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Toreador

TrustwOrthy model-awaRE Analytics Data platfORm RIA - Grant No. 688797

Requirement specifications for big data analytics related to Energy Production Data Analysis processes.

Deliverable D10.2

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Executive Summary

This document presents the current situation and future plans in Lightsource, the requirements of the energy pilot from the Toreador platform, the expected outcomes from the project and finally the SLA requirements for the energy pilot.

Contents

Chapter 1

Project Definition

1.1 Current situation in Lightsource-Monitoring system

Lightsource has developed an Asset Management Platform (Lightsource Monitoring Platform), whose main goal is to provide, in a timely and concise manner, information to its user on the operation of the solar farms. All data originating from the field will be forwarded to the Lightsource Monitoring Platform, where it will be stored and processed. The system architecture is implemented through the latest digital and IP-based technologies, preserving the necessary mechanisms for redundancy, in order to ensure the correct command and information flows with high accuracy. In order to guarantee some special applications the Lightsource Monitoring Platform must be able to communicate with the plant's components, providing the required signals via a secured and reliable communication data stream channel. Please see below Lightsource's plant monitoring system architecture:

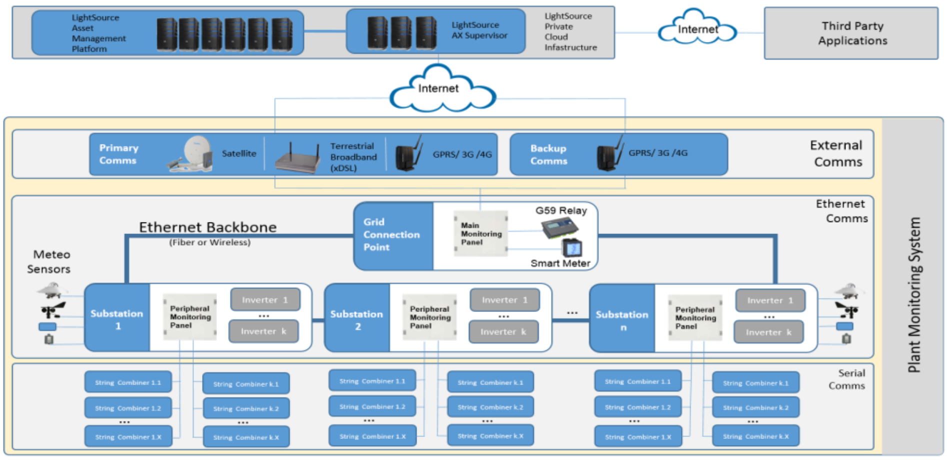


Figure 1. Lightsource's monitoring system

The Main Monitoring Panel (MMP) collects the signals from the G59 relay, the smart meters/power analysers installed at the Grid Connection Point, as well as all the signals collected by the Peripheral Monitoring Panels installed in all peripheral substations. The Peripheral Monitoring Panel (PMP) shall collect the signals from the inverters, private meter at the point of connection (if closer than MMP) and the string combiner boxes (SCBs) of the substation they are installed. It shall also collect the MV transformer alarms as well as the ambient temperature of the transformer cabinet in case of indoor transformers. Depending on the plant design, both the MMPs and the PMPs may collect signals from weather stations, pyranometers and other sensors. The standard communication protocol of all monitored equipment is MODBUS TCP via the RTU units.

Two main categories of measurements are collected into Lightsource's monitoring, the primary measurements and the derived measurements, via several equipment devices' monitoring:

A. **G59 monitoring**: The G59 relay has data logging capabilities and is able to keep a registry list with the event codes. It provides a Modbus TCP port with a fully documented registry list. The categories of data that delivers are listed below:

   - Active energy
   - Reactive energy
   - Active Power
   - Reactive power
   - Voltage levels
   - Current levels
   - Frequency levels
   - Power factor
   - G59/Alarms

B. **Inverter Monitoring**: All the inverters provide MODBUS TCP communication which is fully documented and the categories of data are listed below:

- DC (direct current) current input
- DC voltage input
- DC power input
- Output current per phase
- Output voltage per phase
- Output power per phase

- Total AC (alternative current) Power
- Power factor
- Daily Energy produced
- Total Energy produced
- Local network frequency
- Operating time
- Grounding resistance
- Inverter temperature
- Inverter's alerts/signals

C. **String Combiners Monitoring**: All the string combiners provide MODBUS TCP communication which is fully documented and the categories of data are listed below:

- String current (per string)
- Total output current at the boxes
- Total output voltage at the boxes
- Total output power at the boxes
- In the box temperature
- String combiner details

Moreover, Lightsource monitoring system monitors and stores *irradiance data, ambient temperature data, photovoltaic module temperature data, wind speed/direction data, humidity data, precipitation quantity data etc*. Finally, it calculates some very important measurements (derived measurements) such as *Performance ratio, availability ratio, inverters sum etc*

1.2 Lightsource's future plans

Lightsource considers beneficial to upgrade its monitoring system by developing a "smarter" and more interactive system which will be not only capable of receiving signals but also giving orders towards key components/devices of a solar farm, as the new structure of the energy market demands. This would be possible by the combined function of different devices at the customer's plants (large and residential scale).

For example, the installation of a Power Plant controller (PPC) into the solar farm could control PV (PhotoVoltaic) power plants in accordance with the requirements of the grid operator and, through the adaption of active- and reactive power, contributes to the stabilization of the utility grid by directly communicating with the DNO SCADA system.
More specifically, an SMA PPC could provide very important functions, which could give different orders on the solar park for the most efficient functionality, such as:

- Efficient PV system controllers with fast communication infrastructure
- Central hub for recording, evaluating and implementing measurements
- Receiver for all internal and external control and regulation commands
- Central control unit for coordinating inverters in the power plant
- Real-time recording of all conditions in the power distribution grid (V, f, Q) and in the power plant
- Flexible, expandable concepts for individual hardware and software solutions
- The parametrization and configuration of the Power Plant Controller via remote access

Please see the below schematic which gives an overview of the above:

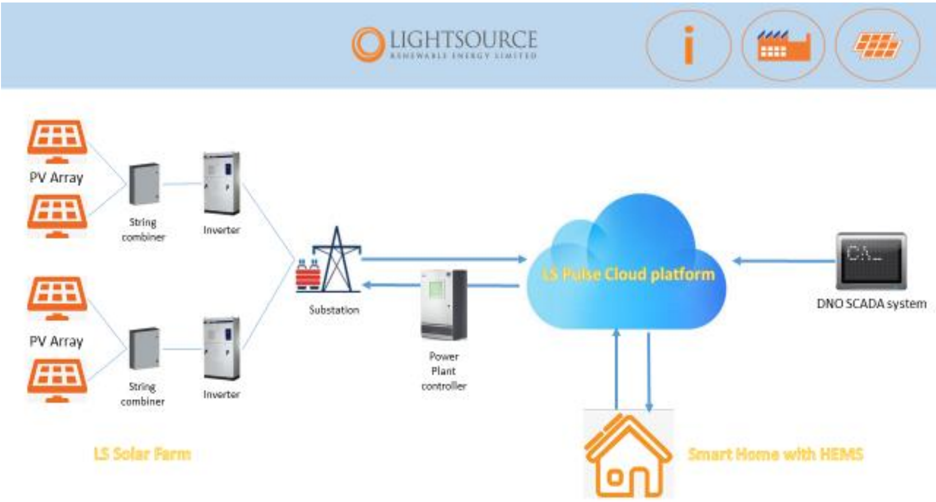


Figure 2. "Smart Network" – Usage of PPC and HEMS with the DNO SCADA system

Based on the above schematic, it is clearly presented that a "bidirectional" interactive communication could be developed with the assistance of the proper equipment which could be beneficial for the best economical outcomes for Lightsource.

