase with 24h TTL

FR3: Optimize - Dynamic Recommendations

User Story: As a plant manager, I want AI-generated optimization suggestions based on my actual forecast data to improve efficiency.

Acceptance Criteria: - [ ] **Generator ON/OFF Table**: - Shows each generator unit with current status, forecasted load, and recommended action - Logic: If forecast < (generator min turndown × capacity), recommend OFF - Example: Thermal Unit 2 (300 MW, 40% min) → If forecast shows 100 MW → Recommend OFF - [ ] **Maintenance Windows**: - Identifies 4-hour+ periods where forecast is <50% of capacity - Displays table: Date/Time, Duration, Forecasted Avg Load, Potential Savings (CHF/) - [ ] **Efficiency Recommendations**: - Plant-specific suggestions (from demo: 13 hardcoded, replace with dynamic) - Priority-coded (High=Red, Medium=Yellow, Low=Green) - Impact estimates: Cost savings (CHF/), Efficiency gain (%), Energy capture (+MW) - [ ] **Apply/Dismiss Actions**: - "Apply" logs recommendation to audit trail (no automated SCADA control in MVP) - "Dismiss" hides from list (persists in session storage) - [ ] Export recommendations as PDF report (executive summary format)

Recommendation Logic (Pseudo-code):

```
# Generator ON/OFF
for unit in plant.generators:
    if forecast_avg < (unit.capacity * unit.min_turndown):
        recommend_action = "Turn OFF to save fuel"
        estimated_savings = calculate_idle_cost(unit, duration_hours)

# Maintenance Windows
low_load_periods = forecast.find_consecutive_periods(
    threshold=plant.capacity * 0.5,
```

```
    min_duration_hours=4
)
for period in low_load_periods:
    recommend_window = {
        "start": period.start_time,
        "end": period.end_time,
        "avg_load": period.avg_mw,
        "impact": "Minimal grid disruption"
    }
```

Technical Notes: - Replace static `PLANT_SUGGESTIONS` array with database table + dynamic generation - Use forecast data from `forecastData` store to calculate real-time suggestions

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FR4: Weather Integration

User Story: As the system, I need real-time weather data to improve forecast accuracy for renewable plants.

Acceptance Criteria: - [ ] On plant creation, user provides lat/lon or selects from map - [ ] System fetches weather data from OpenWeatherMap API every hour - [ ] Weather features integrated into XGBoost input: - Solar: `irradiance`, `cloud_cover` - Wind: `wind_speed`, `wind_direction`, `turbulence` - Hydro: `precipitation` (24h accumulated), `temperature` (snow melt proxy) - [ ] Fallback to historical averages if API fails (no blocking errors) - [ ] Weather data cached in Supabase for 7 days (cost optimization) - [ ] User sees weather icon in forecast header (e.g., Clear, 850 W/m²)

API Response Schema (OpenWeatherMap Solar Irradiance):

```
{
  "lat": 28.6139,
  "lon": 77.2090,
  "date": "2026-01-26",
  "interval": "15m",
  "data": [
    {
      "dt": 1706256000,
      "ghi": 850.5,
      "dni": 920.3,
      "dhi": 120.8,
      "cloud_cover": 15
    }
  ]
}
```

Cost Estimate: 50 plants × 24 calls/day = 36,000 calls/month → ~$180/month

Technical Notes: - Create `weather_cache` table with composite index on (lat, lon, timestamp) - Weather fetcher service runs as cron job (every hour)

FR5: SCADA Real-Time Connector

User Story: As a grid operator, I want the system to automatically pull live data from my SCADA system so forecasts stay current without manual CSV uploads.

Acceptance Criteria: - [ ] Admin configures SCADA endpoint via UI: - Protocol: OPC UA or IEC 61850 - Server URL: `opc.tcp://192.168.1.100:4840` - Node ID: `ns=2;s=PlantOutput.ActivePower` - Poll interval: 5 minutes - [ ] System validates connection (green checkmark if successful) - [ ] Live data populates forecast chart with "LIVE" badge - [ ] Historical CSV data + live SCADA data merged seamlessly on graph - [ ] If SCADA connection fails, system falls back to last CSV data (shows warning) - [ ] Audit log records all SCADA data fetch events (timestamp, value, status)

Security: - SCADA credentials stored encrypted (AES-256) in Supabase vault - Connection over VPN or secure tunnel (no public internet exposure) - IP whitelisting for SCADA server access

Technical Notes: - Use `asyncua` library (Python) for OPC UA client - SCADA connector runs as background worker (Celery or similar) - Create `scada_connections` and `scada_data` tables

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FR6: Export Reports (PDF/Excel)

User Story: As an energy analyst, I want to export forecast data and recommendations as professional reports for management review.

