



*Smart system of renewable energy storage based on **IN**tegrated **EV**s and **bA**tteries to empower mobile, **D**istributed and centralised **E**nergy storage in the distribution grid*

Deliverable n°:	D8.2
Deliverable name:	Cloud based flexibility management system: Flexibility Cloud, phase 2
Version:	2.0
Release date:	14/06/2018
Dissemination level:	Public
Status:	Approved
Author:	Jon Egil Spetaas, Mark Fisher, Susann Kjellin Eriksen, Hoang Minh Tran, Lasya Priya Kotu, Terje Lundby – eSmart Systems AS



Document history:

Version	Date of issue	Content and changes	Edited by
0.1	27/05/2018	First draft version	Jon Spetaas
1.0	06/06/2018	Draft for review	Jon Spetaas
1.5	14/06/2018	Updated after peer-review	Jon Spetaas, Terje Lundby
2.0	14/06(2018	Final update after peer-review	Jon Spetaas, Terje Lundby

Peer reviewed by:

Partner	Reviewer
NTNU	Magnus Korpås
UPC	Roberto Villafafila

Deliverable beneficiaries:

WP / Task
WP4 / T4.5, T4.6
WP7 / T7.2
WP8 / T8.3, T8.4, T8.5, T8.6
WP9 / T9.4
WP10 / T10.2 – T10.7

Table of contents

Executive summary	6
1 Introduction	7
2 INVADE main processes and their relations	8
3 Functionality	9
3.1 Contract Management	10
3.1.1 Overview	10
3.1.2 Contract Management user stories	13
3.2 Meter values management	22
3.2.1 Overview	22
3.2.2 Receive Meter Values	23
3.3 Events and external information	27
3.3.1 Overview	27
3.3.2 Events and external information user stories	28
3.4 Calculator and scheduling	31
3.4.1 Overview	31
3.4.2 Calculations	35
3.4.3 Schedules	35
3.5 Predictions Management	35
3.5.1 Overview	35
3.5.2 Predictions management user stories	38
3.6 Flexibility Management Optimization	42
3.6.1 Overview	42
3.6.2 Calculate optimal flexibility schedule	46
3.7 Follow up and reporting	48
3.7.1 Overview	48

3.7.2	Follow up and reporting user stories	49
3.8	Control signals management	53
3.8.1	Overview	53
3.8.2	Control signals management user stories	54
4	Integrated INVADE Platform - Web UI	56
4.1	Overview	56
4.2	Security	57
4.2.1	Tenants	57
4.2.2	User configuration	57

Abbreviations and Acronyms

Acronym	Description
API	Application programming interface
B2C	Business to Consumer (security model)
BRP	Balance Responsible Party
DSO	Distribution System Operator
EV	Electric Vehicle
FC	Flexibility Cloud (The platform)
FO	Flexibility Operator
GUID	Global Unique IDentifier
IIP	Integrated INVADE Platform
NA	Not Applicable
PV	Photovoltaic
TBD	To Be Determined
ToU	Time-of-Use
TSO	Transmission System Operator
VAT	Value Added Tax
WP	Work Package

Executive summary

In the INVADE project, a central delivery is the cloud-based Integrated INVADE platform, which will be used by the Flexibility Operator to manage flexibility from flexibility providers and offer this to flexibility customers.

The first version of the Integrated INVADE platform will be delivered in June 2018 and implemented at pilots during the autumn 2018. The fundamental parts of the Integrated INVADE platform, namely the asset management, asset control and data repository, was presented in D8.1. This second delivery will focus on the business intelligence in the Integrated INVADE platform covering Contract management, Meter values management, Events and external information, Calculator and scheduling, Predictions Management, Flexibility optimization management, Follow-up and reporting, and finally describe the Control signals management.

The delivery focuses on the flexibility services offered to a prosumer; ToU optimization, kWmax control and Self-balancing. To support the three flexibility services listed above, each of the above-mentioned platform functionalities are needed. These can be seen as individual processes and the overall platform functionality consist of these processes and their linkage.

A main finding in the document is that all parts of the Integrated INVADE platform must work together to make the complete process work efficiently.

1 Introduction

This document contains the deliverable *D8.2 Cloud based flexibility management system: Flexibility Cloud, phase 2*. The main purpose with the current deliverable is to document the business intelligence part of the Integrated INVADE platform (IIP). The intended audience of the deliverable is mainly the INVADE project partners to whom the implementation of the flexibility management system is relevant.