Database will be stored into the cloud platform and via the commands of the DNO Scada system, Lightsource could give specific instructions, with the assistance of the power plant controller to key components of the assets. In parallel, the same procedure could be tracked from the cloud platform, for the residential assets, more specifically for the smart home installations. Please see below, Lightsource's approach in the residential scale market.

In the residential scale, Lightsource renewable energy holdings has already developed the smart home based on the below schematic diagram and collects a significant amount of data in daily basis, with many primary and derived measurements coming from the monitoring system via the Home energy management system (HEMS). The next figure shows the smart home that Lightsource has developed:

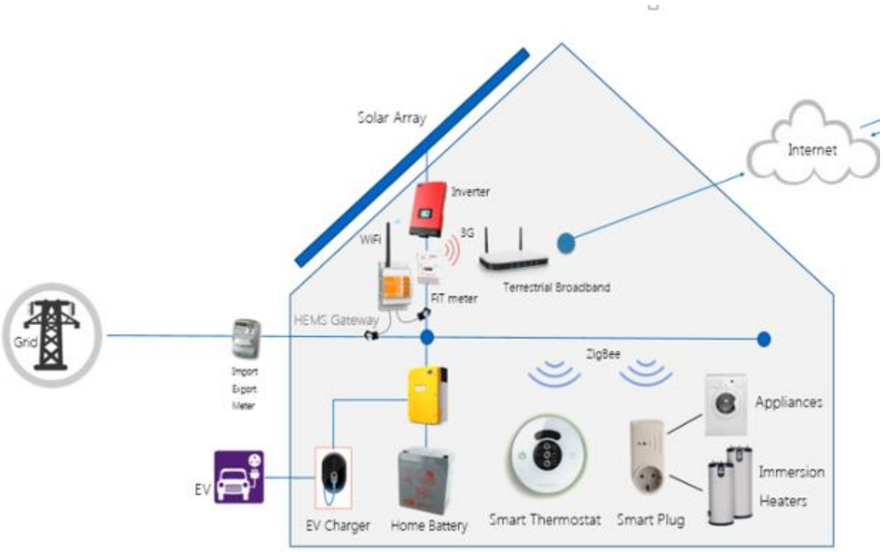


Figure 3. Lightsource's Smart Home

The main characteristics of the smart home are listed below:

- PV system
- Home energy monitoring
- Energy storage systems (Immersion heaters/Batteries)
- Smart meters
- Smart gateway devices
- Smart plugs

Lightsource's monitoring system collects different categories of data such as Generated Power/energy, Consumed Power/energy, Export-Import Power/energy (primary measurements), Frequency and Voltage Levels and based on these measurements some important outcomes are produced for the assets such as the self-consumption and the self-efficiency (derived measurements)

From all the above, for both large scale and residential scale assets, the amount of data is very big and with a scenario, of collecting 400 measurements / MW, producing 600 derived measurements / MW based on a granularity of 1 min, delivers **2.016.000.000 data points per day**. Lightsource wants to modify the granularity from 1min to 1sec, so the amount of data will be totally different with many real time calculations which will give a better understanding of the assets' functionality and will increase their efficiency with many economic benefits. It is clear that the Toreador platform with the usage of the predictive analytics, and not only, could provide different solutions in many challenges that Lightsource faces in daily basis.

Chapter 2

Project Objective

2.1 Introduction

A combination of a smart network with the usage of the TOREADOR platform services, can give a huge boost to Lightsource with significant benefits in different categories of our activities.

Firstly, predictive analytics models, which are based on smart learning machine algorithms, can increase the efficiency of the assets (a solar park or a smart home), by maintaining and operating these assets according to real time data, historical data and data from similar assets and past maintenance records.
In the future, Lightsource want to achieve 1 sec granularity in its database, as mentioned before and predictive analytics is defined as predicting at a more detailed level of granularity. Lightsource would like to follow the below model (graphically represented) with the combination of the Toreador platform and the predictive analytics, in order to grow its business value:

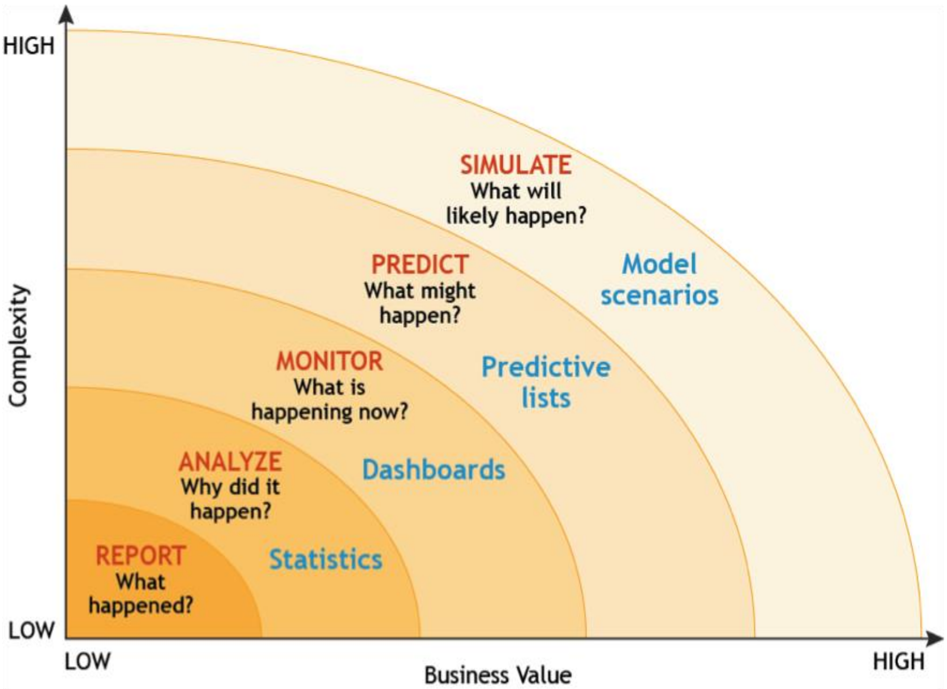


Figure 4. Predictive analytics contribution

More specifically, the first three categories-labels (REPORT, ANALYZE, MONITOR) have already been developed by Lightsource, via its monitoring system although the Toreador platform can be used to connect all different assets, manage the amount and variety of collected data and enable a predictive approach, so that the analysis on these data can be used to optimize in real-time the performance of the energy generation processes. The predictive analytics (PREDICT, SIMULATE labels), connected to the Toreador platform, could play a fundamental role in complex challenges (Y axis) by providing higher business value for Lightsource through simulation of several scenarios for future cases (X axis). Below, figure 2 is displayed with the addition of the Toreador platform and the predictive analytics:

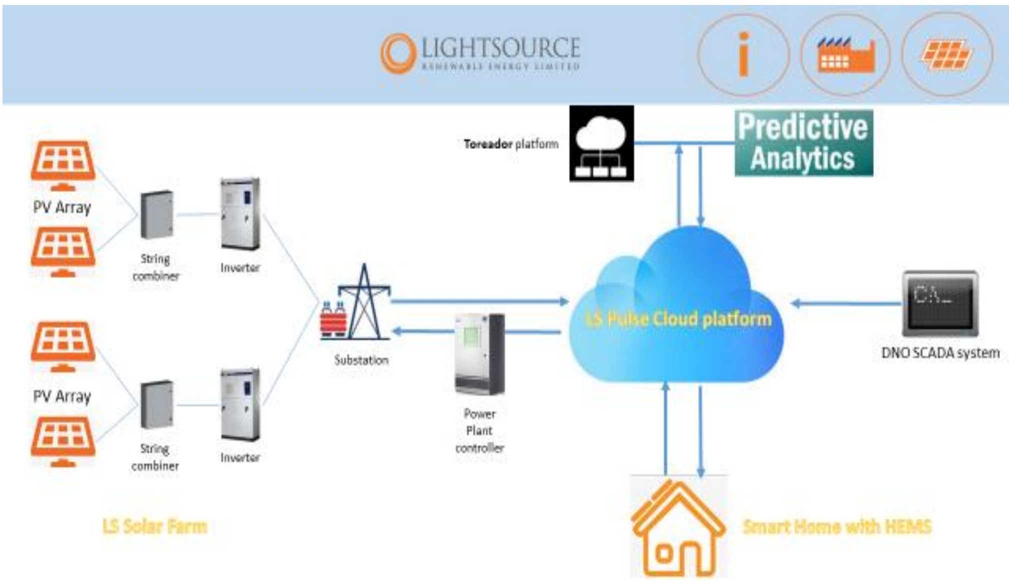


Figure 5. “Smart network” with the Toreador platform and predictive analytics

For the large assets/solar farms, based on the above schematic, Lightsource could have a lot of benefits and instead of using, the standard maintenance services which are quite expensive and time-consuming, the predictive models can store all the variables and conditions that provoke past failures in order to predict future failures (inverters, transformers, batteries etc. failures). The predictive analytics models can provide to Lightsource various advantages such as:

- Cheaper component repair and replacement services
- Reduced revenue loss
- Focussed and more efficient O&M activity
- Better equipment management
- Better operational practices

For the residential assets, Lightsource could use the Toreador platform to deliver towards the grid several services such as frequency response and voltage stability during different circumstances that would be alerted from the DNO SCADA system. For instance, in frequency emergency situations (peak demand times), the community could export surplus energy from the storage systems towards the grid. Please see below the relevant schematic:

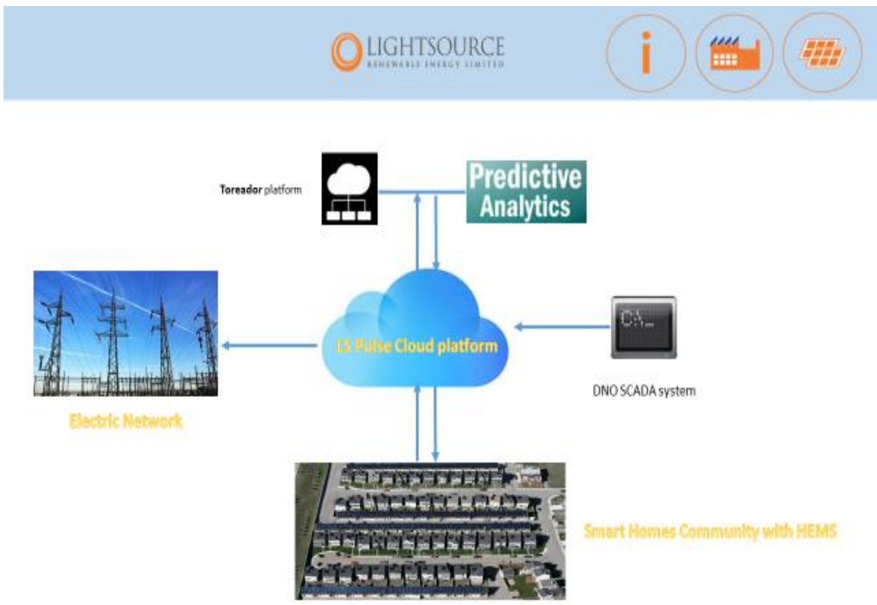


Figure 6. “Smart Homes” Community with Toreador and Predictive analytics

So combination of figure 5 and figure 6, produces the below figure which represents the energy pilot into the TOREADOR platform:

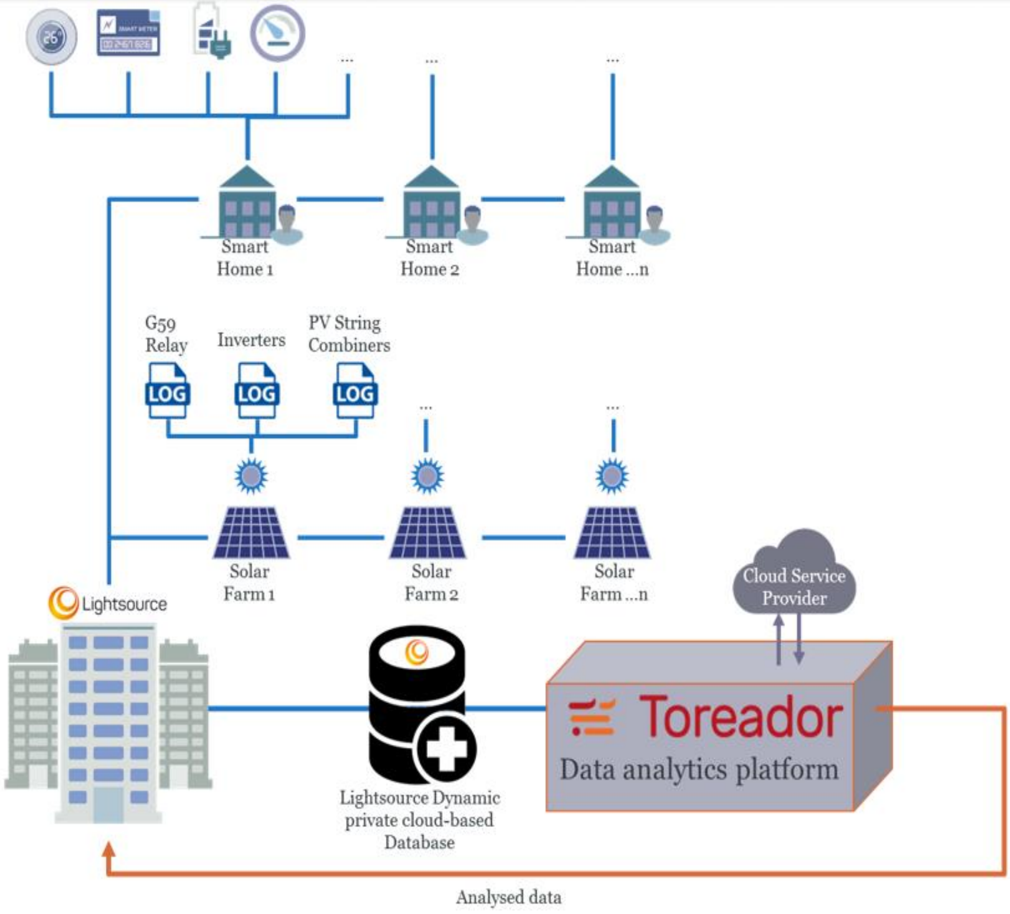


Figure 7. Overview of the energy pilot

Moreover, all the above details show clearly that Lightsource's energy scenario could have different benefits, as the Toreador platform could develop the best predictive services for different scenarios. The big volume data integration that can be achieved via the Toreador project, based on different circumstances that influence a PV asset (weather forecasting, irradiance forecasting, temperature data etc.) or the electrical network (voltage and frequency instability etc.) can give important outcomes that Lightsource's could take advantage of them. The requirements from Lightsource's side are presented in more detail into the next chapter.