Acceptance Criteria: - [ ] **Excel Export**: - Contains 3 sheets: "Forecast Data", "Metrics Summary", "Recommendations" - Forecast Data: timestamp, output_mw, q10, q50, q90, actual (if available) - Charts embedded (line chart for forecast, bar chart for metrics) - File naming: `{PlantName}_Forecast_{Date}.xlsx` - [ ] **PDF Export** (Executive Summary): - Cover page: Plant name, logo, date range, report period - Page 1: Key Metrics (Peak, Avg, Efficiency, Savings) - Page 2: Forecast chart with annotations (peak hours highlighted) - Page 3: Top 5 Recommendations with impact estimates - Page 4: Accuracy analysis (if historical data available) - File naming: `{PlantName}_ExecutiveSummary_{Date}.pdf` - [ ] Export triggered from "Download" button in Forecasts/Optimize tabs - [ ] Progress indicator

during generation (typically 3-5 seconds) - [ ] Files auto-downloaded to user's device (no email in MVP)

Technical Notes: - Excel: `openpyxl` (Python) or `exceljs` (Node.js) - PDF: `ReportLab` (Python) with custom templates - Charts rendered as PNG via `matplotlib` or `Recharts` server-side

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Non-Functional Requirements

NFR1: Performance

Metric	Requirement	Measurement Method
Forecast Generation	P95 latency <5s	API endpoint monitoring (96-interval prediction)
Page Load Time	<3s (first contentful paint)	Lighthouse CI in build pipeline
Chart Rendering	8,760 points in <3s	Browser DevTools Performance tab
API Throughput	100 concurrent forecasts	Load testing with Locust/k6
Database Queries	<200ms (95th percentile)	Supabase query analyzer

NFR2: Scalability

- **Horizontal Scaling**: Backend API supports auto-scaling (3-10 instances based on load)
- **Data Volume**: Handle 1,000 plants × 8,760 data points/year = ~8.76M rows
- **Concurrent Users**: Support 500 simultaneous users across India + Switzerland timezones
- **Forecast Storage**: Partition time-series data by month (PostgreSQL partitioning)

NFR3: Security & Compliance

India Compliance: - **Data Localization**: Store Indian utility data in Mumbai region (AWS ap-south-1) - **Audit Logs**: Retain for 7 years (as per CEA guidelines) - **Encryption**: AES-256 at rest, TLS 1.3 in transit - **Access Control**: Role-based (Admin, Analyst, Viewer)

Switzerland Compliance: - **GDPR**: Right to erasure, data portability, consent management - **Data Residency**: EU region (Frankfurt - eu-central-1) - **Audit Logs**: 3-year retention

Multi-Tenancy Isolation: - Row-Level Security (RLS) in Supabase (each plant belongs to one organization) - API keys scoped to organization ID - No cross-tenant data leakage (verified via penetration testing)

NFR4: Reliability

- **Uptime SLA**: 99.5% (max 3.65 hours downtime/month)
- **Data Backup**: Automated daily backups, 30-day retention
- **Disaster Recovery**: RTO=4 hours, RPO=15 minutes
- **Failover**: Multi-region deployment (India: Mumbai + Delhi, Switzerland: Frankfurt)

NFR5: Observability

- **Logging**: Structured logs (JSON) to CloudWatch/Datadog
- **Metrics**: Prometheus for API latency, error rates, forecast accuracy
- **Tracing**: OpenTelemetry for distributed request tracing
- **Alerting**: PagerDuty for critical errors (forecast failure, SCADA disconnect)

User Journey Flows

Primary Flow: Generate First Forecast

```
1. User logs in → Dashboard tab
2. Selects plant type (e.g., Solar)
3. Enters plant name ("Rajasthan Solar Park") + capacity (500 MW)
4. Adds generator units:
   - Inverter 1: 200 MW, Min 20%, Ramp 5 MW/min
   - Inverter 2: 300 MW, Min 20%, Ramp 8 MW/min
5. Uploads CSV (solar_farm_data.csv) → System validates
6. Clicks "Initialize Forecast" → Redirects to Forecasts tab
7. Views 24h forecast chart with confidence bands
8. Selects 7-day horizon → Chart updates
9. Reviews recommendations in Optimize tab
10. Exports PDF executive summary
```

