TQS: Product specification report

Gabriel Silva [113786], Henrique Teixeira [114588], João Roldão [113920], Sebastião Teixeira [114624]

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1 Introduction

1.1 Overview of the project

As the world transitions to sustainable transportation, electric vehicles (EVs) are becoming more common. However, EV adoption is often hindered by a disjointed and inconsistent charging experience. SparkFlow is a next-generation EV charging platform designed to bridge the gap between drivers and station operators by unifying discovery, booking, usage, and payment into a single platform. This platform aims to simplify and enrich the EV charging experience, promote station utilization, and encourage sustainable mobility.

1.2 Known limitations

<explain the known limitations, especially the features that were planned/expected but not implemented (and why…)

To be reviewed and completed by the end of the project >

1.3 References and resources

<document the key components (e.g.: libraries, web services) or key references (e.g.: blog post) used that were really helpful and certainly would help other students pursuing a similar work>

2 Product concept and requirements

2.1 Vision statement (to review in end of work to clarify what was planned/expected to be included but was changed to a different approach/concept)

SparkFlow is a unified EV charging platform that connects EV drivers and station operators through a centralized and data-driven experience.

For EV drivers, the platform provides a comprehensive discovery system that allows users to search for charging stations based on key criteria such as price per kilowatt-hour, charging speed, connector type, and proximity to their current or destination location. This feature is enhanced by real-time data integration, ensuring that drivers only see currently available chargers. In addition to station discovery, SparkFlow offers the ability to book charging slots in advance. If a charger becomes unavailable after a booking is made, the system automatically reroutes the user to the nearest suitable alternative, maintaining a seamless user experience. Once at the station, drivers can unlock and initiate a charging session directly through the app and complete payment within the same interface, eliminating the need to interact with multiple systems. After the session ends, users are provided with receipts and usage summaries. They can also access a personal dashboard that tracks all past charging sessions.

For station operators, SparkFlow delivers a robust set of administrative tools. Operators can register new charging stations by specifying their location, number of chargers, supported connector types, pricing models, and access rules. The system also supports the deactivation and removal of underutilized or malfunctioning stations, all while keeping a historical record of performance data. Through the admin dashboard, operators can continuously monitor the health of their infrastructure, receive automatic fault alerts, and schedule maintenance or diagnostics as needed. To support smarter business decisions, operators can implement pricing rules.

SparkFlow takes inspiration from existing commercial apps such as Chargemap, PlugShare, and Tesla’s Supercharger Network, but differentiates itself by offering a neutral platform that unifies multiple providers and supports both drivers and station operators and emphasizing smart automation, such as recurring bookings, rerouting logic, and pricing experimentation.

The requirements and concept for SparkFlow were developed through group brainstorming sessions during the first weeks of the project and a role-based scenario writing and persona development to ensure feature alignment. Defining the MVP scope with the project guidelines also helped better us define the project requirements and key features to better plan our work.

2.2 Personas and scenarios

SparkFlow is built with two main actors in mind, the EV Driver and the Station Operator.

The EV Driver is the primary end-user of SparkFlow, representing individual consumers who use electric vehicles for commuting, travel, or everyday transportation. This actor interacts with the platform through a user-facing interface. The goals of this actor with this software solution are to find available charging stations nearby or along planned routes, reserve a charging time slot and pay for this reservation seamlessly. Finally, being able to monitor historical charging data, costs, and environmental impact is also of interest to this actor.

The Station Operator can represent either an individual or an organization responsible for managing EV charging infrastructure. They may own a few private chargers or operate a network of public stations.

They use SparkFlow via a back office web dashboard. The objective of the Operator is to maximize usage of the charging infrastructure as well as maintaining station uptime and service quality. By monitoring consumption and performance metrics, they can also offer promotional pricing to attract customers during off-peak times.

EV Driver Personas

Daily Urban Commuter - Cláudio Martins

Cláudio Martins is a 29-year-old HR Coordinator living in Lisbon, Portugal. Tech-savvy and environmentally conscious, he relies on his Nissan Leaf to commute daily between his suburban home and his downtown office. His routine is consistent: he uses his electric vehicle twice every weekday, and efficiency is always top of mind.

His primary goals revolve around convenience and cost-efficiency. He wants to quickly find affordable charging stations near both his home and workplace and aims to minimize the time spent waiting at or using these stations. In addition, he carefully tracks his monthly EV expenses to ensure he stays within his transport budget.