Chapter 3

Project Analysis

3.1 Functional and non-functional requirements

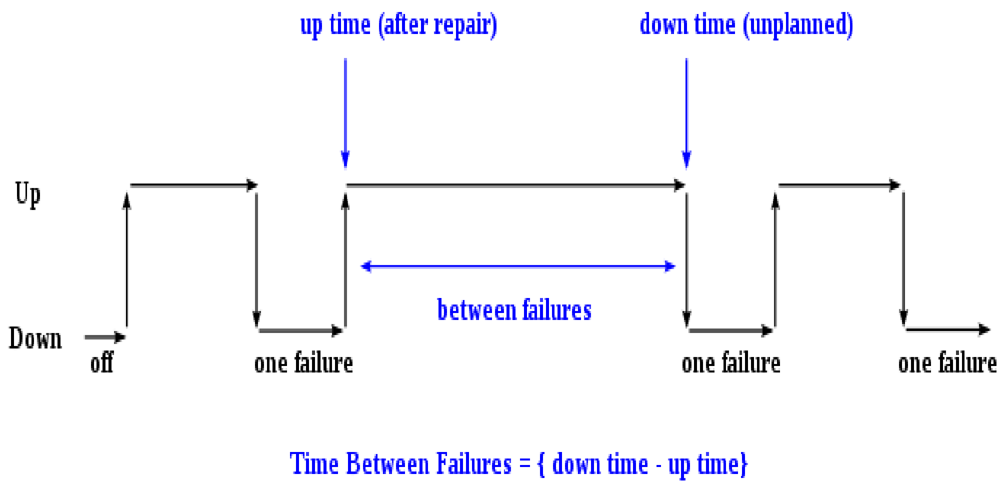
The functional and non-functional requirements expected from the TOREADOR platform:

- REQ01: TOREADOR platform shall support predictive analysis. Prediction will be performed based on the prediction models that will be used on the platform in order to support knowledge extraction and prediction of our equipment's functionality.

- REQ02: TOREADOR analytics must support real time data integration via APIs support in order to allow real time combination of data extracted from different sources (both large scale and residential scale assets).

- REQ03: Prediction for equipment maintenance based on historical data and for equipment anomalies in work cycles of the devices (inverters, transformers, smart meters' failures). More specifically, data from the large scale solar of 3 years and from our residential assets will be provided by Lightsource, for preventing anomalies regarding spikes in voltage, giving frequency response of the grid quality, and receiving temperature of inverters and ampere information. We expect the platform to support predict maintenance of tools and machines involved in the monitoring process.

- REQ04: Increasing the assets' lifetime by using Mean time between failures methodology, in order to protect our equipment for future failures. In more detail, Lightsource considers that the usage of the MTBF models could be very significant as they refer to the average amount of time that a device or product functions before failing. This unit of measurement includes only operational time between failures and does not include repair times, assuming the item is repaired and begins functioning again. MTBF figures are often used to project how likely a single unit is to fail within a certain period of time. The definition of MTBF relies on the category of a system failure and specifically for the solar assets there are several failures such as inverters failures, transformers failures, smart meter failures etc. which are quite expensive and time-consuming to be repaired and replaced if it is necessary (long / very long lead items for a solar asset). A brief summary of the MTBF models is presented via the below schematic:



A big amount of revenue has been lost for Lightsource during the "between failures" and these scenarios could be avoided by using the results from the Toreador platform that could possibly combine both the Predictive analytics and MTBF models. This development can also be very significant for increasing the lifetime and the value of a Lightsource's asset for the large-scale and residential-scale assets.

- REQ05: Privacy support and anonymization mechanisms to be supported with the name and location (general info as well) of the assets to be protected and anonymized. The protection of sensitive data that will be provided to the TOREADOR platform, will be extremely important and one of the main requirements from Lightsource.

- REQ06: TOREADOR shall support behavioural analysis algorithms based on behavioural algorithms that could be used from the platform.

- REQ07: Inspection process monitoring of data which means that the data correlation and analysis and the predictive maintenance to specific activities for the inspection process during and after a work cycle.

3.2 Protection requirements

The LIGHT pilot is about proper management of general and personal electric power generation and consumption, so there are specific protection requirements that is useful to be analysed below:

- Data access & rectification

This requirement falls mostly under the ‘access’ and ‘rectification’ data subject rights.

The power generation and usage done at household level is being managed via a contract signed between the final end user and the power providing company. In order to function properly, the power company requires personal information from the user, such as his or her name, address and billing information. It is legally required to ensure users can access the data stored by the company and have the possibility to update it. This is particularly relevant in this pilot use-case as the personal information has a direct impact on the power delivery.

There is as such the requirement to allow easy access and rectification of data by end users, and the proper reconfiguration of services depending on this information upon update.

- Protection against spoofing and tampering

This requirement falls under the ‘spoofing’ and ‘tampering’ threats of the STRIDE methodology.

Data spoofing/tampering or system spoofing in the context of the LIGHT use-case can have extremely dire consequences, including power theft (a data sink pretending being the legitimate end-user) and safety concerns (sensors reporting wrong measures leading to a power surge being delivered).

Where spoofing and tampering threats need to be considered for any architecture design, the requirement is particularly crucial in the context of this pilot.

- Protection against information disclosure

This requirement falls under the ‘information disclosure’ threat of the STRIDE methodology.

Information disclosure is another very crucial threat in the context of the LIGHT pilot, as leaking sensor data or simply an analysis of the amount of data being transmitted between devices can offer to an attackers very sensitive information about the end user, including the number of people living in the target home and whether the house is empty or not. A house having a high power consumption (possibly containing many electronic devices) and being detected (or even, predicted) as being empty could be a tempting target for burglars.

- Protection against denial of service

This requirement falls under the ‘denial of service’ threat of the STRIDE methodology.

Since the LIGHT pilot is about electrical power delivery, a denial of service scenario can have immediate consequences such as deprivation of heat, light and more often than not, communication capabilities. Denial of service may be triggered by tampering with sensor data or by directly attacking the physical devices hosted on the house.

The LIGHT pilot is the only one pilot where devices are directly hosted at the end user’s location, raising the likeliness of having successful physical attacks against them

Chapter 4

4.1 LIGHT-TOREADOR Architecture

The final system architecture is depicted in Figure 8.

