RAG for EU Regulatory Compliant EV Battery End-of-Life Management

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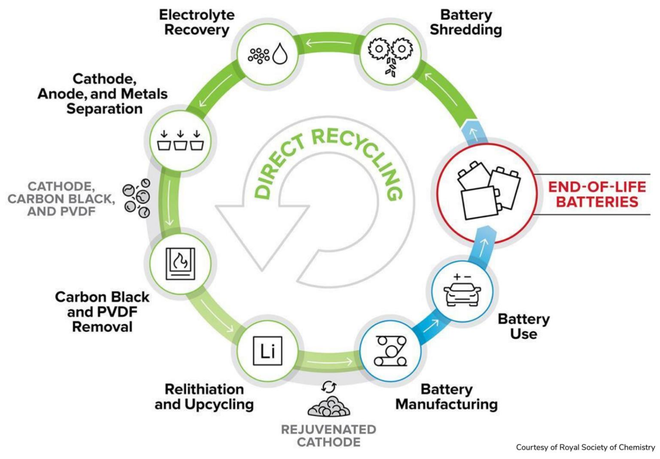
Women in Data Science Worldwide | Regensburg

Introduction:

- 2.4 million new electric vehicle (EV) registrations in 2023[1] ~ **Increase Battery Waste**
- Demands **Battery End-of-Life (EoL) management** and its **compliance with regulatory documents**.
- **Extended Producer Responsibility (EPR) policy**, formalized in EU Regulation 2023/1542[2] states EV producers are **accountable** for tracking EV components and batteries throughout their lifecycle.
- **Sustainable Lifecycle for EVs** is the goal of effective EoL management.
- **Predicting EoL actions** and **ensuring compliance** remains a challenge.

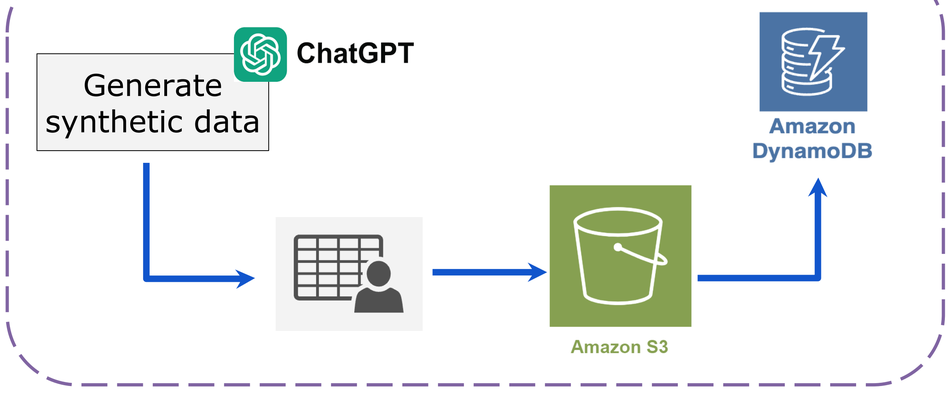


Source: Electric vehicle battery end-of-life management | MOBI

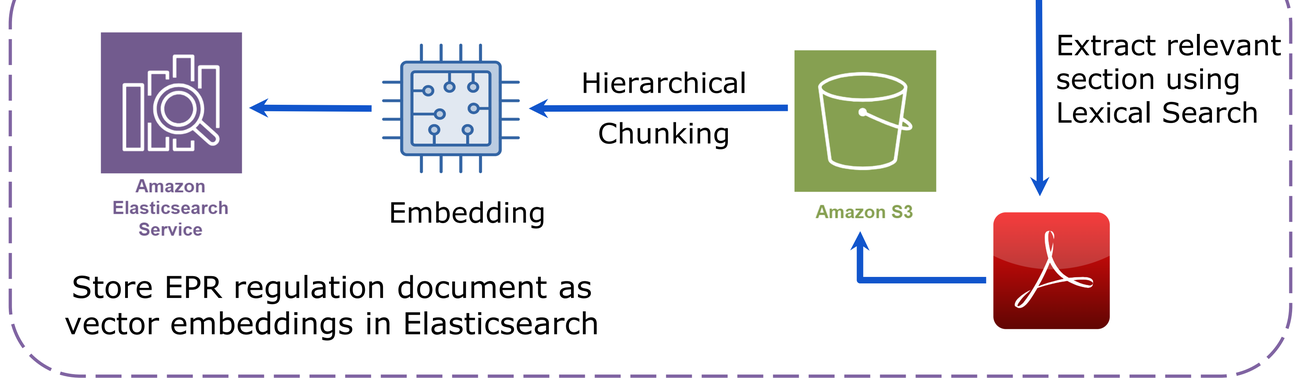
Workflow for determining Battery EoL Action and its compliance with EPR regulation

DATA INGESTION

Battery and Vehicle Usage Information



Data Indexing of EPR Regulation



RETRIEVAL AND GENERATION

Battery Parameters

1. Battery capacity
2. Production date
3. Mileage
4. Vehicle maintenance records
5. Location

Battery Status

1. Remaining health percentage
2. Recommended EoL Action

Prompt

Answer the question using the additional context:
{User Question}
{Retrieved Doc chunk 1}
…
{Retrieved Doc chunk n}

Response

Battery Data:
{
Remaining health percentage, Recommended EoL action
}

EPR Compliance:
{
Producer cost, Compliance of Recommended EoL action
}

User Query

Input:
- **Battery parameters**

Answer the following questions:
- **What is the remaining health percentage of the battery?**
- **What action is recommended?**
- **What costs must the producer incur?**
- **Does the recommended action comply with the relevant EPR regulations?**

AWS Lambda
OPENAPI
Bedrock Agent-Action Groups

Semantic Search

Retrieve answers to the question by performing a semantic search using vector database

Gen AI Model (LLM)

Receive {prompt + context} to generate the answer. Links for the citation purposes are also added

Bedrock Agent

Conclusion:

- **Retrieval-Augmented Generation (RAG) based pipeline** for battery health assessment and **compliant** EoL actions.
- Enhanced **sustainability** in EV battery lifecycle.

Discussion:

- The current solution uses synthetic data, **but** it can be extended to real industrial battery & vehicle usage data.
- Apply the solution to **every** component of the EV.

Beneficiaries:

- ❖ Assists **producers in interpreting EPR regulations** by analyzing complex regulatory documents and ensuring comprehensive tracking of vehicles and batteries from production to end-of-life.
- ❖ Enables **manufacturers to optimize** repurposing, remanufacturing, and recycling processes based on projected volumes and component conditions.

Demo Video

References

1. European Environment Agency (31 Oct 2024). New registrations of electric vehicles in Europe. Accessed on 18 May 2025
2. European Union - Regulation - 2023/1542 - EN - EUR-Lex. Accessed on 18 May 2025

Acknowledgements:

- Roy, Samuel, Capgemini Engineering
- Kale, Vishwajeet, Capgemini Engineering