However, his experience is far from seamless. Charging stations near his office are frequently occupied, making it frustrating to plan her day. The need to juggle multiple apps, each corresponding to a different charging network, only adds to her frustration.

Weekend Road-Tripper - Roberto Silva

Roberto Silva is a 38-year-old freelance photographer based in Porto, Portugal, with a passion for weekend road trips and capturing the Portuguese landscape. He drives a Tesla Model 3 and uses it primarily for long-distance travel, heading out two to three times a week for shoots in scenic, often remote locations.

When it comes to his electric vehicle, Roberto has clear priorities. He wants to plan routes that include charging stops optimized not just for speed, but also for convenience. He looks for chargers located near cafés and rest areas, places where he can relax or even get some editing done while his car powers up. Beyond convenience, he also tracks his environmental impact, taking satisfaction in knowing how much CO_2 he’s saved.

But the road isn’t always smooth. Roberto often finds himself frustrated by the lack of a unified planning tool. He has to manually cross-reference multiple apps and websites just to map out a route with dependable charging points. Worse, he sometimes arrives at a charger only to find it offline or already in use, wasting valuable time.

Late-Night Gig Worker - Bruna Lopes

Bruna Lopes is a 24-year-old food delivery driver working the night shift in Coimbra, Portugal. She zips through the city with precision and speed on her electric scooter. As a digital native, Bruna is highly tech-savvy and depends on smart tools to keep her nightly routine running smoothly.

Her vehicle is her livelihood, and keeping it charged is non-negotiable. Bruna is constantly on the lookout for fast, compatible chargers during off-peak hours when demand is low and time is precious.

Despite her resourcefulness, the current charging experience presents daily hurdles. Too often, she arrives at a station only to discover it doesn’t support his EV type, wasting both time and energy. Pricing can be another headache. She finds herself constantly comparing rates across different providers, which is frustrating and inefficient.

Station Operator Personas

Regional Infrastructure Technician - João Faria

João Faria is a 37-year-old regional infrastructure technician working for the municipal transport department in Faro, Portugal. He oversees a network of over 20 public EV charging stations and plays a key role in maintaining their functionality, accessibility, and the public's confidence in the region's growing electric mobility infrastructure.

His mission is to ensure that every charger under his watch is operational and accessible at all times. To do this effectively, João needs real-time monitoring capabilities and instant alerts for outages, errors, or unusual usage patterns. He relies heavily on an admin dashboard, which serves as his central hub for managing the entire network. From here, he checks the health of each unit, runs diagnostics, and exports weekly performance data for internal KPIs.

Despite his technical skills, João often finds himself battling outdated systems that don't provide real-time status updates. On top of that, switching between different tools for diagnostics, reporting, and management slows him down and fragments his workflow.

Green Tech Startup Operator - Rita Neves

Rita Neves is a 32-year-old entrepreneur based in Lisbon, Portugal, at the helm of a green tech startup focused on providing EV charging solutions. With a network of 50 chargers spread across three cities, Rita is building a business that merges sustainability with smart technology, aiming to turn EV charging into a seamless, customer-centric experience.

Her business runs on data. Rita is eager to implement dynamic pricing models that respond to variables like demand, time of day, and location. She also wants to track user behavior and build meaningful loyalty programs that keep EV drivers coming back.

But the road to full control has its challenges. Most platforms she works with offer limited flexibility when it comes to customizing pricing tiers, which hampers her ability to test different business models. She's also frustrated by the lack of detailed customer segmentation data, essential for crafting targeted offers and personalized user experiences.

EV Driver Scenarios

Morning Efficiency Boost - Daily Urban Commuter

Cláudio wakes up at 7:00 AM and is preparing to drive to work, knowing that his car needs to recharge. Opening the SparkFlow app from home, he sets his work location as the destination and filters stations by availability in a 1km radius and lowest price per kWh. Having real-time availability, the application shows the unoccupied chargers and offers a "Book Now" feature. He reserves a spot for a charger near his office building. Upon arrival, he unlocks the charging station via the app and plugs in the car. When charging is complete, SparkFlow notifies him and provides a receipt.

Budget Watchdog - Daily Urban Commuter

At the end of the month, Cláudio wants to check his transport budget. He opens the Driver Dashboard and reviews the Monthly Summary that has information like the number of charging sessions, total kWh consumed, total cost and average price per session. SparkFlow also shows a progress bar comparing actual expenses to his preset monthly budget.