Together with the the asset management, asset control and data repository presented in D8.1 and the flexibility algorithms presented in D5.3, the deliverable explains the implementation of the first version of the Integrated INVADE platform. The implemented platform software is deliverable D8.3. A second version of the IIP, deliverable D8.5, will be delivered in M26.

The document also builds on the already existing eSmart platform, which was partly developed in the H2020 EMPOWER project, and input from work performed in other INVADE work packages: D4.1, D4.2, D5.3, D7.1 and D10.1.

The rest of this document is organized as follows: Chapter 2 contains an overview of the business processes that the IIP will support. Chapter 3 describes the functionalities covered, while Chapter 4 contains a general description of user interfaces and how security is implemented in the client.

2 INVADE main processes and their relations

The main objective with the IIP is to support the Flexibility Operator (FO) delivering flexibility services from the flexibility vendors (the prosumers) to the flexibility customers. The prevailing overview of which flexibility services that will be tested in the different pilots in the INVADE project, is shown in Table 1. Previous versions have been shown in D4.1 and D4.2, among others. Updated overviews will be shown in later INVADE deliveries when conclusions have been made for the fields marked with TBD.

Flexibility customer	Flexibility services INVADE	Norwegian pilot	Dutch pilots	Bulgarian pilot	German pilot	Spanish pilot
DSO	Congestion management	N	Y	N	Y	Y
	Voltage / Reactive power control	N	Y	N	Y	Y
	Controlled islanding	N	N	N	N	Y
BRP	Day-ahead portfolio optimization	N	Y	TBD	Y	TBD
	Intraday portfolio optimization	N	Y	TBD	Y	Y
	Self-balancing portfolio optimization	N	Y	TBD	Y	Y
Prosumer	ToU optimization	Y	Y	Y	Y	TBD
	kWmax control	Y	Y	Y	Y	TBD
	Self-balancing	Y	Y	Y	Y	TBD
	Controlled islanding	TBD	N	TBD	Y	N

Table 1: Flexibility services to be used in each pilot

Prosumer optimization services; ToU optimization, kWmax control and Self-balancing are the only services that will be covered in this document. DSO and BRP flexibility services will be handled in D8.4.

To support the three flexibility services listed above, a set of *main processes* will be needed in the IIP. Each main process can be seen as a business process or an overall function. Figure 1 shows an overview of the main processes and how they are linked together.

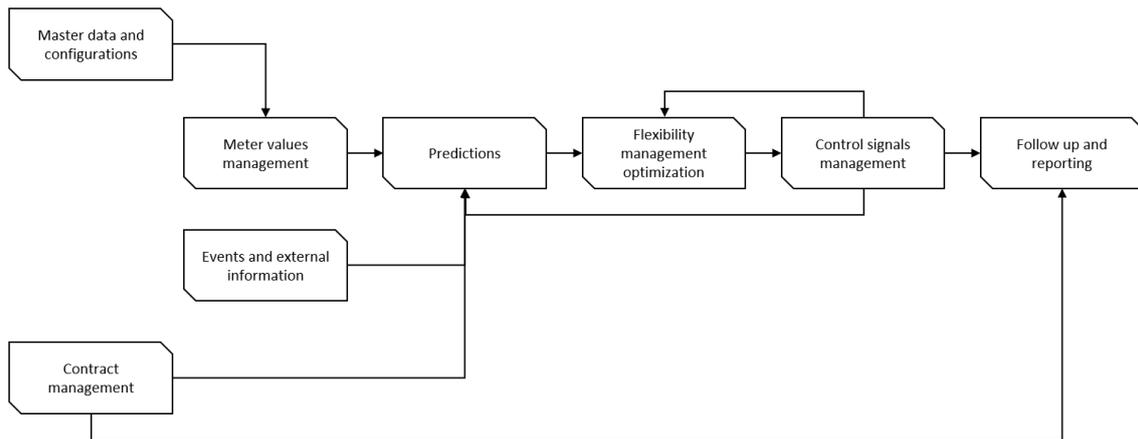


Figure 1. Overview of Flexibility Cloud main processes

Each main process will be further split into sub-processes.

Note that the figure shows all main functions that is covered in D8.1 and D8.2 together. D8.1 contains the main processes Master data and configurations, the rest of the processes are described in this document.

