Analysis of Telecommunications Infrastructure Monitoring and Development of an RFI Process Iberdrola

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Master in Smart Grids

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Abstract

Modern electric utilities depend on robust telecom monitoring to sustain grid operations. This study diagnoses Iberdrola's current environment (characterized by fragmented tools and limited event correlation) and proposes a structured approach combining documentation analysis, workshops with the Network Management Center, and three benchmarking exercises (provider typology, licensing models, and a technical case). Results indicate that an externally managed, open source–based model offers the best balance of cost, scalability, and operational control while avoiding lock in; a preliminary technical specification and roadmap are delivered. The paper recommends piloting 2–3 finalists to validate OSS integrations, correlation logic, and performance under load, while completing TCO modeling and a dedicated cybersecurity assessment. Overall, the work provides a reusable methodology and a pragmatic path toward a unified, scalable, and resilient monitoring architecture for Smart Grid contexts

I. Introduction

SMART grids are becoming a key component for electric utilities due to the economic and operational benefits they provide. Recent studies by Juniper Research show that the adoption of smart grid technologies will generate cost savings of more than 125 billion dollars worldwide by 2027, a huge leap from the approximately 33 billion in 2022 [5]. These numbers indicate that electricity companies will be able to capture a large portion of these benefits if they modernize their networks. Iberdrola has positioned itself as a leader in this area – by 2025, the company had already deployed 17 million smart meters, and virtually 100% of its customers in Spain, which are being served by digitalized smart grids.[3] Achieving these levels of grid digitalization and control improves supply quality and generates revenue and savings from efficient operations. In fact, it is estimated that a complete smart grid has a highly positive return: according to EPRI, building a fully functional smart grid could cost between $ 338–476 billion, but would bring economic benefits of $1.3–2 trillion in the long term. In Europe, the European Commission forecasts a total investments of ≈ 584 billion euros in electricity grids until 2030. [8], Of which 170 billion would be specifically allocated to digitalization (smart meters, automation, control systems). On one hand, these investments are a base for companies like Iberdrola to improve their financial indicators by reducing operating costs, improving energy efficiency, and offering new services associated with smart grid. And on the other hand, end to end (E2E) monitoring of the telecommunications infrastructure is becoming increasingly critical.

Iberdrola currently operates a network of more than 200,000 nodes, whose exponential growth is pushing traditional monitoring tools to the limit. [2]

A. Motivation

Current monitoring at Iberdrola is functional, but looking forward, it is characterized by the heterogeneous use of multiple tools, each covering parts of the system but with minimal integration. This fragmentation creates limitations in scalability, integration, automation, and long term sustainability. In practice, monitoring a complete service requires combining information from several independent systems, which slows down incident detection and difficulties daily operations. For example, Iberdrola currently has a limited unified service view: monitoring a single link or service requires manually checking several separate monitors (radio links, switches, MPLS nodes, etc.). There are also no dynamic, automated topological maps; graphical representations (such as static weather maps in CACTI) must be built manually and do not automatically reflect changes in the network. In addition, alarms are not fully correlated: a single event can trigger multiple independent alerts without being consolidated into a single incident. There is no capability to infer cause–effect relationships between faults (e.g., a DWDM fiber cut is not automatically linked to alarms caused by the outage of associated MPLS services). Likewise, there is a lack of automation in device discovery and documentation validation: the incorporation of new equipment requires manual configuration, with the risk of errors, and there is no automatic verification that the actual network matches the documentation (INSERTEL). These limitations impede scalable and proactive management.

Recent studies highlight that large scale networks require monitoring tools that integrate Big Data techniques to extract real time metrics and detect anomalies through complex correlation [4]. All of the above clearly demonstrates the need to move towards a more unified, intelligent, and automated telecommunications network monitoring solution for Iberdrola.

B. Project Objectives

The main objective of this work is not simply to produce a Request for Information (RFI), but rather to analyze from scratch the current mode of operation: which tools are used, which technologies are deployed, which protocols are implemented, and—at its core—to identify the limitations of the existing operational model. Based on this diagnosis, structured market research is proposed to identify new technologies and solution models, with the aim of outlining a strategic evolution of the system. This master's Thesis also aims to serve as a methodological guide that can be used as a reference for other projects in the electrical sector or in Smart Grid environments. Its approach is not limited to gathering commercial offers; instead, it establishes a framework to understand the operational state of a complex network, detect its limitations, and initiate a search for market solutions

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The result of this work will be a technical specification tailored to Iberdrola's real needs, to be shared with suppliers in the RFI process as both a strategic and practical basis for future solution acquisition phases. To this end, the following objectives are established:

- Identify the main operational issues of the current monitoring model.
- Define a set of requirements and functionalities necessary to enable the transition to a modern, unified, and scalable solution.

Validate that these requirements are neither obsolete nor excessively customized, by cross checking them through meetings with industry suppliers.

- Develop several benchmarking exercises to efficiently guide the search for solutions in a broad and diverse market:
    - Provider benchmarking: general profile, size, experience, market positioning, and support.
    - Licensing and service model benchmarking: most suitable contracting and billing models.
    - Technical functional benchmarking: detailed comparison of solutions against the defined requirements.
    - Practical case: simulation of a real environment to assess the applicability and differential value of each proposal. Prepare a first version of the technical specification, to serve as the basis for an

- RFI/RFQ process to select the appropriate solution

II. OPERATION MODE

A. Monitoring tools

The Iberdrola telecommunications network is monitored using a set of tools that combine open source solutions, proprietary developments, and commercial platforms. Each one addresses specific needs, like metric collection and unified alarm management

a) **CACTI:** is an open source tool for metric collection via SNMP and historical graphical visualization. It is used to monitor traffic, latency, and link status, as well as to represent network topology through weathermaps.