Routine Charging Plan - Daily Urban Commuter

Wanting a more hands-off approach to his weekly charging needs, Cláudio configures a weekly recurring booking in the SparkFlow app. He selects Monday through Friday at 8:00 AM at the Praça Liberdade Parking Garage. The app checks availability and books recurring slots. If a slot becomes unavailable, Claudio receives a Smart Reroute alert with the nearest alternative.

Route Planner with Charging Stops - Weekend Road-Tripper

Roberto is planning a weekend trip to Serra da Estrela for some landscape shoots. He opens the SparkFlow Route Planner and enters the starting point as Porto, the destination Serra da Estrela and the vehicle info Tesla Model 3. SparkFlow then calculates his best routes and inserts optimized charging stops based on the battery range and charger availability and also pre-books his preferred chargers along the route.

Environmental Impact Tracker - Weekend Road-Tripper

After his road trips, Roberto likes to reflect on his environmental contribution. For that information, he opens the Trip Summary in the dashboard, presenting him with information like distance driven, energy consumed and CO2 saved compared to a gasoline car.

Report a Broken Charger - Weekend Road-Tripper

Arriving at a rural charger he booked through the SparkFlow app, he finds it to be offline and unresponsive. He opens the app and taps in the Report Issue button directly on the charger's profile. He selects a charger offline from a quick list of issues presented and adds a short comment along with the report "Screen frozen and not accepting charge".

Fast Match - Late-Night Gig Worker

It's 11:30 PM. Bruna has just completed a round of deliveries and needs a quick recharge to finish her shift. She opens the app and taps in Quick Charge Finder. The system auto-detects her location and EV type (electric scooter), then filters by connector compatibility, availability, speed and lowest price. SparkFlow highlights three nearby chargers, she picks one and books it.

Instant Reroute When a Station Fails - Late-Night Gig Worker

Bruna arrives at the station she booked, but it's showing an error on the charger screen. She taps Report Issue in SparkFlow, marks the charger as Out of Service and leaves a quick comment. The system flags the station in real-time for others and automatically suggests the next closest working charger within 1 km, offering to transfer the reservation. Bruna accepts the transition.

Station Operator Scenarios

Registering a New Station - Regional Infrastructure Technician

The municipality has installed two new chargers at a park-and-ride location on the outskirts of Faro. João logs into the SparkFlow Admin Dashboard and selects "Add New Station". For the first one, he enters details like Station Name (Faro Norte P&R), Charger Count (2), Connector types (CCS and Type 2), Location (map pin or GPS), Operating Hours, Pricing Tier, and Accessibility Info. The new chargers appear on the public map within minutes.

Real-Time Fault Alert and Fast Response - Regional Infrastructure Technician

It's 9:15 AM. João is in a team meeting when an alert pops up on his phone. SparkFlow detects that Charger #12 (Downtown Bus Terminal) has failed to respond to routine pings. He opens the SparkFlow Admin Dashboard and sees the charger status, last session and recent logs. João attempts a remote soft reboot from the dashboard. If successful, the charger returns to green, no further action needed. If failed SparkFlow auto-creates a maintenance ticket.

Weekly Station Performance Review - Regional Infrastructure Technician

Every Monday morning, João prepares a KPI report for his department. He logs into SparkFlow and opens the Reports Dashboard. João generates a weekly performance summary with total uptime per station, number of sessions per location, average charging time and utilization rates and maintenance events and downtime logs. The report is automatically formatted as a PDF export. He downloads the files and attaches them to his email to the department head, all done in under 5 minutes.

Deactivating or Removing a Station - Green Tech Startup Operator

Rita is decommissioning two underperforming chargers in a private coworking space in Porto. She opens the Station Management panel and selects the 2 underperforming stations, and in the context menu, she chooses Mark as Inactive. The system notifies users with active reservations and excludes them from the map.

Pricing Strategy Rollout - Green Tech Startup Operator

Rita wants to increase charger usage at less busy stations during off-peak hours across her network. She opens the SparkFlow Operator Dashboard and selects the “Pricing Rules” module. She sets a pricing rule in Coimbra by selecting the time range and discount. Rita reviews the data after one week, sees increased midday usage, and decides to scale the model to Lisbon stations.

2.3 Project epics and priorities

SparkFlow will be developed iteratively over a series of timeboxed implementation periods. Each iteration introduces new functionality aligned with prioritized epics, enabling continuous integration, validation, and feedback. The plan is structured to ensure core user journeys are operational early in the development cycle, while backend tools and advanced features are layered in progressively.