3 Functionality

This chapter describes the functionalities of each of the processes in the IIP.. Each main process is described with an overview, that gives an overall description of the content, including the purpose, the split into sub-processes and, if relevant, a flow chart or sequence diagram. Then, each sub-process is further described according to the following structure:

- Purpose
- Involved roles. Describes which roles (entities, systems and different types of users) that are involved in the user stories.
- Preconditions. Things that must be in place before initiating the process
- Main steps/list of user stories. Defines the steps at an overall level. Also lists the user stories (will be further detailed later)
- User interfaces. Lists user interfaces that are needed to support the functionality

3.1 Contract Management

3.1.1 Overview

In general, a contract is the link between a Contract owner, a Customer, a Contract Product and the customer's Site with all controllable and none controllable assets.

The pilots' flexibility contracts between the FO and the prosumer will be designed as part of WP10, and the development of related business models will be done in WP9. In this section, it is described how a flexibility contract between an FO and a prosumer is configured in the IIP. The configuration of flexibility contracts between the FO and other flexibility buyers will be covered in D8.4.

The links between different data objects in Contract management are described in Figure 2.

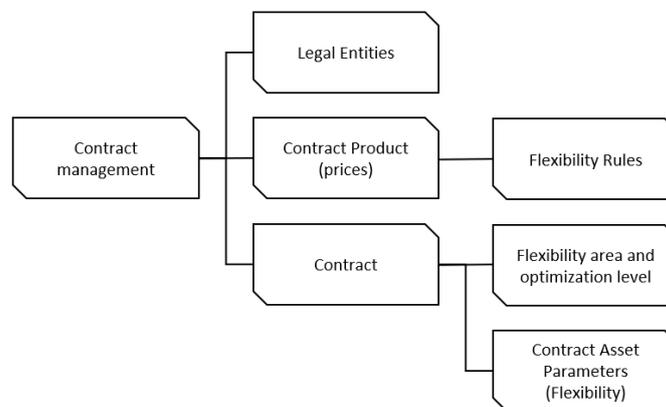


Figure 2: How data is linked in Contract Management

Definitions

Legal Entity is the general term in the IIP defining any partner to a contract. Both the Contract owner and the Contract Customer are legal entities described with different entity roles. We strive to keep the Contract platform as general as possible with any type of legal entity as both contract owner and contract customer. Relevant legal entity types in this delivery are FO and Prosumer. Other legal entity types will be described in D8.4.

Contract Products forms the pricing of the contract. Multiple lines of pricing are possible, and it is the combination of lines that gives the total price for the contract.

A contract product has a series of properties for the operator to choose from. These properties enable the operator to make elements for pricing of energy contract, grid contract and flexibility contract.

The Prosumer Optimization contract (in this document referred to as Flexibility Contract) may have Contract Product elements from energy and grid contracts as parameters for optimization when no energy or grid contract is to be settled with the FO.

Some pricing examples:

- Energy contract elements
 - Variable consumption and Spot price with mark-up – energy consumption
 - Variable production and Spot price with multiplier – surplus energy delivered back to the grid
 - Fixed monthly fee
- Grid contract elements
 - Variable consumption and Fixed fee per kWh – energy fee
 - Variable tiered consumption and fixed fee – subscribed energy and overconsumption
 - Max Consumption and variable fee – demand charge tariff calculated from the hour with the highest energy per month
- Flexibility contract
 - Fixed monthly fee – FO charge of prosumer optimization

Flexibility Rules describes overall parameters for optimization. The set of flexibility rules regulates how, when and how often the optimization should be executed. Flexibility Rules are defined on the Contract Product which may be used for several contracts. Thus, a limited number of these configurations are required.

The parameters are:

- Resolution – Time resolution for the results from optimization algorithm
- Optimization Frequency – How often is the optimization executed
- Optimization Horizon in Resolution intervals – How long is the optimization planning ahead
- Optimization History in Resolution intervals – How long is the history basis for optimization
- Optimization Seed Time in Minutes – How long before the next regulating time interval is the optimization executed

- Optimization Strategy – In IIP version 1, Prosumer Optimization is the only choice of optimization strategy. Additional alternatives will be added for DSO and BRP optimization in IIP version 2.

Contract - Types sets the definition of what parameters are required on a contract. Energy, Grid, Service and Flexibility forms the main types of contract.

The Contract types are:

- Energy Contract - Retail and other types of trade with energy between any two legal entities. For prosumer this contract will have elements of prices and taxes for both purchase of energy and sales of surplus energy back to the grid.
- Grid Contract – Contract between any legal entity and DSO. For prosumer this contract type will have elements of prices and taxes with DSO.
- Service Contract – In use when FO sells or buys commodities and services. This contract type will be calculated as part of the settlement in IIP version 2. The contract type does not influence optimization.
- Prosumer Optimization - Flexibility services contract between FO and prosumer. Connect the prosumer to its sites and resources with parameters required for optimization.