Secondary Flow: SCADA Live Integration

```
1. Admin goes to Settings → SCADA Connectors
2. Clicks "Add SCADA Source"
3. Enters OPC UA endpoint: opc.tcp://10.0.1.50:4840
4. Selects data tags: ActivePower, Frequency, Voltage
5. Tests connection → Green checkmark
6. Sets poll interval: 5 minutes
7. Saves configuration
```

```
8. System starts background polling
9. Forecasts tab shows "LIVE" badge
10. Graph auto-updates every 15 minutes with new data
```

Roadmap & Milestones

Phase 1: MVP (Months 1-3)

Goal: Single-plant forecasting with XGBoost + basic UI

Week	Deliverable	Owner
1-2	Backend API scaffold (FastAPI + XGBoost model loader)	Backend Team
3-4	Frontend dashboard + forecast visualization (Next.js)	Frontend Team
5-6	CSV upload + validation + generator config	Full Stack
7-8	Weather API integration (OpenWeatherMap)	Backend Team
9-10	Dynamic recommendations engine	ML Team
11-12	PDF/Excel export + QA testing	Full Stack

Milestone: Beta launch with 3 pilot customers (1 India, 1 Switzerland, 1 internal)

Phase 2: Scale (Months 4-6)

Goal: Multi-plant comparison + SCADA integration

Feature	Priority	Estimated Effort
SCADA real-time connector (OPC UA)	P0	3 weeks
Multi-plant comparison dashboard	P0	2 weeks
Historical accuracy tracking	P1	2 weeks
Alert/notification system (email)	P1	1 week
API for third-party integrations	P2	2 weeks
Role-based access control (RBAC)	P2	1 week

Milestone: Production launch, onboard 15 utility companies

Phase 3: Advanced (Months 7-12)

Goal: Anomaly detection + carbon tracking

Feature	Priority	Estimated Effort
Anomaly detection with ML alerts	P1	4 weeks
Carbon footprint tracking	P1	3 weeks
What-if scenario analysis	P2	3 weeks
Mobile app (React Native)	P2	6 weeks
Advanced analytics (Prophet, LSTM)	P3	4 weeks

Milestone: Market leader in India renewable forecasting

Success Criteria & KPIs

Technical KPIs

Metric	Target	Measurement
Forecast Accuracy (MAPE)	<8%	Weekly validation against actual data
Thermal/Nuclear MAPE	±5%	Plant-type specific tracking
Solar/Wind MAPE	±12%	Seasonal analysis (monsoon vs clear sky)
P95 API Latency	<5s	Prometheus metrics
Uptime	99.5%	Pingdom/Uptime Robot
Chart Render Time	<3s for 8760 points	Lighthouse CI

Business KPIs

Metric	Target (Year 1)	Measurement
Active Customers	15 utility companies	Subscription tracking
Revenue (ARR)	CHF 500K	Billing system
Cost Savings Delivered	CHF 2.5M	Customer success surveys
User Adoption Rate	70% of pilots convert	Sales pipeline
NPS Score	>40	Quarterly surveys

User Satisfaction

Metric	Target	Measurement
Time Saved vs Manual	80% reduction	User interviews

Metric	Target	Measurement
Forecast Trust Score	4.2/5.0	In-app rating
Feature Adoption	60% use recommendations	Product analytics

Risk Analysis & Mitigation

Technical Risks

Risk	Likelihood	Impact	Mitigation
XGBoost model drift (accuracy degrades)	Medium	High	Automated retraining pipeline (weekly), A/B testing
SCADA integration failures (protocol incompatibility)	High	Medium	Support multiple protocols (OPC UA, IEC 61850, Modbus), fallback to CSV
Scalability bottlenecks (100k+ forecasts/day)	Low	High	Horizontal scaling, Redis caching, database partitioning
Weather API downtime	Medium	Medium	7-day cache, fallback to historical averages

Business Risks

Risk	Likelihood	Impact	Mitigation
Slow pilot adoption (utilities resist change)	Medium	High	Free 3-month trial, on-site implementation support
Regulatory changes (CERC/FOR new rules)	Low	Medium	Modular architecture, compliance expert on retainer

Risk	Likelihood	Impact	Mitigation
Competitive entry (Siemens, GE launch similar)	Medium	High	First-mover advantage, focus on emerging markets (India)

Compliance Risks

Risk	Likelihood	Impact	Mitigation
GDPR violations (data breach)	Low	Critical	Penetration testing, SOC 2 certification, insurance
Data localization non-compliance (India)	Low	High	Multi-region deployment, legal review

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Implementation & Onboarding Strategy

Overview

To ensure successful adoption in the Indian market (primary focus for MVP), Powercast AI will employ a **hybrid implementation model** that balances scalability with hands-on customer success.