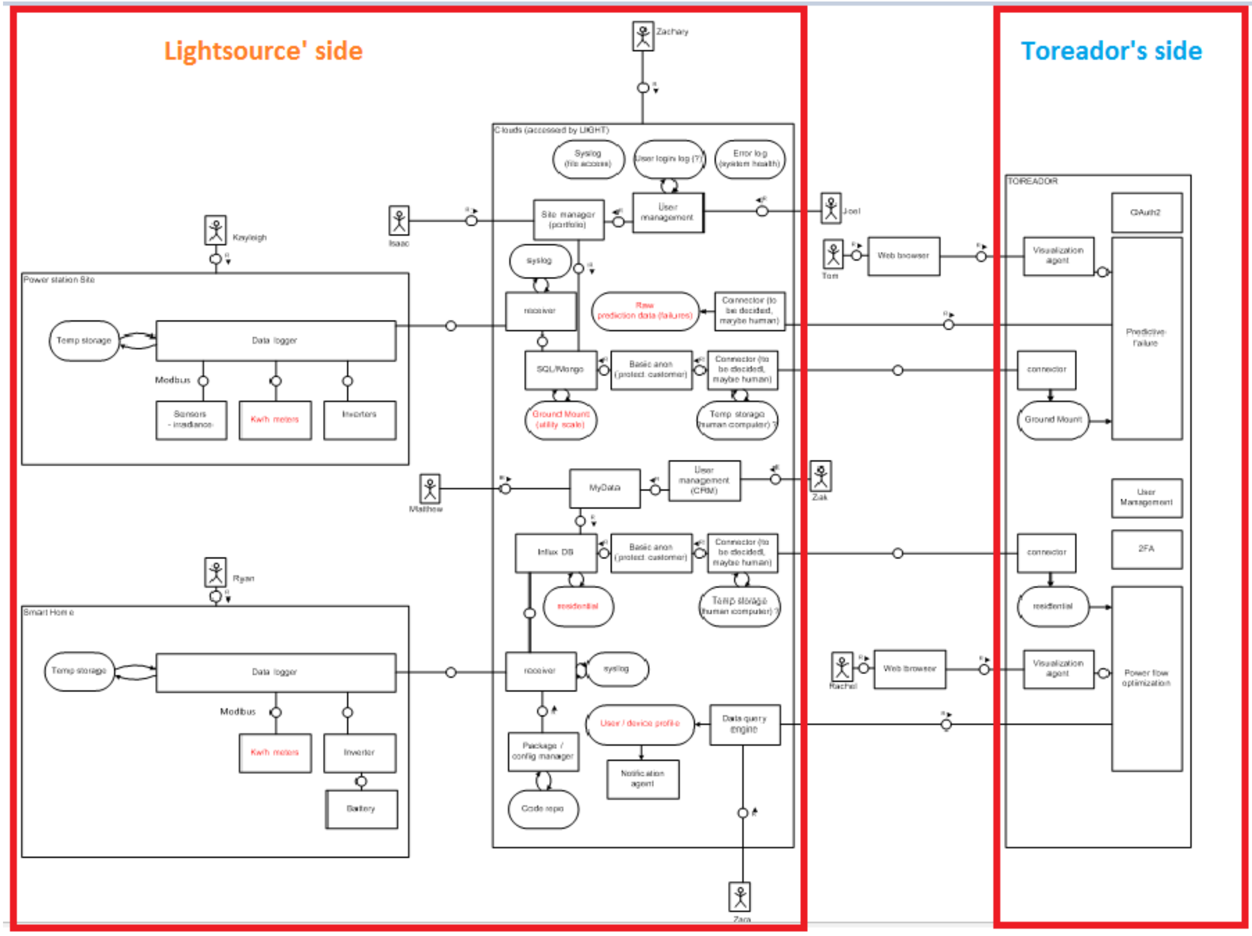


Figure 8 – Lightsource Architecture

Kw/h meters and inverters are sensor devices generating data about power emission and consumption. This data is being collected by a Data logger, via the MODBUS protocol. Data loggers will transmit data to the LIGHTSOURCE cloud infrastructure over HTTPS.

Power Station sites are physical sites where solar panels are being deployed. These panels are monitored by sensors connected to a data logger hosted in a dedicated building where only authorized personnel can enter (e.g. Kayleigh).

Smart Homes are homes belonging to private individuals, into which physical boxes owned by LIGHTSOURCE are being installed. These boxes contain the data logger and are plugged to the house's power sensors. The boxes shall not be physically opened by unauthorized personnel.

The main servers of LIGHTSOURCE are hosted on a Cloud infrastructure. There, receivers are collecting data from Power stations and from Smart homes, and storing it into separate databases. Dedicated applications run on top of this data, respectively for site managers (such as Isaac) to monitor its power plants and for individuals (such as Matthew) to review data about his smart house. These applications are being administered by role managers, ensuring that each external user has access to his data and to his data only.

Diverse logs are being kept, such as user access log by the user management agent and syslog and error logs by the database platforms.

Both main data storages (Ground Mount and Residential) follow the same (separate) architecture model. They are being polled by a Basic Anon agent, performing removal of data un-necessary for the analysis (to be refined in later WP10 deliverables) and pseudonymization of identifiers (such as device vendors for Ground Mount and end-users for Residential) for having the data as minimal as possible for analysis by the TOREADOR platform while enabling the possibility to take decision on which device to replace / buy (in use-case #1) and on which user to notify (in use-case #2).

The data is then sent to the TOREADOR platform, hosted on a possibly separate cloud platform. It shall be decided how the data should be uploaded to the TOREADOR platform from the LIGHT cloud platform, either automatically or via a manual process. Both approaches have advantages and disadvantages, the risk analysis provided in the later section expands on these considerations.

Once in the TOREADOR platform, the data is processed by specific analysis algorithms and made available via a dedicated service for visualization through a web browser, as well as for download (as text data) for further analysis locally on the LIGHT cloud platform. Once downloaded, the data is being made available to authorized persons; the authorizations are being managed by the LIGHT user management tools (and are beyond the scope of this threat modeling exercise).

The TOREADOR platform has a User Management module, supports 2-factor authentication via its 2FA module and uses the OAuth2 protocol for session and authorization management.

Chapter 5

Energy pilot use cases

5.1 Introduction

This section details the two main use-cases supported by the WP10 pilot once deployed through the TOREADOR platform.

The TOREADOR platform shall be implemented in a way making possible the deployment of a system coping with these two use-cases/examples.

The energy pilot work package WP10 is a system aimed at maximizing the efficiency of solar energy. It consists in a set of components retrieving data from solar plants as well as from smart homes running their own local solar appliance in an effort to respectively predict hardware failure (avoiding power cuts) and optimize energy consumption (avoiding waste and minimizing costs).

The data comes from locally deployed sensors and is being sent to a cloud platform. It is there used directly for diverse metrics and reporting. It is also prepared before being sent to another cloud platform, where it is processed, generating respectively reports predicting failures and power consumption analysis graphs for optimizing energy creation and consumption.

5.2 Large scale asset case – Predictive maintenance

The predictive maintenance scenario, in a large scale asset example, is described into the below steps:

1- Sensors placed at power station sites send data about power to their data logger
2- The data logger sends the data to a receiver, which stores the data into the Ground Mount data storage
3- The Basic Anon agent retrieves the data and applies some preparation including removal or pseudonymization of metadata related to customer names and details
4- The prepared data is being sent to a connector on the Toreador platform (either automatically or through a manual process, to be decided upon implementation)
5- The Ground Mount data is locally stored, then processed for predicting failures
6- Tom logs into the Visualization agent and can drill into the prediction details
7- Upon a Lightsource's employee's action or via a batch job, the prediction's raw data is being retrieved to the Raw Prediction Data storage for further action which is beyond the scope of the pilot (including making buying decisions and pro-actively changing components at the power station)

Please see below some screenshots from this use case (Lightsource monitoring system – Large scale assets)