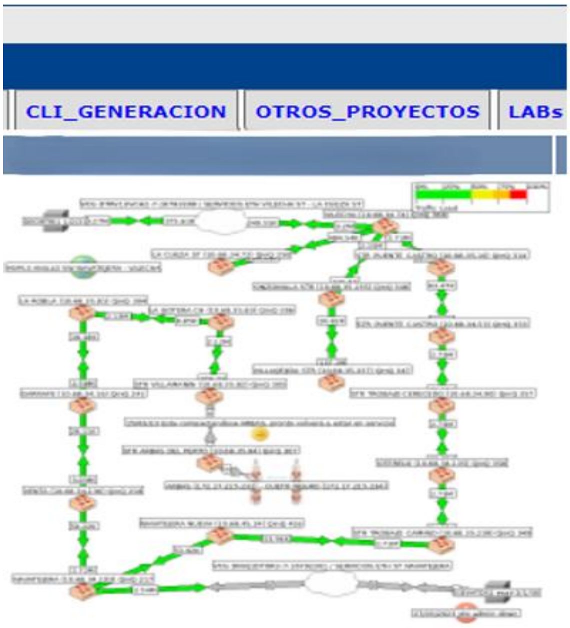

Figure 1:Weathermap in access networks

b) **Grafana:** is a real time visualization platform that integrates multiple data sources. At Iberdrola, it is used to monitor radio links, servers, and field equipment, with interactive dashboards and automatic alert generation. It performs similar functions to Cacti but offers two advantages:

1. It stores historical data for a longer period, meaning that data from a week ago can be queried at any moment, whereas Cacti only keeps one hour resolution data for the past week
2. Grafana offers a greater granularity in queries and data representation (seconds), while Cacti performs queries every five minutes.

Figure 2: Traffic visualization in Grafana

c) **SNMPc:** is oriented towards centralized monitoring of thousands of distributed nodes, like in the STAR project (Iberdrola infrastructure). It combines ICMP and SNMP checks to verify availability and extract detailed metrics.

d) **COMCYS:** is an internal development for managing PDH networks, its presented in legacy environments, allowing visibility and operation to be maintained during the transition to IP technologies.

e) **Nagios:** it used for monitoring of services, servers, and communications through status and event detection, with alert management and defined procedures.

f) **Zabbix:** it´s used for mass ICMP monitoring and node validation before commissioning, including availability and 48 hour latency checks. It also stores data in the Elastic database for further analysis using Kibana.

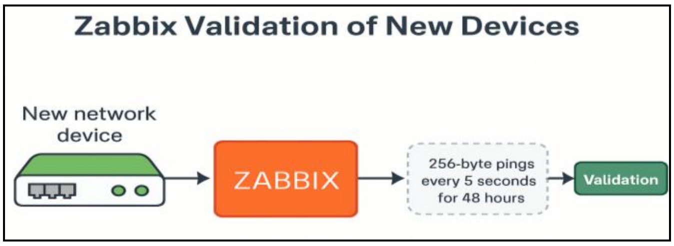

Figure 3: 48h validation in Zabbix

g) **Kibana:** it's used for exploitation of data stored in Elasticsearch for historical analysis and detection of performance or availability patterns.

h) **Fiber Watch:** is a tool used for detection and location of physical faults in optical fiber using OTDR technology, integrated with alarm management systems.

i) **GEMIS:** used for control and management of M2M SIM cards for field devices connected via mobile networks.

B. Management tools

Unlike the tools mentioned above, the following tools are part of the management infrastructure and are not intended to be replaced at any time or in any way. The goal is for the new solution to be capable of integrating these tools into its software through APIs:

1. **CASTEL**: is a tool for centralized system for alarm correlation and management from multiple platforms. This software acts as the backbone of all other tools, receiving alarms from the rest and displaying them in a single interface.

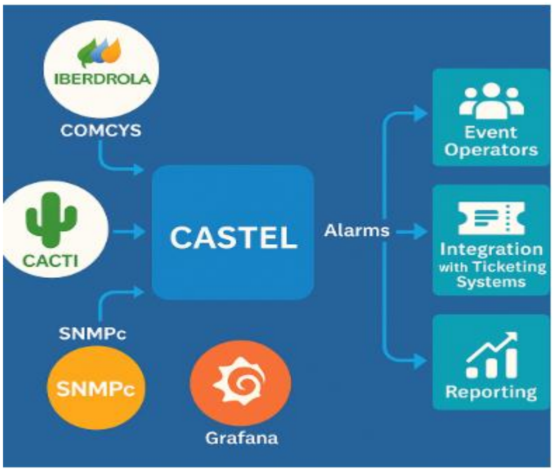

Figure 4: CASTEL platform for alarm

2. **GADIP**: is a tool centralized management of IP addressing, with inventory, traceability, and alarm analysis functions.
3. **LdI (Trouble Ticketing):** Comprehensive management of incidents, changes and tasks of the CGR, with integration into other
4. **INSERTEL**: Telecommunication Service Information: is the internal tool used at Iberdrola to document and model, in a structured way, the elements that make up the telecommunications network. This system introduces a new logic of entities and relationships that facilitates the traceability of services, circuits, equipment, facilities, and physical connections.

III. Limitations and Current Challenges

The current monitoring tool ecosystem used by Iberdrola, while fulfilling its operational role and integrated into existing workflows, presents a series of limitations that interfere with efficient and scalable management and complete visibility of the telecommunications infrastructure. Theese shortcomings affect both daily monitoring and medium to long term planning. The main identified challenges are described below:

A. Fragmented monitoring and lack of unified service view:

One of the main limitations is the fragmentation of the tools, which are oriented to specific network technologies and do not offer a consolidated view. There is currently no single interface that consolidates the full status of a service, integrating device status, traffic graphs, and link information. For example, to monitor a telecontrol service in a substation it is necessary to manually consult the RICI, the switch, the MPLS SAP and the involved SDH or DWDM links in different tools, without a screen that unifies all this information, which wastes a lot of time and translates into an inefficient system.