Iteration 2 (May 14 - May 20)

Goal: Deliver a usable foundation for drivers and station operators, enabling discovery and station registration.

Involved Epics:

- Epic 1 – Charging Station Discovery
    - Implementation of map and basic station filters (location, distance, availability).
- Epic 5 – Station Onboarding and Configuration
    - Operator interface to register a new station with metadata. Station visibility toggling included.

Outcome: Users can search for chargers, operators can register them.

Iteration 3 (May 21 - May 27)

Goal: Finalize core driver interaction loop and introduce driver-facing history tools as well as booking.

Involved Epics:

- Epic 1 – Charging Station Discovery
    - Complete advanced filters (price, connector type) and rating/review display.
      Initial Quick Charge Finder prototype.
- Epic 2 – Slot Booking and Management
    - Basic booking system with time-slot selection and reservation storage. Users can view and cancel bookings.
- Epic 3 – Charging Session Interaction
    - Implement remote unlock, in-session status updates, and error reporting.
- Epic 4 – Station Onboarding and Configuration
    - Initial dashboard with session history, usage summaries, and cost breakdown.

Outcome: Drivers can now complete a full charging journey from discovery to usage, and review their consumption.

Iteration 4: May 18 – May 31

Goal: Introduce payments and initial station monitoring features for operators.

Involved Epics:

- Epic 6 – Station Monitoring and Maintenance
    - Operators view session logs, and are alerted to faults.
- Epic 9 – Payment and Billing Integration
    - Chargers now display pricing, and a basic in-app payment process is connected to a sandbox gateway

Outcome: SparkFlow adds transactional value. Operators begin monitoring their infrastructure. Users can now pay for charging sessions within the app.

Iteration 4: May 22 – June 4
Goal: Deliver business tools and location-aware user enhancements.
Involved Epics:

- Epic 7 – Business Rules Management
    - Operators configure time-based or location-based pricing rules. System tracks usage impact.
- Epic 8 – Map and Location Services Integration
    - First version of a route planner.
- Epic 9 – Payment and Billing Integration
    - Expand payment features to include receipts, stored billing history.

Outcome: Operators gain tools to optimize pricing and charger utilization. Users benefit from smarter navigation and full billing visibility.

2.3.1 Detailed Epics

Epic 1 - Charging Station Discovery
As a driver, I want to search and filter charging stations so I can quickly find the most suitable option based on my needs.
Acceptance Criteria:

- Real-time availability map
- Filters (price, distance, speed, connector type)
- “Quick Charge Finder” feature
- View charger details, reviews, and ratings

Epic 2 - Slot Booking and Management
As a driver, I want to reserve a charger ahead of time so I can avoid waiting and ensure availability.
Acceptance Criteria:

- Booking system with time slots
- Recurring bookings
- Booking modification and cancellation
- Conflict management and rerouting

Epic 3 - Charging session Interaction
As a driver, I want to unlock, use, and end a charging session smoothly using the app.
Acceptance Criteria:

- Remote unlock via app
- Charging status updates
- End-of-session alerts
- Error handling and reporting

Epic 4 - Driver Dashboard & History
As a driver, I want to view my charging history and performance stats to manage costs and track usage.
Acceptance Criteria:

- Monthly summary: sessions, kWh, cost, average rate
- Environmental impact (CO_2 savings)
- Session history and receipts

Epic 5 - Station Onboarding and Configuration

As an operator, I want to register and configure charging stations so they are available to drivers.
Acceptance Criteria:

- Register a new station
- Add station data (connector types, location, pricing)
- Station visibility toggling (active/inactive)
- Station removal

Epic 6: Station Monitoring and Maintenance
As an operator, I want to monitor and maintain my stations to ensure high availability and user satisfaction.
Acceptance Criteria:

- Monitoring of Stations
- Fault alert system
- Session logs

Epic 7: Business Rules Management
As an operator, I want to set pricing and rules to improve charger utilization and profitability.
Acceptance Criteria:

- Set pricing logic and rules
- View the impact of pricing changes

Epic 8: Map and Location Services Integration
As a driver, I want to view stations on a map and get location-based suggestions.
Acceptance Criteria:

- Interactive map interface for all users
- Location-aware suggestions
- Route planner
- Geolocation tagging for stations