SCADA Integration Approach

Phase 1: MVP (First 5-10 Customers) - Hands-On - **Powercast AI team** handles all SCADA integrations - On-site visits to customer facilities (2-3 days per plant) - Direct collaboration with customer IT/OT teams - **Objectives**: - Understand common SCADA configurations in Indian utilities - Build integration templates for popular systems (ABB, Siemens, GE) - Document edge cases and troubleshooting guides - Create video tutorials and setup guides

Phase 2: Scale (Post-MVP) - Hybrid Model - **Self-Service Option** (0 implementation fee): - Comprehensive documentation portal - Video tutorials (Hindi + English) - Pre-built connectors for common SCADA systems - Community forum for peer support - **Target**: Technical customers with in-house IT/OT teams

- **Assisted Setup** (50,000 one-time fee):
  - 2-day on-site implementation by Powercast AI engineer
  - SCADA connection configuration + data mapping
  - Operator training (4 hours)
  - 30-day post-launch support
  - **Target**: State utilities, large industrial plants
- **Managed Service** (2.5 lakh/year add-on):
  - Dedicated integration engineer
  - Quarterly health checks
  - Priority support (4-hour SLA)
  - Custom integration with legacy systems
  - **Target**: Enterprise customers, multi-plant portfolios

Customer Onboarding Journey

Week 1: Kickoff - Sales handoff to Customer Success - Technical requirements gathering call - SCADA system assessment (OPC UA/IEC 61850 compatibility check) - Credentials exchange (secure portal)

Week 2-3: Integration - **Self-Service**: Customer follows guide, support via Slack/email - **Assisted Setup**: On-site visit, live configuration - Data validation (historical CSV upload + live SCADA test) - Weather API location configuration

Week 4: Training & Go-Live - User training session (grid operators, plant managers) - Generate first forecast (24h, 7d horizons) - Review optimization recommendations - Establish success metrics baseline

Week 5-8: Adoption - Weekly check-ins (Customer Success) - Feature adoption tracking (which tabs used?) - Feedback collection for product improvements

Training & Support

Self-Service Resources: - **Documentation Hub**: Step-by-step guides, FAQs, API reference - **Video Library**: - "Getting Started" (10 min) - "SCADA Integration for OPC UA" (20 min) - "Reading Forecast Charts" (8 min) - "Exporting Reports" (5 min) - **Webinars**: Monthly live Q&A sessions (Hindi + English)

Direct Support Channels: - **Email**: support@powercastai.com (24-hour response SLA) - **WhatsApp Business**: +91-XXX-XXXX (for critical issues, India only) - **Slack Channel**: Shared workspace for pilot customers - **Phone**: +91-XXX-XXXX (Mon-Fri, 9 AM - 6 PM IST)

Success Metrics for Onboarding

Metric	Target	Measurement
Time to First Forecast	<14 days from contract signing	Onboarding tracker
SCADA Integration Success Rate	>85% (no escalation needed)	Support tickets
Training Attendance	80% of licensed users	Webinar registrations
Feature Adoption	60% use 3+ tabs within 30 days	Product analytics
Customer Satisfaction (CSAT)	>4.0/5.0 post-onboarding	Survey

Pricing Model (India-Focused MVP)

Subscription Tiers

Starter (50,000/month/plant) - 1 power plant (any type: Solar/Hydro/Wind/Thermal/Nuclear) - Unlimited forecasts (hours/days/weeks horizons) - CSV upload + manual refresh - Basic recommendations (static) - Standard support (24-hour email response) - **Self-service SCADA integration** (documentation only) - Export to Excel - **Target**: Small independent power producers, industrial captive plants

Professional (75,000/month/plant) - Everything in Starter, plus: - **Real-time SCADA integration** (OPC UA/IEC 61850) - Weather API integration (OpenWeatherMap) - Dynamic recommendations (based on actual forecast data) - PDF executive reports - Priority support (4-hour response SLA) - **One-time 50,000 assisted setup** (included in first month) - **Target**: State utilities (SLDC level), large renewable farms