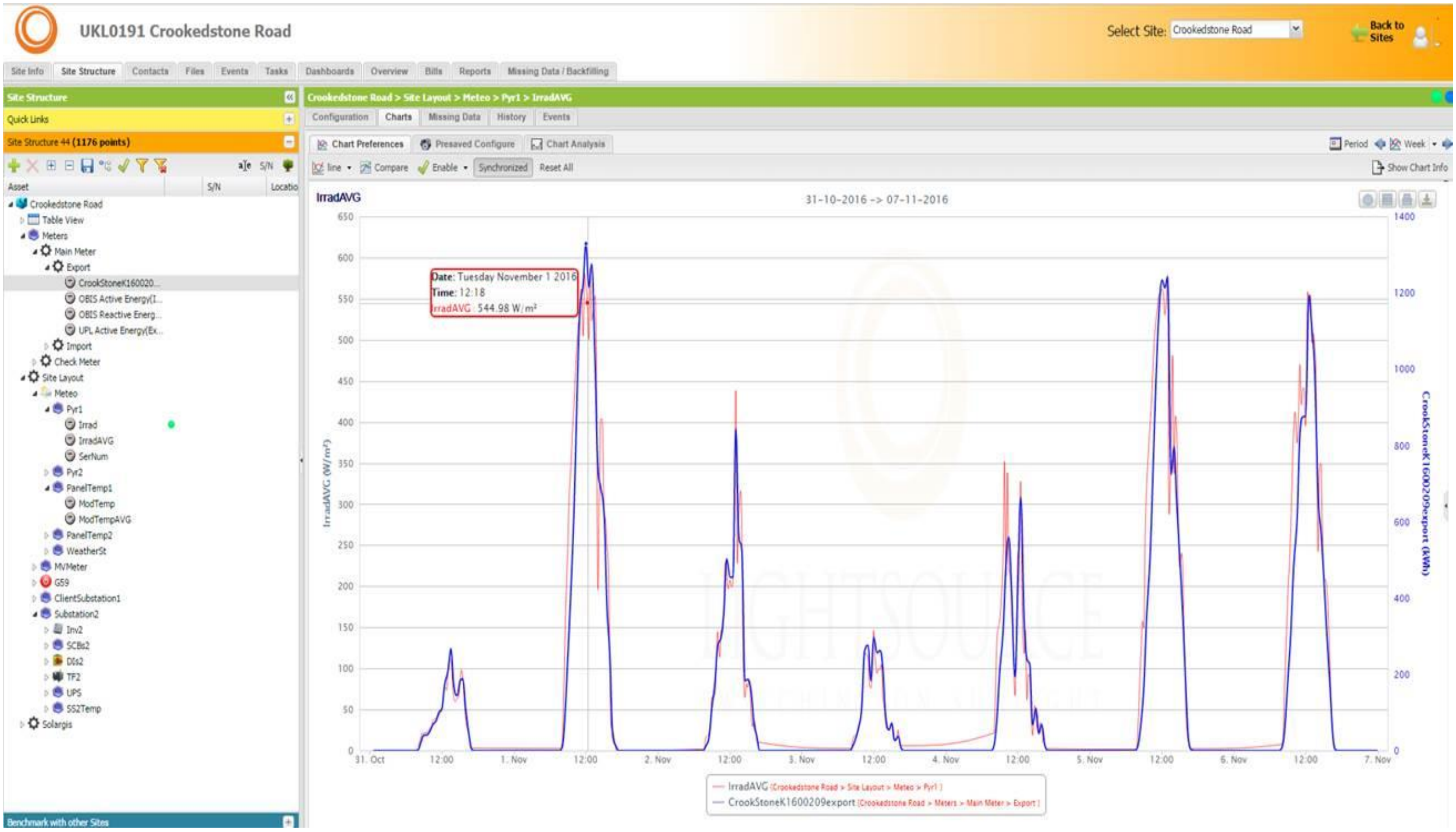


Figure 9: Red line presents the irradiance date and the blue line presents the export data to the grid

Figure 10: The green line displays the quarterly power production of two inverters within a day.

5.3 Residential scale asset case - Smart house power optimization

The power optimization in a smart home is described into the below steps:

1- Sensors located in smart houses send data about power to their data logger
2- The data logger sends the data to a receiver, which stores the data into the Residential data storage
3- The Basic Anon agent retrieves the data and applies some preparation including removal or pseudonymization of metadata related to customer names and details
4- The prepared data is being sent to a connector on the Toreador platform (either automatically or through a manual process, to be decided upon implementation)
5- The Residential data is locally stored, then processed for power optimization
6- A Lightsource's employee logs into the Visualization agent and can drill into the analyzed data, such as inference about the types and usage of electric devices at the customers' smart home
7- The data is further being pulled into the User/device profile storage area, where from Lightsource's side can perform several queries, including the possibility to re-identify which house is being concerned by certain data elements, offering the possibility to send notifications to the customer with information about abnormal power usage or suggestions for better

A detailed overview of Lightsource's Home Energy Management System is described, which will be the main source of residential data, is presented in the next pages.

Lightsource has already developed a residential scale scheme entitled GoSunplug, which provides energy services to residential customers. This system will be the main source of data towards the TOREADOR platform, regarding the power optimization in a smart home, as described into the previous section.

Please see below some screenshots from the HEMS:

Figure 11: Overview of the HEMS platform with three main categories of data sources (*Generated energy, Imported energy, Energy from the battery*) – Real time graph

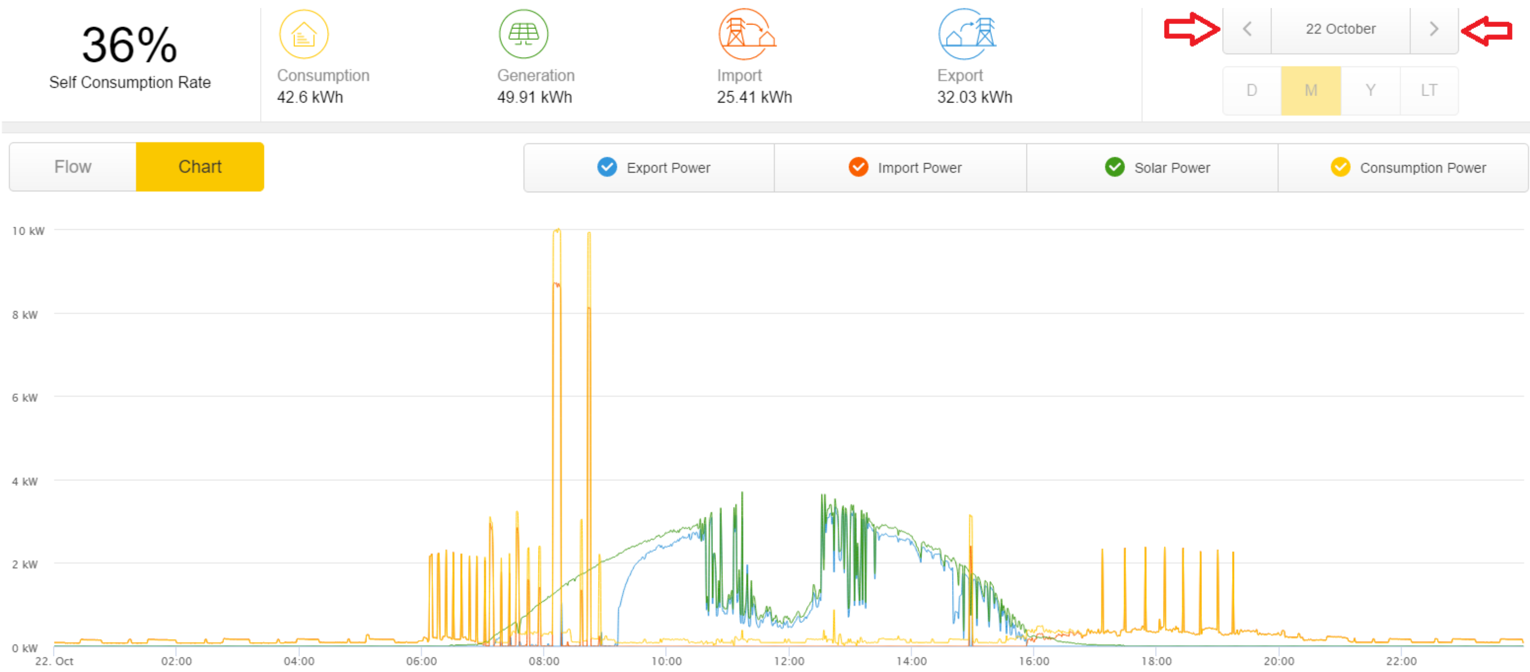


Figure 12: Electricity chart in hourly resolution, in daily basis

The power chart displays a more detailed reading of the electricity that is consumed, generated, imported and exported on a daily basis with hourly resolution. The chart only shows readings of the Sunplug system on a daily basis, but also stores historical information on the system functions, which can be accessed by scrolling through different days. All this data can be used and implemented into the TOREADOR platform for producing different outcomes (presented in detail into the next section), which will be beneficial to Lightsource.

Chapter 6

Expected outcomes

The big volume data integration that can be achieved via the Toreador project, based on different circumstances that influence a PV asset (weather forecasting, irradiance forecasting, temperature data etc. from our monitoring system) or the electrical network (voltage and frequency instability etc.) can give important outcomes that Lightsource could take advantage of them.