Epic 9: Payment and Billing Integration
As a user, I want to handle payments smoothly and securely through the app.
Acceptance Criteria:

- Pricing display per charger
- In-app payments (wallet or gateway)
- Session billing and receipts

3 Domain model

<which information concepts will be managed in this domain? How are they related?>
<use a logical model (UML classes) to explain the concepts of the domain and their attributes, not a entity-relationship relational database model>

4 Architecture notebook

4.1 Key requirements and constraints

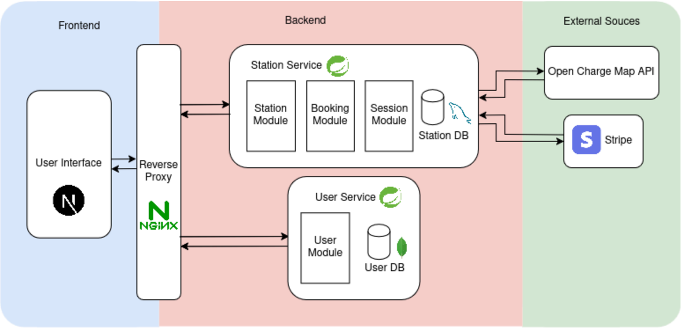
<**Identify issues that will drive the choices for the architecture** such as: Are there hardware dependencies that should be isolated from the rest of the system? Does the system need to

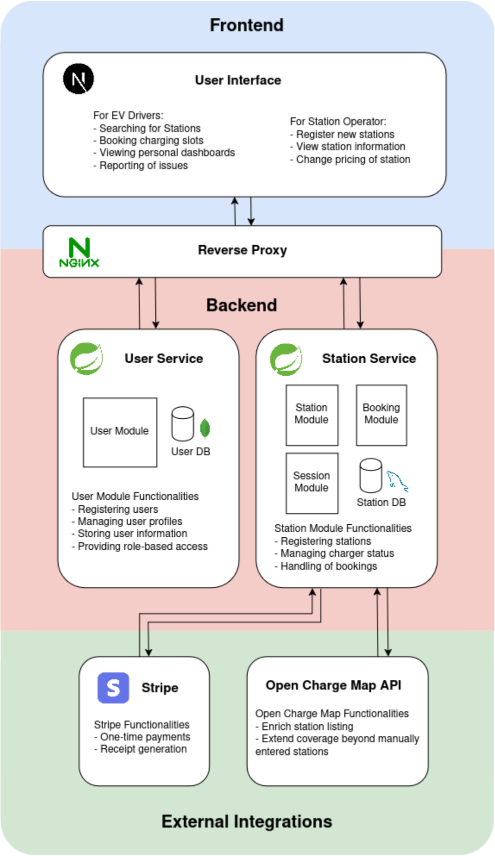
function efficiently under unusual conditions? Are there integrations with external systems? Is the system to be offered in different user-interfacing platforms (web, mobile devices, big screens,…)? For a more systematical approach:

- Note the collection of Architectural Characteristics the software architect should be aware
- Identify architectural characteristics that are relevant for your project (will drive the key design decisions). Note the case study and the explicit characteristics related to users and extensibility. This will support later non-functional tests.

4.2 Architecture view

→ Discuss architecture planned for the software solution: what are the main building blocks? include a diagram (a logical view, such as a package or block diagram). Avoid implementation technology or deployment references, but protocols/standards can be included.
→ refer to the architecture style applied, if any
□ explain how the identified modules will interact. Use a sequence diagram to clarify the interactions along time, when needed
→ discuss more advanced app design issues: integration with Internet-based external services, data synchronization strategy, distributed workflows, push notifications mechanism, distribution of updates to distributed devices, etc.>





4.3 Deployment view

[Explicar a organização prevista da solução em termos configuração de produção (*deployment*). Anotar, no diagrama, as tecnologias de implementação, e.g.: colocar o simbolo do PostgreSQL na Base de dados,…]. Indicar a existência de containers (Docker), endereços IP e portos,... Esta parte será completada quando houver efetivamente deployments

5 API for developers

[Explicar genericamente a organização da API e coleções principaus. Os detalhes/documentação dos métodos devem ficar numa solução *hosted* de documentação de APIs, como o Swagger, Postman documentation, ou incluída no próprio desenvolvimento (e.g.: maven site)

□ Be sure to use best practices for REST Api design. Keep minda REST API applies a resource-oriented design (APIs should be designed around resources, which are the key entities your application exposes, not actions)