B. Limited port level traffic visibility:

Although some tools currently used at Iberdrola, such as CACTI and GRAFANA, allow for detailed traffic analysis through SNMP (including unicast, multicast, and broadcast data), this functionality has clear limitations. While these tools can offer deep and granular insights, they require accessing each technology separately through its own management interface. As a result, traffic monitoring must be performed independently for each technological domain, leading to a fragmented and inefficient approach. This lack of integration makes it harder to get a global view of the network and slows down operational response times. As already mentioned in Section 4.1, this contributes to higher operational effort and reduced efficiency when managing the network. This obstructs proactive detection of saturations or failures, especially in direct connections with clients. As noted by D'Alconzo et al. (2020)[1], large scale network traffic analysis requires tools that integrate big data techniques, with the ability to extract real time metrics and detect anomalies through complex correlation. This reinforces the need for solutions that go beyond simple SNMP polling.

C. Absence of dynamic and intelligent graphical representations

Currently, tools like CACTI allow static weather map type maps but there is no functionality that automatically generates dynamic topological maps. The information available in INSERTEL about relationships between elements iss not used to construct automatically (fot now) updated visualizations. Any change in MPLS configuration or in the connectivity of a substation requires a manual update in the visual tools, which delays operations and can lead to errors due to lack of synchronization.

D. Basic alert generation without correlation

The current system is capable of generating alerts for failures, but these alerts are not correlated. It is common for a single event, such as loss of communication with a substation, to generate multiple independent alerts (switch failure, RICI failure, SDN peer paths failure), without grouping them under a main incident. Moreover, there is no cause and effect logic between events. For example, a failure in a DWDM link is not automatically linked to alerts about degradation of the MPLS services that traverse it, obstructing real impact analysis.

E. Lack of automation and device discovery:

There is no automated system for device discovery or to validate if the real network matches the documented one. The addition of new equipment requires manual configuration, increasing the operational workload and the possibility of errors. Nor are there mechanisms to automatically verify if a MAC address enters the network through the node planned in INSERTEL, something particularly useful in environments with RICIs or switches connected to multiple points. According to TM Forum (2019) [9], the evolution toward autonomous networks requires monitoring platforms that not only visualize metrics, but also enable automated decision making based on event correlation and predictive analytics. This approach is key to preparing Iberdrola for future scenarios of autonomous operation.

IV. Benchmarking Of Providers

In this initial benchmarking phase, the objective was to identify and classify providers of network monitoring solutions according to their strategic profile and market position, without yet performing a detailed technical evaluation. The aim was to map the relevant actors, hold exploratory meetings, and define technical criteria that will guide the following phases.

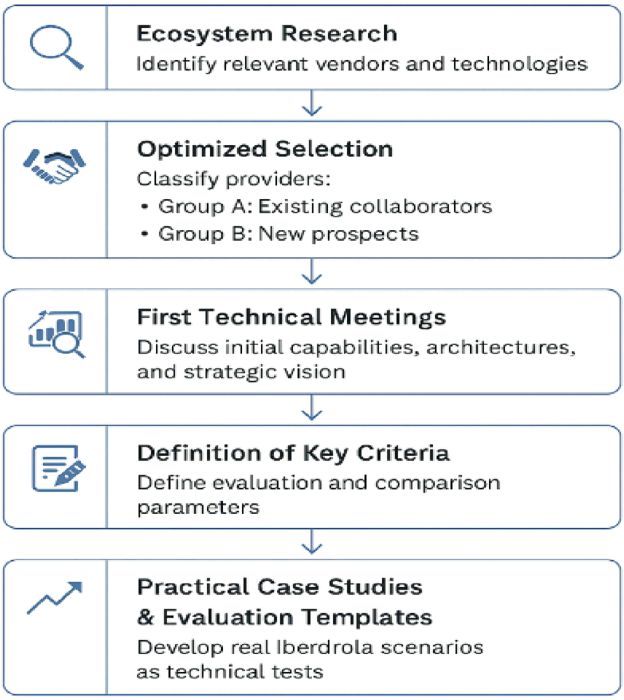

Figure 5: General benchmarking process

A. Summary methodology

The process was structured in five steps:

1. Identification of actors: open research and internal review of current and past providers.
2. Optimized selection:
   - Group A: prior collaboration, directlyinvited to a meeting.
   - Group B: no prior relationship, with technical proposal required before meeting.
3. Definition of criteria and requirements to standardize comparisons (volumetrics, licensing, integration, etc.).
4. Design of practical cases and evaluation templates to obtain homogeneous and comparable responses.
5. Preliminary filtering to discard proposals that did not meet minimum requirements.

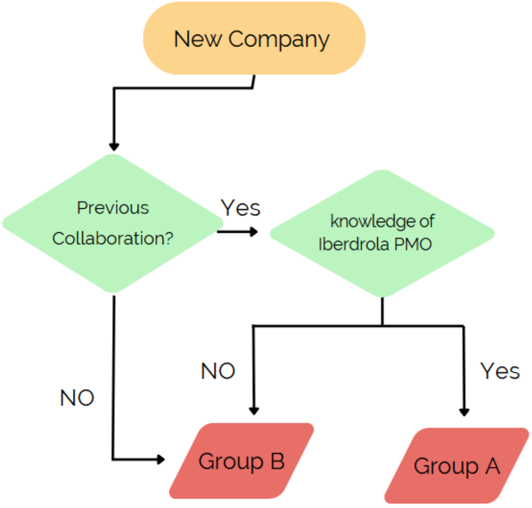

Figure 6: Initial classification of providers (Group

B. Analysis Criteria

The criteria discussed in the project are:

- **Type of tool: commercial vs. open source.**
- **Licensing model (Table 1):**
  - Per node/device: easy to estimate, unfeasible for large networks.
  - Per element/sensor: granular but complex and costly.
  - Infrastructure based: more predictable cost, high initial CAPEX.
  - Based on data volume: flexible but risky during traffic peaks
- **Support model**
- **Tool consolidation capability.**
- **Integration with OSS/BSS systems**

Note : Each of these criteria will be analyzed using the information gathered in meetings, technical documentation from providers, and proof of concepts, and will subsequently be incorporated into the comparative evaluation matrix for the final selection phase.