More specifically the overall targets, that Lightsource expects and they could be achieved by the Toreador's results are listed below:

- Real time monitoring analysis by gathering a big amount of data from several assets.
- Onsite & Cloud analytics.
- Real time aggregation in a Virtual Power Plant (VPP mode).
- Real time Decision Support System that could be achieved by the bi-directional circulation of information via the PPCs and the HEMS.
- Real time controls of key equipment into both the large scale and residential assets.
- Data logging of balancing events performance.
- Providing services to the grid when it is necessary (frequency response/voltage control).
- Predicting failures of key components of the assets.
- Increasing the assets' lifetime by using Mean Time Before Failures models (MTBF) with the predictive analytics and the Toreador platform.

The resources from the TOREADOR platform, which can help make decisions on the functionality of different key equipment components will be to a large extent the visual resources we have just examined. Aside from these, TOREADOR should be able to offer another type of resource in the form of reports –the format of which can vary between CSV, Excel and so forth. These reports should contain the results obtained after the analysis phase and after applying machine learning algorithms and data mining on the TOREADOR platform, in order to deliver the above outcomes.

Chapter 7

SLA (Service Level Agreement) requirements for the energy pilot

7.1 Introduction

In this section, we describe requirements regarding the management of service level agreements for the energy pilot. These requirements have been identified after consulting the needs of the pilot owner in TOREADOR (i.e., Lightsource) and the general landscape of smart energy production and distribution systems. The requirements listed have been classified in three different categories:

(a) requirements regarding SLA specification
(b) requirements regarding SLA negotiation
(c) requirements regarding SLA assessment

In the following, we describe the requirements under each of these categories. The requirement descriptions have been expressed based on the following requirement template:

Name: *a unique identifier that can be used to refer to the requirement in an unambiguous manner and distinguish it from any other requirement*
Property: *The property(ies) that the requirement asks to be satisfied by the TOREADOR platform in the case of the specific pliot.*
Rationale: *The reason why the requirement is relevant and important.*
Scope: *The broad capability area(s) of the TOREADOR platform that is relevant to the requirements.*
Dependencies: *Other requirements that need to be satisfied for this particular requirement to be satisfied as well.*

7.2 Requirements regarding SLA specification

Name: REQ-S-01
Property: TOREADOR shall support the specification of SLAs, including service level objectives regarding functional, quality, security and privacy properties for BDA services.
Rationale: BDA SLAs should cover a comprehensive range of properties that may be relevant to BDA services, including functionality, quality, security, privacy, etc.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot
Priority: Essential
Dependencies: -

Name: REQ-S-02
Property: TOREADOR shall support the specification of actions that should be undertaken under different circumstances during the life of an SLA (e.g., when the SLA is violated). These actions shall, for example, include SLA party notification actions, SLA modification actions, BDA service and service platform modification actions and application of penalties, SLA suspension and SLA re-negotiation actions.
Rationale: Different events during the operational life of an SLA (e.g., SLA violations, temporary inability to monitor an SLA etc.) need to be handled in different ways depending on the nature and context of the BDA service. The SLA specification language should support the specification of such actions as they often form part of the agreement between the BDA service provider and consumer.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot
Priority: Essential
Dependencies: -

Name: REQ-S-03
Property: TOREADOR shall support the specification of SLAs covering two-party and multi-party agreements.
Rationale: Most SLAs are agreements between a service provider and a service consumer (two party agreements). Multi-party agreements are SLAs where more than one service providers are jointly responsible for the provision of a BDA service to a service consumer. For example, more than one providers may be involved in the provision of data for a BDA service or a BDA service may be deployed on a cloud federation with more than one infrastructure level cloud service providers. Such cases should be supported by TOREADOR.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot

Priority: Medium
Dependencies: -

Name: REQ-S-04
Property: TOREADOR shall provide reference catalogues of properties that could be used in defining SLAs.
Rationale: Reference catalogues of SLA properties are a common practice in different areas and domains (e.g., security and quality properties for cloud services). They are useful as they are often standardized and easy to use, and promote compliance with standards.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot
Priority: High
Dependencies: -

Name: REQ-S-05
Property: TOREADOR shall provide reference templates of properties that could be used in defining SLAs.
Rationale: Reference templates of SLA properties are a common practice in different areas and domains. SLA templates are useful from a specification content as they provide parametric definitions of service level objectives that are precise enough to lead to monitorable SLAs. Furthermore, they can be easily customized through the provision of values to the parameters of the templates. Also SLA templates promote compliance with standards. Non parametric SLA templates are also common in cases where service providers have fixed forms of SLAs and expect their customers to use one of them, rather than embarking on full negotiation.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot
Priority: High
Dependencies: -

Name: REQ-S-06
Property: TOREADOR shall provide a generic high-level language for BDA platform agnostic SLA specification that can be usable by non-expert service providers and service consumers. The high-level SLA specification language of TOREADOR must support the specification of properties and actions identified in REQ-S-01, REQ-S-02 and REQ-S-03, and accommodate the use of SLA property catalogues and SLA templates and be transformable to equivalent BDA platform specific SLAs.
Rationale: A high-level specification language for defining SLAs is important for making the SLA negotiation and agreement process readily accessible to service consumers. The high level SLA specification language of TOREADOR should be transformable to BDA platform specific SLA in order to enable the runtime monitoring and management of the SLAs.
Scope: TOREADOR PLATFORM SLA specification capabilities

Source: Energy pilot
Priority: High
Dependencies: REQ-S-01, REQ-S-02, REQ-S-03, REQ-S-04, REQ-S-05

Name: REQ-S-07
Property: TOREADOR shall provide a reference language for the specification of operational SLAs (i.e., SLAs that can be monitored, managed and actioned) at runtime and the transformation of SLAs expressed in its high-level platform agnostic language into it.
Rationale: High level SLAs that are platform agnostic and oriented towards service consumers are rarely monitorable in their original form and need to be transformed into an operational form that can be monitored. TOREADOR should provide at least one reference operational level language for SLAs.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot
Priority: High
Dependencies: REQ-S-06

Name: REQ-S-08
Property: TOREADOR shall support the transformation of SLAs expressed in its high level language into SLAs that can be monitored and managed on specific targeted BDA platforms selected by the project and the reference operational SLA specification language (REQ-S-06).
Rationale: High level SLAs that are platform agnostic and oriented towards service consumers are rarely monitorable in their original form and need to be transformed into an operational form that can be monitored. This transformation must be supported by the TOREADOR platform and be automated to the maximum possible extent.
Scope: TOREADOR PLATFORM SLA specification capabilities
Source: Energy pilot
Priority: High
Dependencies: REQ-S-06, REQ-S-07

7.3 Requirements regarding SLA negotiation

Currently, the cloud service providers offer pre-defined SLAs that are not negotiable with their customers. This situation is gradually changing due to two reasons: (a) the introduction of new regulations regarding the privacy and security of data held on cloud platforms and the need to be able to demonstrate compliance to them in an auditable manner, and (b) the emergence of small cloud service providers, which in order to compete with large providers, penetrate into the market and obtain a share of it, are willing to offer SLAs customisable to the cloud service consumers needs.
These developments are relevant to the energy production and distribution sector, and, in response to it, we have identified the following requirements in TOREADOR:

Name: REQ-N-01
Property: TOREADOR shall support SLA negotiation over a full continuum of service levels for the guarantee terms defined in SLAs.
Rationale: Often SLA negotiation process may need to be entirely open with regards to the agreeable service levels regarding specific service properties. Typically, this is the case when the service levels required by different service consumers vary significantly and service providers are willing to accommodate such differences.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: Low
Dependencies: -