Enterprise (2.5 lakh/year base + 60,000/plant/year) - Everything in Professional, plus: - Unlimited plants (portfolio management) - Multi-plant comparison dashboard (Phase 2) - Custom integrations (legacy SCADA, proprietary protocols) - Dedicated Customer Success Manager - Quarterly Business Reviews (QBRs) - Managed service (health checks, upgrades) - White-label option - **On-site implementation included** - **Target**: National utilities (POSOCO, PowerGrid), large industrial groups

Add-Ons (All Tiers)

Add-On	Price	Description
Historical Accuracy Tracking	10,000/month	Compare forecasts vs actual data, MAPE reports
Alert & Notifications	5,000/month	Email/SMS alerts for anomalies, maintenance windows
API Access	15,000/month	REST API for third-party integrations, 10,000 calls/month
Additional Plants (Starter/Pro)	40,000/month	Discounted rate for 2nd+ plant
On-site Training	25,000/session	Half-day workshop (up to 10 users)

Payment Terms

- **Monthly billing** (Starter, Professional)
- **Annual pre-payment** (Enterprise - 10% discount)
- **Free trial**: 30 days (limited to 1 plant, manual CSV only)
- **Pilot program**: 3 months at 50% discount (first 10 customers)

Revenue Projections (Year 1)

Conservative Scenario (10 customers): - 5 × Professional (75K × 12) = 45 lakh - 3 × Starter (50K × 12) = 18 lakh - 2 × Enterprise (2.5L base + 3.6L/6 plants) = 12.2 lakh - **Total ARR**: 75.2 lakh (~CHF 90K)

Target Scenario (25 customers): - 10 × Professional = 90 lakh - 8 × Starter = 48 lakh - 7 × Enterprise = 42.7 lakh - **Total ARR**: 180.7 lakh (~CHF 215K)

Open Questions & Assumptions

Assumptions

1. Utility companies have CSV historical data (15-min intervals, 6+ months)
2. SCADA systems support OPC UA or IEC 61850 (90% market coverage)
3. Users have stable internet (3G+ for dashboard access)
4. Weather API costs scale linearly with plant count
5. Renewable forecasting accuracy will improve 15% with weather integration (to be validated)

Open Questions (Require Stakeholder Input)

1. **Localization**:

- UI translation to Hindi/German?
- Support local currencies (and CHF in same deployment)?
- Regional date/time formats?

2. **Data Ownership**:
   - Can we use anonymized data to improve model?
   - Customer consent for benchmarking reports?
   - Data retention policy (how long to keep historical forecasts)?
3. **Regulatory Compliance**:
   - Do we need CEA/CERC certification for India market?
   - Energy Audit compliance requirements?
4. **Competitive Positioning**:
   - Pricing comparison with Siemens EnergyIP, GE Digital?
   - Key differentiators to emphasize in sales?

Appendices

A. Glossary

Term	Definition
MAPE	Mean Absolute Percentage Error - forecast accuracy metric
SCADA	Supervisory Control and Data Acquisition - industrial control system
OPC UA	OPC Unified Architecture - industrial communication protocol
IEC 61850	International standard for power utility automation
POSOCO	Power System Operation Corporation - India's national grid operator
SLDC	State Load Despatch Centre - regional grid control
CEA	Central Electricity Authority - regulatory body (India)
ENTSO-E	European Network of TSOs for Electricity
GHI/DNI/DHI	Global/Direct/Diffuse Horizontal Irradiance (solar metrics)

B. References

1. Indian Grid Code - CERC Indian Electricity Grid Code
2. POSOCO Real-Time Data - National grid data portal
3. OpenWeatherMap Solar API - Weather integration
4. XGBoost Documentation - ML model reference
5. Swissgrid Transparency - Swiss grid data

C. Change Log

Version	Date	Changes	Author
2.1	2026-01-26	Added Implementation & Onboarding Strategy section, India-focused pricing model (50K- 75K/month tiers), SCADA integration approach (hybrid: self-service + assisted setup)	Senior PM
2.0	2026-01-26	Complete PRD rewrite based on actual codebase + user requirements	Senior PM
1.0	2026-01-16	Initial draft (deprecated - contained errors)	Previous PM

Document Status: **APPROVED FOR DEVELOPMENT**
Next Review: 2026-02-26 (Monthly stakeholder sync)