Licensing Model	Definition	Advantages	Disadvantages	Suitability for Iberdrola
Per node or device	Fixed cost per monitored device (router, switch, server).	Easy to estimate if inventory is known; simple management (includes all metrics of a device).	Cost scales directly with number of devices; prohibitive in very large networks.	Limited; with >190k nodes, cost would be extremely high.
Per element or sensor	Charges per individual metric or element (e.g., CPU load, port traffic).	Allows very granular monitoring; flexible selection of metrics.	Complex to manage; easily becomes economically unfeasible in large networks.	Not advisable; Iberdrola's scale would generate unsustainable costs.
Infrastr-ucture based	Licenses based on server capacity (per monitoring server or CPU core) or appliance with included license.	Decouples cost from number of nodes; more predictable costs; encourages software efficiency.	High initial costs; scales in steps (new server = new license); often tied to specific hardware or VM configurations.	Potentially suitable; if servers handle high loads, fewer licenses needed, but careful analysis required.
Per metric/log ingestion	Cost depends on data volume ingested (GB/day or stored/month).	Aligns cost with actual data usage; encourages optimization of data collected.	Difficult to estimate; spikes in events can exceed license; high data volumes = very high costs.	Risky; power grid events can cause unpredictable spikes, risking cost overruns or data loss.

Table 1: Summary of main licensing models for network monitoring solutions

C. Market Classification

A quadrant inspired by the Gartner model (market vision vs. execution ability) was used, resulting in:

1. Leaders: is the best category, perform in accordance with the actual market view and are well positioned to successfully implement their solution in several scenarios.[6]
2. Visionaries: perform strongly on completeness of vision for understanding where the market is going or for technical innovation, but their ability to execute is also still limited.
3. Challengers: well positioned in the market and provide a high possibility of success in implementing their solution, but do not demonstrate a proper understanding of the direction in which the market is moving. (e.g., companies replicating existing solutions without distinctive innovation).
4. Niche Players: successfully focus on a specific market segment and therefore fail to take a global view of their performance in order to understand where the market is going [7].

Most vendors fall within the Leaders quadrant (See Figure 7), which is not unexpected. Prior to initiating contact with the selected companies, a filtering process was carried out precisely to identify those suppliers that already demonstrated solid capabilities, relevant references, or a leadership position in the sector.

This does not, however, disregard the potential value of other vendors that may fall into different quadrants. Some companies categorized as Visionaries, Challengers, or even Niche Players may offer highly specialized solutions or innovative approaches that could be valuable for specific needs within Iberdrola's network environment.

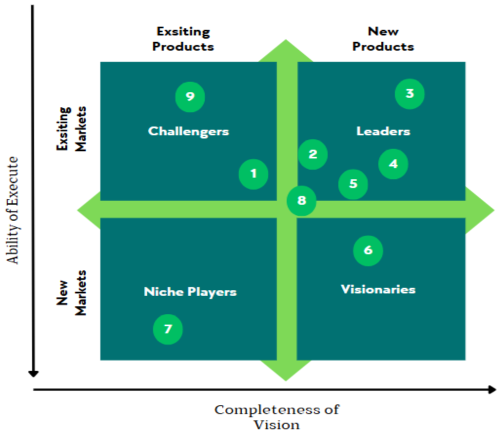

Figure 7: Strategic positioning of providers

V. Benchmarking OF Monitoring Models

In a large scale industrial network like Iberdrola's (more than 190,000 nodes), choosing the right monitoring model is important. There are three main approaches to consider

1. Implementing an internal solution using open source tools
2. Adopting an integrated commercial solution from a vendor
3. Hiring a specialized external integrator to build a platform using open source components.

A. Evaluation Criteria and Weighting:

- **Total Cost of Ownership (35%):**

This includes initial costs (licenses, implementation) and recurring ones (support, staffing, OPEX costs). In large scale networks, licensing models can drive up costs significantly, especially if charged per node or data volume. This criterion is weighted at 35% because long term financial viability is important: the solution must be affordable enough to monitor everything necessary without being limited by cost.

- **Technical Capabilities and Functional Coverage (20%)**

This evaluates the monitoring scope (supported devices and technologies), advanced features (e.g., auto discovery, performance analysis, event correlation), and the overall completeness of the solution. Given the size and complexity of the network, the tool must be reliable cover multiple domains (network, systems, logs) with carrier grade dependability. It is weighted at 20% because although technical compliance is a must, monitoring is a broad field, and some tools may offer more, or fewer features than currently needed at Iberdrola. Thus, the benefit to cost ratio may not always be high.

- **Ease of Implementation and Operation (25%)**

This considers the learning curve, deployment ease, integration with existing systems, staffing needs, and daily maintenance effort. It is assigned a 25% weight (higher than the previous criterion) because a solution that is too complex to operate may fail in practice, even if it is technologically superior or offers modern features.

- **Strategic Long Term Considerations (20%)**

This includes vendor lock in risks, alignment with corporate strategy, technological independence, standards compliance, and future adaptability. In a long term model, it is vital to avoid being tightly bound to a single vendor and to ensure that the solution can evolve with future needs and technologies. It is given a 20% weight, as Iberdrola values sustainability. Prioritizing independence and reducing long term OPEX without losing vendor support or industrial backing.

B. Summary of Options

Option 1: Internal Open Source:

- Cost: no licenses; the main expense is staff and integration. Scales well if the internal team is properly managed.
- Technical: very flexible but fragmented; it requires setting up and maintaining several tools (Zabbix, Grafana, etc.).
- Operation: the most demanding option; high learning curve and continuous maintenance needed.
- Strategy: maximum independence and zero vendor lock in, but there is a risk if the community loses interest.

