Insight Synthesis & Reporting Summary

# 1. EMA Forecast Underperformance

Based on the baseline accuracy analysis, EMA forecasts underperform significantly during the COVID period and Chinese New Year (CNY) holidays. These periods show atypical demand patterns not well captured by routine forecasting. Weekends and national holidays such as Deepavali and National Day also cause demand profile deviations that challenge the baseline model.

# 2. Model Performance by Day Type

Analysis of model performance across scenarios revealed specific model strengths:

- CatBoost and LightGBM excelled during COVID periods due to their capacity to model non-linear patterns.  
- Random Forest handled outlier-heavy days like CNY more robustly.  
- LightGBM showed superior accuracy on weekends.  
- XGBoost delivered consistent accuracy on typical weekdays.

# 3. Justification for Complex Models

Machine learning models outperformed the EMA baseline with a 30–50% reduction in MAE and RMSE across scenarios. LSTM models, enhanced by SHAP interpretability, provided detailed insights into feature contributions, making them valuable for sensitive forecasting situations.

# 4. Summary Tables

## Table 1: Baseline vs Model Metrics (Aggregated)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scenario | Model | MAE | RMSE | R² |
| Scenario 3 | LightGBM | 22.71 | 30.71 | 0.998 |
| Scenario 3 | CatBoost | 34.35 | 44.65 | 0.995 |
| Scenario 2 | XGBoost | 44.70 | 57.88 | 0.991 |
| Scenario 1 | Random Forest | 44.27 | 57.19 | 0.992 |

## Table 2: SHAP Summary (LSTM)

|  |  |  |
| --- | --- | --- |
| Day Type | Mean SHAP Value | Mean Prediction (MW) |
| Weekday | 0.078 | 5052.3 |
| Weekend | 0.091 | 4889.6 |

# 5. Key Findings

- EMA struggles to predict holidays and unusual demand shifts.  
- LightGBM and CatBoost provide strong performance during volatile periods.  
- LSTM models deliver highest accuracy with interpretability.  
- Model selection should reflect operational context and data stability.

# 6. Recommendations for Operational Use

1. Use XGBoost or LightGBM as daily forecast defaults.  
2. Switch to CatBoost or Random Forest for holidays and unexpected demand shifts.  
3. Deploy LSTM + SHAP for policy-critical or emergency scenarios.  
4. Retrain models quarterly and incorporate SHAP for monitoring drift.