Manufacturing Downtime Analysis Project

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1. Project Planning & Management

Project Proposal

Title: Manufacturing Downtime Analysis and Performance Optimization
Overview:
This project focuses on analyzing downtime across manufacturing lines to identify performance bottlenecks, reveal key factors influencing interruptions, and enhance decision-making using Power BI dashboards.

Objectives:

1. Analyze downtime patterns across lines, operators, and products.
2. Identify top downtime causes and quantify their impact on production.
3. Develop interactive dashboards in Power BI for management insights.
4. Support process improvement through data-driven visualization and KPIs.

Scope:
Covers all downtime events recorded across lines, operators, products, and factors, as well as temporal trends (by date, shift, or hour).

Project Plan – Manufacturing Downtime Analysis

Phase	Tasks	Duration	Milestone
1 – Data Collection	Gather downtime logs, machine details, shift schedules, operator info, and maintenance records	Week 1	Raw dataset collected
2 – Data Cleaning & Transformation	Handle missing timestamps, remove duplicates, standardize downtime reasons, format date/time, merge with dimension tables (machine, shift, operator)	Week 2	Cleaned and transformed dataset ready
3 – Data Modeling	Build relationships between Fact_Downtime, Dim_Machine, Dim_Shift, Dim_Operator, and Dim_Line tables; create calculated columns and DAX measures (e.g., Total Downtime, Avg Downtime, OEE)	Week 3	Data model and key metrics established
4 – Dashboard Development	Design Power BI dashboards showing downtime by machine, line, shift, reason, and operator; integrate KPIs	Week 4	First version of Power BI dashboard ready
5 – Review & Refinement	Validate data accuracy, enhance visuals, optimize DAX measures, apply consistent color themes, and add interactivity (filters, drill-throughs)	Week 5	Final, polished dashboard completed
6 – Presentation & Documentation	Create project documentation (methodology, insights, recommendations), prepare presentation slides, and present findings to stakeholders	Week 6	Project completed and presented

Task Assignment & Roles:

Team / Function	Key Responsibilities	Tools Used	Assigned Members
Data Engineering / Data Preparation	- Clean raw data and build data pipelines. - Create structured, reliable data models for analysis.	SQL, Python, Excel	Azza Amen, Mahmoud Elaraby (all the team involved)
Data Analysis / Business Analysis	- Explore data and answer business-driven questions. - Identify KPIs, trends, and anomalies. - Collaborate with stakeholders to refine business questions.	Python, SQL, Excel, Power BI	Malek Mohammed (Lead), Rana Wagih, Islam Mohamed (Business Insights)
Data Visualization / BI	- Develop dashboards and reports for decision-makers. - Focus on storytelling and accessible visual insights.	Power BI, Tableau	Islam Mohamed, Nada Abdullah, Azza Amen (Support)
Documentation / Project Management	- Manage project documentation and coordination. - Track deliverables, ensure alignment with goals. - Prepare reports and presentations.	—	Malek Mohammed (Lead), Mahmoud Elaraby (Support)

Risk Assessment & Mitigation Plan

Risk	Impact	Solution / Mitigation
Incomplete or missing downtime data	Leads to inaccurate analysis and unreliable insights	Communicate with data owners early to ensure full data extraction and verify completeness before modeling
Poor data quality (duplicates, missing values, incorrect timestamps)	Skewed KPIs and wrong downtime patterns	Perform thorough data cleaning, validation, and profiling before loading into Power BI
Data integration issues between tables	Incorrect relationships causing wrong aggregations	Standardize column names, create unique IDs, and validate joins carefully
Errors in DAX calculations or data modeling	Misleading KPIs (OEE, MTTR, MTBF)	Test all measures manually with small samples and review with a peer or supervisor
Performance issues in Power BI	Slow dashboard loading and poor user experience	Optimize data model (star schema, reduce visuals per page, use aggregations)
Time constraints	Project delays and missed deadlines	Set mini-milestones for each week and track progress closely
Stakeholder misalignment on KPIs or visuals	Rework and wasted effort	Share early prototypes for feedback and confirm KPI definitions upfront
Limited access to factory or operational data	Incomplete understanding of downtime causes	Use anonymized or partial datasets and document all assumptions
Misinterpretation of analysis results	Wrong business decisions	Add clear explanations, KPI definitions, and visual tooltips for context
Data or file loss	Project disruption or rework	Maintain frequent backups of datasets and Power BI files in cloud storage

KPIs

- Total Downtime (Minutes/Hours)
- Downtime % by Line
- Top Downtime Reasons (%)
- Downtime Frequency by Factor
- Average Downtime per Event
- Downtime Trend (Week-over-Week or Month-over-Month)
- Units Lost due to Downtime
- Downtime by Shift / Operator / Line

Technology Stack Summary

Tool	*What It Was Used For*
Excel	Collected and stored the raw downtime records, including machine, line, shift, and reason data.
SQL	Queried and extracted downtime and production data from databases; used for filtering, joining tables, and initial data validation.
Python (Pandas)	Performed advanced data cleaning, preprocessing, and exploratory data analysis before visualization.
Power Query	Transformed and shaped the data inside Power BI — handled missing values, corrected data types, and standardized formats.
Power BI (DAX)	Built data models, created calculated KPIs such as OEE, MTTR, and MTBF, and established relationships between tables.
Power BI (Visualization)	Designed interactive dashboards to visualize downtime trends, root causes, and production efficiency.
GitHub	Stored project files, Power BI reports, Python scripts, and documentation for version control and collaboration

Database Design

- **Fact Table:** Fact_Line_Downtime (includes downtime duration, units lost, factor keys, etc.)
- **Dimensions:**
    - Dim_Line — Line details
    - Dim_Product — Product information
    - Dim_Operator — Operator details
    - Dim_Date — Date/time attributes
    - Dim_Downtime_Factor — Cause or category of downtime

Relationships: Star Schema
Fact_Line_Downtime connected to all dimension tables through their keys.