Option 2: Commercial Vendor Suite

- Cost: high and increases with network size and volume; significant recurring OPEX.
- Technical: all in one, from day one (maps, flows, KPIs, correlation).
- Operation: the easiest to manage; vendor handles deployment and support, less internal workload.
- Strategy: strong dependency (vendor lock in) and risk of pricing or model changes.

Option 3: External Service with Open Source (Integrator)

Cost: No per node license; predictable cost per service and infrastructure.

- Technical: full or almost full coverage if the integrator is solid; can be customized.
- Operation: medium to low workload; the integrator manages the back end and automation.
- Strategy: high flexibility and low vendor lock in; key to ensure contract includes support and knowledge transfer.

In one sentence: if there is strong internal capacity and full control is the goal → Option 1.

If speed and simplicity are the priority and higher cost is acceptable → Option 2

If you want the best of each one → Option 3

C. Recommendations

In the overall evaluation, weighting all the criteria, it can be seen in the following chart that the third option (external service based on open source) stands out as the most balanced alternative for Iberdrola. While the integrated commercial solution achieves the highest ratings in operational ease and immediate breadth of functionalities, its disadvantages in cost and vendor dependency reduce its total score.

Of course, the final decision must be aligned with Iberdrola's strategic priorities, which will be better analyzed after launching the RFI. If deployment speed and having a single support contact are prioritized, a negotiated commercial tool could be considered the safe path. However, if long term cost optimization and technological independence are valued, it would recommend reinforcing the open source architecture with the help of an integrator. Additionally, the risks associated with selecting an open source tool can be mitigated, since monitoring is not part of Iberdrola's core business processes. Therefore, a potential incident in monitoring would not have an immediate impact on end services in the short term. This makes it a manageable and acceptable risk, as its potential impact can be contained.

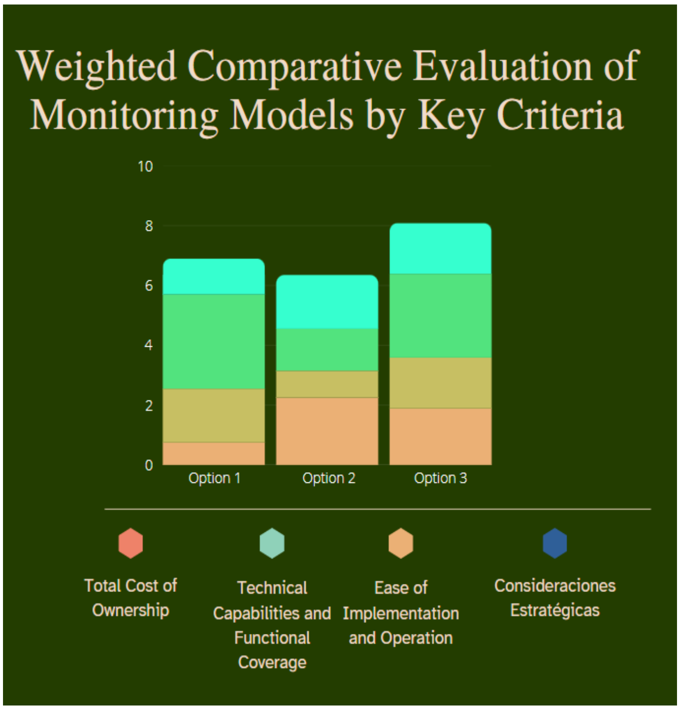

Figure 8: Weighted Comparative Evaluation of Monitoring Models by Key Criteria

VI. Technical benchmarking of Providers

After having conducted a comparative analysis of the types of providers and of the monitoring tool, this section addresses the third dimension of the study: the technical and functional benchmarking of the solutions proposed by each provider.

In the previous analyses, the 9 selected providers were considered. All of them received a practical case to delve into the technical and operational aspects of their proposals. After the established deadline, complete responses were received from 6 of the 9 providers. The remaining three (Vendors 4, 5 and 6) did not responde or mantain contact and were therefore excluded from the technical evaluation process. The final analysis is therefore based on the responses of 7 providers.

The proposals received varied in format and level of detail, but in general, most adequately covered the minimum established requirements. To structure the comparative process in an objective and uniform manner, the following evaluation criteria were defined:

- Substitution of tools
- Integration with existing tools
- Graphical representation and interface
- Licensing model
- Functional requirements
- Deployment model and technical scalability
- Support model offer

A. Technical Benchmarking Criteria

- **Substitution of tools:** This criterion evaluates which existing tools each provider recommends replacing, as well as the scope of such replacement. It's not just about how many tools their solution can replace, but whether the migration effort and functional maturity justify that replacement. For example, a tool may be technically capable of replacing CACTI, but the provider may not recommend it due to the complexity of migrating all historical graphs and existing templates.
- **Integration with existing tools:** In this case, the solution's ability to integrate with Iberdrola's current management and operation tools is analyzed, such as CASTEL, INSERTEL, GADIP or the Tickting tool (LdI). This criterion is important, as Iberdrola's strategy is not to replace these platforms, but to improve their interconnection and interoperability. Providers are scored higher if they already have integrations implemented for similar clients, as well as if they offer open APIs, standard connectors, and proven experience in similar projects.
- **Graphical representation and interface:** The solution must provide clear, configurable, and useful visualizations for different user profiles. This criterion evaluates the quality of dashboards, topological maps, performance graphs, and alarm panels, as well as the ease of configuration and customization. Aspects such as usability and support for report generation are considered. Additionally, it includes the ability to simplify operational workflows by making sure that the main operating interface can centralize most operational tasks, reducing complexity for end users.
- **Licensing model:** The type of licensing proposed by each provider is analyzed (per node, per sensor, per server, per data volume, etc.), as well as its flexibility, scalability, and suitability to Iberdrola's network size. This criterion also considers whether the provider has delivered a clear pricing model, if there are hidden costs, if the licenses are perpetual or

subscription based, and whether there are penalties for network growth. The licensing comparison is complemented with what was previously analyzed in the earlier chapter.