Name: REQ-N-02
Property: TOREADOR shall support SLA negotiation based on a selection of specific pre-defined SLAs (e.g., bronze, silver, gold).
Rationale: TOREADOR should support SLA negotiation processes where service consumers may only choose SLA from a set of specific pre-defined templates (e.g., “gold”, “silver”, or “bronze” service levels), and not from a full continuum of possible service levels that might not be practically possible or desirable from the perspective of the service provider.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: Medium
Dependencies: -

Name: REQ-N-03
Property: TOREADOR shall support static SLA negotiation, i.e., negotiation of SLAs only prior to the deployment of the BDA service regulated by it.
Rationale: SLA negotiation is often an important step prior to the selection and deployment of a service as a means of regulating service provision.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: High
Dependencies: -

Name: REQ-N-04
Property: TOREADOR shall support dynamic SLA negotiation, i.e., negotiation of SLAs after the deployment and during the provision of the BDA service regulated by it.
Rationale: TOREADOR shall support a dynamic SLA negotiation process, to allow re-negotiation of the terms of an SLA when needed. This may be useful in cases where the BDA service provider might need to be changed dynamically (e.g., migration of service to a different cloud platform) or it becomes clear that an existing SLA cannot be fulfilled. Dynamic SLA negotiation may be triggered by the consumer or the provider(s) of the BDA service.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: Low
Dependencies: -

Name: REQ-N-05
Property: TOREADOR platform shall support automatic SLA negotiations.
Rationale: TOREADOR platform shall support a fully automatic SLA negotiation process, to minimize the human intervention to this process.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: Low
Dependencies: REQ-N-07

Name: REQ-N-06
Property: TOREADOR platform shall support semi-automatic SLA negotiations.
Rationale: TOREADOR platform shall support a semi-automatic SLA negotiation that to allow the participation of human agents representing the parties involved to the negotiation process.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: Medium
Dependencies: REQ-N-07

Name: REQ-N-07
Property: TOREADOR platform shall allow parties to be able to define criteria for SLA negotiation.
Rationale: TOREADOR platform shall allow parties to define criteria and guarantee terms of the SLAs, when using an automated SLA negotiation process, to provide a more flexible and customizable SLA specification.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: High
Dependencies: -

Name: REQ-N-08
Property: TOREADOR platform shall provide criteria for SLA negotiation that can be changed dynamically.
Rationale: TOREADOR platform shall allow the dynamically change of the criteria, to address the dynamic changes that might occur in cloud environments, without the need of re-negotiation of the defined terms.
Scope: TOREADOR PLATFORM SLA negotiation capabilities
Source: Energy pilot
Priority: Medium
Dependencies: -

7.4 Requirements regarding SLA assessment

Name: REQ-A-01
Property: TOREADOR shall support the definition of SLA guarantee terms that can be monitored continually.
Rationale: This is important for ensuring the provision of BDA services in an SLA compliant manner.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Essential
Dependencies: REQ-S-07, REQ-S-08

Name: REQ-A-02
Property: TOREADOR should support the regular inspection of guarantee terms that can only be assessed in this manner.
Rationale: Some SLA guarantee terms cannot be continually monitored and can only be assessed through regular inspection (e.g., the existence of adequate physical protection measures in data centers). TOREADOR should support the conduct and recording of inspection processes.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: High
Dependencies: -

Name: REQ-A-03
Property: TOREADOR shall support the assessment of SLA terms that need to be assessed only by one off inspections.
Rationale: As in REQ-A-02.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: High
Dependencies: -

Name: REQ-A-04
Property: TOREADOR shall support predictive monitoring of SLA guarantee terms, i.e., estimates of the likelihood of having a violation of an SLA guarantee term at some point in the future.
Rationale: Predictive SLA monitoring may be useful for taking prevention or mitigating measures for the relevant violations.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Medium
Dependencies: -

Name: REQ-A-05
Property: TOREADOR shall support the diagnosis of violations of SLA guarantee terms, i.e., the identifications of the reasons underpinning the detected violations.
Rationale: Diagnosis is important as detecting the reason of SLA violations can enable the attribution of responsibility to the entity that should be held responsible for the violation. It is also useful in taking measures that can prevent such violations in the future.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Low
Dependencies: -

Name: REQ-A-06
Property: TOREADOR shall support SLA monitoring for the provider and the consumer of BDA services.
Rationale: This is important because the platform should support the definition of guarantee terms both from the side of the consumer and the provider. In some cases it might not be appropriate to disclose certain information of the provider's infrastructure to the consumer e.g. in a public cloud. In that case the SLA should provide the tools to make that distinction possible and allow the definition of filters as to the lever of granularity of monitoring data that should be disseminated.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Essential
Dependencies: -

Name: REQ-A-07
Property: TOREADOR shall support scalable SLA monitoring.
Rationale: Scalable SLA monitoring is important for dealing with the complexity of individual SLAs and the vast number of SLAs that may be simultaneously operational on the same platform.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Essential
Dependencies: REQ-A-08

Name: REQ-A-08
Property: TOREADOR shall support efficient SLA monitoring, i.e., monitoring which is guaranteed to produce and notify its results within a specific time boundary following the detection of a violation or the confirmation of the satisfaction of an SLA guarantee term.
Rationale: Timely SLA monitoring and notification of its results is essential for the management of SLAs and reactions necessary for addressing deteriorated service levels and restoring them to the required levels.
Scope: TOREADOR PLATFORM SLA assessment capabilities

Source: Energy pilot
Priority: Essential
Dependencies: -

Name: REQ-A-09
Property: TOREADOR shall support the definition of SLAs that determine the acceptable level of intrusiveness of their monitors.
Rationale: This is important because the platform should support the ability to service consumers and providers to make a choice with respect to the level of intrusion of the monitors when performing the monitoring data collection. This allows for a finer level of control as to how the monitor will affect the resources that it monitors. E.g. some business critical services might be more sensitive on how often a monitor might probe them to verify that they are up and running, affecting their overall performance.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Low
Dependencies: -

Name: REQ-A-10
Property: TOREADOR shall support automatically configurable SLA monitoring when SLAs change dynamically and when BDA provision platforms change.
Rationale: This is important because the changes listed in the requirement may be frequent and manual adaptation of the SLA monitoring infrastructure may be costly to perform and/or prevent continuous SLA monitoring.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Medium
Dependencies: -

Name: REQ-A-11
Property: TOREADOR shall support secure SLA monitoring.
Rationale: This is important because the platform should guarantee that the data that is being collected and analyzed by the monitor are stored and communicated in a manner that guarantees basic security properties including confidentiality, integrity, availability and non-repudiation.
Scope: TOREADOR PLATFORM SLA assessment capabilities
Source: Energy pilot
Priority: Essential
Dependencies: -

Name: REQ-A-12
Property: TOREADOR shall support trustworthy SLA monitoring, i.e., monitoring where the trustworthiness of both the primitive monitoring data that are analysed to establish the compliance of BDA service provision with

SLAs and the results of the monitoring process can be assessed and guaranteed.

Rationale: This is important because the platform should guarantee that the data that is collected and analyzed by the monitor can be trusted to be genuine and exhibit the real state of the system that is being monitored. The platform needs to be able to verify if the monitoring data or the monitor itself has not been tampered with in order to ensure the non-repudiation of the monitor's produced results. Untrustworthy monitoring data can lead monitors to draw conclusions that do not reflect the reality, which in turn can result in holding accountable the wrong party in the case of an SLO violation. Finally, it can also let SLO violations to go undetected, which defeats the purpose of monitoring an SLA in the first place.

Scope: TOREADOR PLATFORM SLA assessment capabilities

Source: Energy pilot

Priority: Essential

Dependencies: -

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