Additional contract types will be defined and explained in D8.4.

Flexibility area and optimization level describes what level in the asset topology level the contract covers and what level is optimized. An example is a contract that regulate a prosumer site (flexibility area) and optimizes on site level (optimization level). Another example is the large scale public parking where the same contract parameters are valid for all the postal codes (defined as a flexibility area of all postal codes) and the contract is optimized per postal code. Each postal code will be defined as a site (optimization level) with all the EV charge points connected to it.

Contract Assets is a set of default parameters for each type of controllable and non-controllable assets within the flexibility area of the contract. These defaults may be updated for the specific contract or for single assets and stored to the contract asset repository.

3.1.2 Contract Management user stories

3.1.2.1 Purpose

The purpose of this process is to enter, update and remove information about a contract, legal entities, a contract product and the parameters required for optimizing the contracts flexibility.

3.1.2.2 Involved roles

The user stories involve a FO user role.

3.1.2.3 Preconditions and Assumptions

Relevant input data must be ready at pre-defined format.

3.1.2.4 Main Steps/List of user stories

New information will be entered manually by FO user. The process will typically be like this:

1. The FO negotiate all necessary parameters with the Contract partner.
2. The FO opens a screen and enters the parameters
3. The parameters are validated and stored

The following user stories are covered:

1. Enter new Legal entity
2. Update Legal entity
3. Remove Legal entity
4. Reinstate deleted Legal entity
5. Enter new Contract Product
6. Update Contract Product with Energy and Grid prices
7. Remove Contract Product
8. Reinstate deleted Contract Product
9. Enter new Contract
10. Update Contract
11. Remove Contract

12. Reinstate deleted Contract

3.1.2.5 Enter new Legal Entity

Purpose

The purpose of this process is to enter a new Legal Entity as a Prosumer in the system

Description

As an operator of the system I want to be able to

- Add a new Legal Entity with all required information.
- Mark the Legal Entity with the role Prosumer.

Roles

FO configures a new prosumer into the system.

Preconditions and Assumptions

Relevant information about Prosumer is available

Acceptance Criteria

New Legal Entity marked as Prosumer ready for Contract for flexibility for its site.

3.1.2.6 Update Legal Entity

Purpose

To capture amendments to a Legal Entity

Description

As an operator of the system I want to be able to

- Locate the Legal Entity via a set of search criteria.
- Amend the stored Legal Entity address and connected roles.

Roles

FO reconfigures, enhances the definition of a Legal Entity in the system.

Preconditions and Assumptions

Relevant information about legal entity is available.

Acceptance Criteria

Legal Entity is stored with new properties.

3.1.2.7 Remove Legal Entity**Purpose**

To indicate a Legal Entity is deleted.

Note: the system will only tag entities as deleted in the system. This will restrict them from being shown in the UI unless the user sets a system option to Show Deleted data.

Description

As an operator of the system I want to be able to

- Locate the Legal Entity via a set of search criteria.
- Mark the Legal Entity as deleted (by setting its entity status to Deleted).

Roles

FO decides when a Legal Entity is to be marked as deleted.

Preconditions and Assumptions

No valid contract with the Legal Entity.

Acceptance Criteria

Legal Entity is stored with entity status of Deleted.

3.1.2.8 Reinstate deleted Legal Entity**Purpose**

To indicate a Legal Entity is Active.

Note: the system will only tag entities as deleted in the system. This will restrict them from being shown in the UI unless the user sets a system option to Show Deleted data.

If a Legal Entity has been deleted due to an error, it can easily be reactivated via this user story.

Description

As an operator of the system I want to be able to

- Locate the Legal Entity to be reinstated via a set of search criteria (that includes the retrieval of deleted areas).
- Mark the Legal Entity as Active (by Setting its entity status to active).
- When reactivating a Legal Entity, the normal validation that is applied on adding/editing an area will be verified.

Roles

FO decides if to reactive a Legal Entity.

Preconditions and Assumptions

None

Acceptance Criteria

On supply of valid data, the Legal Entity is persisted to the systems data repository (with entity status Active), else get an appropriate error message.

3.1.2.9 Enter new Contract Product

Purpose

The purpose of this process is to enter a new Contract Product to use for flexibility contracts.