- **Functional requirement**: This criterion evaluates the functional compliance with the requirements defined in the practical case: supported protocol types (SNMP, NetFlow, syslog, ICMP, etc.), collected metrics, support for different types of devices, auto discovery capability, event correlation, alarms, and report generation. Native functionalities, tasks automation, modularity, and whether additional development is needed to meet the requirements are valued.

- **Deployment model and technical scalability:** This evaluates the technical architecture of the solution: whether it is based on a distributed model, supports cloud or hybrid deployments, and how it scales with network growth or new centers. The goal is to ensure that the solution can adapt to a multi node, multi service, and geographically dispersed environment.

- **Support model offer:** This criterion assesses the technical support offered by the provider: whether it is available in Spanish, offers 24x7 support, response times (SLA), access to updates, included training, communication channels, and whether they have local presence or remote assistance.

B. **Phases of the Technical Benchmarking**

In this first phase, a general comparison of the proposed solutions is made, with the objective of determining which providers meet the minimum criteria to continue into the detailed technical evaluation. The final evaluation is structured in two phases: (1) a pre selection to determine which solutions may proceed to further analysis, and (2) a more exhaustive second phase with graphical representation through radar charts to identify specific strengths and weaknesses of each alternative.

Although the initial set included 9 providers, only 6 responded to the practical case. Of these 6, two providers (Vendor 3 and Vendor 8) proposed exactly the same manufacturer's tool, so they are grouped as a single solution. The comparison is therefore made across 6 providers representing 5 different solutions

First Phase: The following table summarizes key information extracted from the providers' responses. As shown, Vendor 1 was discarded in this phase due to its uncompetitive licensing model: their proposal is based on per node or per device licensing, with no support included, and multiple offered services as paid add ons. This significantly increases operational costs, making it unfeasible for a network the size of Iberdrola.

Criteria	Vendor 1	Vendor 2	Vendor 3 & 8	Vendor 7	Vendor 9
Graphical representation of service status	Yes	No	Yes	Yes	Yes
Visual device inventory	Yes	Yes	Yes	Yes	Yes
Automatic network maps	Yes	No	Yes	Yes	Yes
Detailed network exploration	Yes	Yes	Yes	Yes	Yes
Resource reservation and tracking	Yes	Yes	Yes	Yes	Yes
Internal identifier/code generation	Yes	Yes	Yes	Yes	Yes
TMForum standards compliance	Yes	Yes	Yes	Parcial	Yes
Technical report generation	Yes	Yes	Yes	Yes	Yes
Node discovery and reconciliation	Yes	Yes	No	Yes	Yes
Route stitching or logical joining	Yes	Yes	Yes	Parcial	Yes
Incident impact analysis	Yes	Yes	Yes	Yes	Yes
Impact analysis by service	Yes	Yes	Yes	Yes	Yes
Ticket visualization in interface	Yes	Yes	Yes	Yes	Yes
Contextual alarm visualization	Yes	Yes	Yes	Yes	Yes
Visual resource reservation	Yes	Yes	Yes	Parcial	Yes
Logical grouping of services or nodes	Yes	Yes	Yes	Yes	Yes
Advanced device/service search	Yes	Yes	Yes	Yes	Yes
Solution type	Vendor solution	Hybrid	Vendor solution	Open source	Vendor solution
Recommended installation	Yes	Todas	Yes	Yes	Yes
Log management (syslog, traps, events)	Yes	Yes	Yes	Yes	Yes
Monitorable layers	Yes	Todas las capas	Yes	N/A	Yes
Root cause correlation/analysis	Yes	No	Parcial	Parcial	Yes
Automation / AI / Prediction	Yes	Yes	Yes	No	Yes
REST API & Webhooks	Yes	Yes	Yes	Yes	Yes
PDH/OTDR protocol support	Yes	Yes	N/A	Yes	Yes
Licensing	Yes	TB	Yes	License GPLv2	Yes
Learning curve	Easy	Easy	Easy	Medium	Easy
Results	✗	✓	✓	✓	✓

Note: based on the final results, it should be noted that the analysis includes only one open source provider, which comes from Iberdrola's existing ecosystem. The majority of the evaluated providers offer vendor-based solutions.

Table 2:Techinical Benchmarking of Providers

Second Phase: Detailed Technical Evaluation of Finalist Solutions. In this second phase, the four distinct technological solutions that passed the initial screening are compared in detail. The technical evaluation is carried out using the seven previously defined criteria. The results are presented in two complementary formats:

- A table of normalized scores out of 10 points per criterion.
- A radar chart that visualizes the relative strengths and weaknesses of each solution.

Criterion	Vendor 2	Vendor 3 & 8	Vendor 7	Vendor 9
Replacement of tools	5	8.5	6	9
Integration with existing tools	9	9	8	8
Graphical representation and interface	2	9	7	8
Licensing model	6	2	9	4.5
Functional requirements	7	8.5	7	9
Deployment model and scalability	7	7	9	7
Support model offered	7	6	6	9
Total Score (out of 70)	43	51	52	54

Table 3: Comparative score of finalist solutions by technical criteria

As seen in the table above (Table 3)

Vendor 2: Hybrid proposal that combines open source tools (Zabbix, Grafana) with proprietary components, especially for storage and analytics (Elastic). It stands out for its adaptability and technical expertise, but has two key weaknesses: it does not offer dynamic maps, and its modular nature prevents replacing all current tools without additional integrations. API integration is robust, but the scope for replacement is limited.

Vendors 3 & 8: Consolidated and mature commercial solution, distributed through intermediaries. S stands out for its dynamism, precise documentation, and detailed technical response, with real world examples. Its licensing model is complex and expensive (perpetual licenses per device and log volume, with key features such as HA or configuration under additional licenses). Support entails high annual OPEX (15–21%). Even so, it is a robust option in terms of technical and functional maturity..

Vendor 7: Proposal 100% based on consolidated open source software (Grafana, Zabbix, Elastic Stack). It is clear, coherent, and close to the current model, which facilitates its deployment. Zabbix, under the GPL v2 license, does not entail licensing costs and allows great freedom of use and modification. It requires an integrator for implementation and ongoing support, but is very efficient in OPEX. It has a high initial CAPEX, and it is recommended to carefully negotiate support costs, its main source of income. Its great advantage over the rest is that, since the tools they propose are part of the tools currently used, the operator is already familiar with them and has a smoother learning curve

Vendor 9: High level commercial proposal, both technically and functionally, with an annual subscription model that includes licensing, support, and maintenance. Flexible licensing configuration based on modules, adapters, and monitored elements. Although the cost may be high, support and updates are included in the fee. High technical and customer service maturity; the total cost should be assessed in the RFI phase with actual volumetric data.

To conclude this final analysis, the radar chart below summarizes the benchmarking:

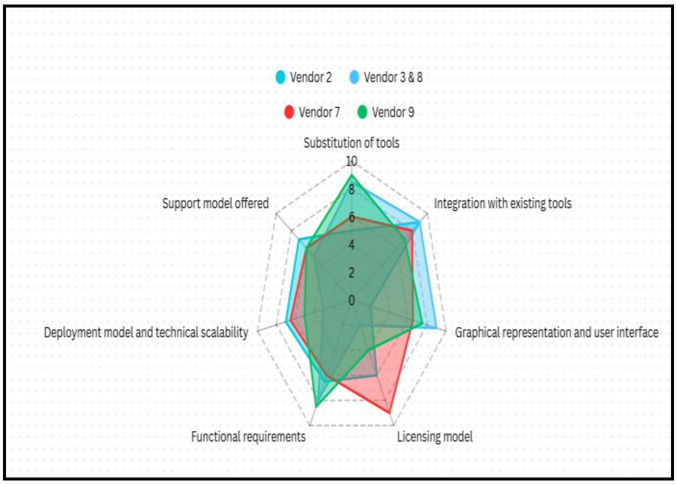

Figure 9: To conclude this final analysis, the radar chart below summarizes the

C. Conclusions and Recommendations of the Technical Evaluation

As a result of this technical analysis, Vendor 9 stands out as the most complete and competitive proposal on paper. Although it is a commercial tool (a model that, as analyzed in Section: Benchmarking of Monitoring Models), was not the most recommended from a long term strategic perspective this result make a sense with the current stage of the project, since we are still in a preliminary phase, prior to the final definition of the technical specification and before the formal launch of the RFI process.

At this stage of the study, special attention is recommended for the proposals of the four best positioned providers: **Vendor 3, Vendor 8, Vendor 7, and Vendor 9.**

Finally, if multiple providers successfully pass the technical evaluation, their candidacies will be forwarded to the purchasing department. This department will carry out a purely economic comparative analysis (evaluating licenses, OPEX, services, and maintenance) to determine the awarded provider that offers the best balance between cost, risk, and long term value.

VII. Integrated Analysis of Benchmarking Results

After conducting the three benchmarking exercises, it becomes necessary to integrate their outcomes to obtain a comprehensive view of the positioning of the analyzed providers. Each benchmarking exercise addresses a different and complementary dimension of the problem, and their combination enables more informed decisions about which vendors should be prioritized in the next phases of the project. The first benchmarking, focused on the strategic profile of providers, does not aim to discard any options but rather to position them based on their track record, type of company, international presence, and degree of maturity. This classification serves as a foundation for later filtering.

The second analysis focuses on licensing models and the types of solutions offered (commercial, open source, or hybrid). In this case, it is recommended to prioritize proposals that offer flexible, transparent, and sustainable licensing schemes for a large scale environment like Iberdrola's. Open source and hybrid based solutions stand out for their adaptability and customization potential.

the third benchmarking provides a detailed evaluation of the technical compliance with the defined functional requirements. Here, clear differences emerge, as some providers show significant technical limitations, while others present advanced solutions with a high degree of integration, automation, and scalability.

Below is a graphical representation that summarizes the intersection of these three analyses, helping to visualize which providers successfully meet the various stages of the comparative process.

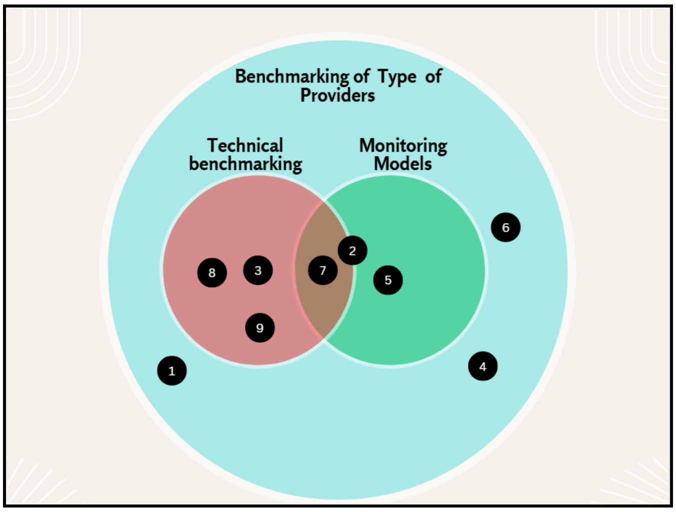

Figure 10: Venn diagram showing the intersection of vendors across the three benchmarking exercises

As shown in Figure, out of the four vendors that passed the technical benchmarking, only one (although Vendor 2 is not bad but has not fully passed) corresponds to a fully consolidated open source solution with direct support from the company. While there are two other vendors also based on open source technologies, their performance was more limited: Vendor 5 did not follow up or respond to the practical case and is therefore excluded from the process; and although Vendor 2 uses an open source solution, it scored lower on the established technical criteria and is on the borderline of being considered viable.

On the other hand, Vendor 7, despite good technical performance, was classified as a niche player in the strategic analysis, implying certain risks related to its size, stability, or long term support capacity. As previously mentioned, it is not advisable to rely on a single potential provider but rather to keep multiple options open to avoid compromising the process's flexibility.
This outcome is consistent with the current stage of the project, which is still in a preliminary phase. It will be in the next stage once full responses to the technical specification and detailed use cases are available that the selection can be refined and candidates can be eliminated with greater justification.

VIII. Development of the technical specification

Since the specification is an internal document and can only be shared with suppliers participating in the RFI process, information about its content cannot be shared. Therefore, the following is the index of the ET that was developed to launch to suppliers.

Table of Content

IX. Limitations of the Study and Future Work

Despite having achieved the main objectives of this Master's Thesis, there are certain limitations that constrain the scope of the analyses carried out, as well as clear opportunities for future expansion of the project.

A. Data Access and Testing Limitations

Firstly, although full access to the technical documentation of the current solutions was available and with the continuous support of the Iberdrola team, it hasn´t been easy to perform direct tests with the analysed tools due to their fragmentation, complexity, and criticality. The functional knowledge has been obtained mainly through meetings and observations made with Iberdrola colleagues and from the study of technical documentation. Likewise, the study has managed to gather the responses of most of the contacted providers, although many of the participants have confirmed their interest, the response times have been delayed as expected, since this was conducted during a holiday period but precisely for this reason, this phase was brought forward to avoid such issues. Some companies have provided insufficiently detailed responses, limiting the ability to perform in depth comparisons at this initial stage.

B. Pending Economic Analysis

Another limitation has been the impossibility of carrying out a detailed economic analysis. Although different licensing models have been identified and the factors influencing the Total Cost of Ownership (TCO) have been studied, there is still insufficient information available regarding exact volumetrics, reference prices, or specific commercial conditions. Consequently, any economic estimation at this point would lack the necessary rigor to draw useful conclusions. Regarding the next steps, it is considered important to consolidate the functional and technical requirements, launch new practical cases that allow a deeper exploration of the capabilities of each solution with different approaches, and request demos or proof of concept trials from the providers. These tests will allow the evaluation of the actual usability and functionality of the tools and verify what type of inputs and documentation are necessary for their integration, which will help detect potential shortcomings or the need for adaptation of the existing systems.

C. Cybersecurity Considerations

On the other hand, aspects such as cybersecurity have not been analysed in depth. Since the monitoring solution accesses critical network information and could become an attack vector, it will be important in the future to conduct a specific security impact assessment, as well as validate regulatory compliance and integration with corporate cyber resilience policies.

Also, an aspect not yet addressed is how the monitoring solution could be leveraged to detect potential cyberattacks. It is recommended that the project includes a plan specifying how the selected solution should incorporate such analysis, using relevant network parameters as detection indicators.

Finally, once a definitive tool is selected, Iberdrola will be able to advance in the standardization of processes and the automation of documentation, supervision, and analysis tasks. In the medium and long term, this project aligns with the company's strategic objectives in the field of Smart Grids, as it will enable progress towards comprehensive supervision (full observability) of telecommunications infrastructures, improving operational efficiency and response capacity to incidents

X. Conclusion

Throughout the development of this work, the objectives initially set out have been addressed, verifying their level of completion and the way in which they have been achieved. The following table details them one by one:

Objective	Completion	Description
Identify the main issues of the current monitoring model	Achieved	The current tools (Nagios, SNMPc, Zabbix, etc.) were analyzed, and limitations such as fragmentation, low integration, and lack of automation were identified.
Define the requirements and functionalities needed for a modern and scalable solution	Achieved	Requirements were established and organized by key areas: scalability, OSS integration, licensing, automation, and security.
Validate that the requirements are neither obsolete nor overly customized	Partially achieved	Meetings were held with providers to contrast the requirements. Although the RFI process was not completed, the proposed functionalities were partially validated.
Carry out benchmarking exercises to guide the solution search	Achieved	Three benchmarking analyses were developed (provider type, licensing models, technical analysis) and a practical case was sent to providers.
Draft a preliminary technical specification to launch an RFI/RFQ process	Achieved	A structured technical specification was drafted and is ready to launch an RFI whenever the company decides. It includes requirements, tables, and an evaluation framework.
Economic Analysis	Pending	A detailed cost–benefit analysis is still pending. This will involve estimating implementation, licensing, and maintenance costs for each shortlisted solution, and comparing them with the expected operational and efficiency benefits over the medium and long term. To be done based on the final ET
Cybersecurity Considerations	Pending	This analysis should include reviewing the solution's capacity to perform security-related network parameter analysis and recommending measures to integrate such capabilities into the monitoring system.

Table 4: Summary of project objectives achieved

A. Summary of recommendations

In response to the problem and based on the previous conclusions, the following recommendations are proposed as a solution to the current problem:

a) Evolve towards a unified, scalable, and resilient monitoring solution. The current system is about to reach its operational limits. It is recommended to initiate a progressive migration towards a distributed architecture, with high availability and event oriented, which allows the supervision of more than 200,000 devices efficiently and securely.

b) After the analysis of licensing and technical benchmarking, it is concluded that open source based models offer advantages in flexibility, costs, and control. It is recommended to avoid closed solutions that imply long term dependence or per node licenses, unless they provide a clearly differential technical value.

c) Define realistic functionalities, adjusted to what the market can offer. It is recommended to avoid both over customization and the use of obsolete requirements. This can be validated through technical meetings and pilot tests with suppliers before launching a formal RFQ.

d) It is recommended not to propose a totally new system, but to consolidate and integrate the best of the current ecosystem (Cacti, Zabbix, Grafana) with newer tools, taking advantage of investments already made and avoiding unnecessary migrations.

e) It is recommended to execute a proof of concept with the 2–3 best positioned suppliers (Vendor 7, 2, 3& 8 and 9). This will validate the real functionalities, the integration with current OSS systems, and the performance under real load.

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