Description

As an operator of the system I want to be able to

- Add a new Contract Product for prosumer optimization.
- Add the required Contract Product elements.
- Add the Flexibility rules for the set of contracts which this Contract Product will be used.

Roles

FO configures a new Contract Product into the system.

Preconditions and Assumptions

Relevant information about Contract Product is available.

Acceptance Criteria

New Contract Product for use in prosumer flexibility contract is stored to the system.

3.1.2.10 Update Contract Product with Energy and Grid prices**Purpose**

To capture additional Contract Product elements for Energy and Grid prices to a Contract Product.

Description

As an operator of the system I want to be able to

- Locate the Contract Product via a set of search criteria.
- Amend Contract Product with elements of Energy and Grid price properties.

Roles

FO reconfigures, enhances the definition of a Contract Product in the system.

Preconditions and Assumptions

Relevant information about Energy and Grid contract with prosumer is available.

Acceptance Criteria

Contract Product is stored with new Contract Product elements.

3.1.2.11 Remove Contract Product**Purpose**

To indicate a Contract Product is deleted.

Note: the system will only tag entities as deleted in the system. This will restrict them from being shown in the UI unless the user sets a system option to Show Deleted data.

Description

As an operator of the system I want to be able to

- Locate the Contract Product via a set of search criteria.
- Mark the Contract Product as deleted (by setting its entity status to Deleted).

Roles

FO decides when a Contract Product is to be marked as deleted, additionally they have the option to phase out the use of a Contract Product by setting its valid from and to dates as an alternative.

Preconditions and Assumptions

No valid contract with prosumers using the Contract Product.

Acceptance Criteria

Contract Product is stored with entity status of Deleted.

3.1.2.12 Reinstate deleted Contract Product

Purpose

To indicate a Contract Product is Active.

Note: the system will only tag entities as deleted in the system. This will restrict them from being shown in the UI unless the user sets a system option to Show Deleted data. If a Contract Product has been deleted in error, it can easily be reactivated via this user story.

Description

As an operator of the system I want to be able to

- Locate the Contract Product to be reinstated via a set of search criteria (that includes the retrieval of deleted areas).
- Mark the Contract Product as Active (by Setting its entity status to active).

- When reactivating a Contract Product, the normal validation that is applied on adding/editing an area will be verified.

Roles

FO decides if to reactive a Contract Product.

Preconditions and Assumptions

None

Acceptance Criteria

On supply of valid data, the Contract Product is persisted to the systems data repository (with entity status Active), else get an appropriate error message.

3.1.2.13 Enter new Contract***Purpose***

The purpose of this process is to enter a new flexibility contract and all required parameters.

Description

As an operator of the system I want to be able to

- Add a new Contract for prosumer optimization
- Have the Contract Asset defaults added to the Contract

Roles

FO configures a new Contract into the system.

Preconditions and Assumptions

Relevant information for the flexibility contract have been negotiated with the prosumer.

Acceptance Criteria

New flexibility contract is stored to the system.

3.1.2.14 Update Contract

Purpose

To capture specific Contract Asset parameters to a flexibility contract.

Description

As an operator of the system I want to be able to

- Locate the Contract via a set of search criteria.
- Amend a Contract Asset default with parameters specific for this prosumer to the Contract.

Roles

FO reconfigures, enhances the definition of a Contract in the system.

Preconditions and Assumptions

Relevant information about prosumers Contract Assets is available.

Acceptance Criteria

Contract is stored with new Contract Asset parameters.

3.1.2.15 Remove Contract

Purpose

To indicate a Contract is deleted.

Note: the system will only tag entities as deleted in the system. This will restrict them from being shown in the UI unless the user sets a system option to Show Deleted data.

Description

As an operator of the system I want to be able to

- Locate the Contract via a set of search criteria.
- Mark the Contract as deleted (by setting its entity status to Deleted).

Roles

FO decides when a Contract is to be marked as deleted, additionally they have the option to phase out the use of a Contract by setting its valid from and to dates as an alternative.

Preconditions and Assumptions

None

Acceptance Criteria

Contract is stored with entity status of Deleted.

3.1.2.16 Reinstate deleted Contract**Purpose**

To indicate a Contract is Active.

Note: the system will only tag entities as deleted in the system. This will restrict them from being shown in the UI unless the user sets a system option to Show Deleted data. If a Contract has been deleted in error it can easily be reactivated via this user story.

Description

As an operator of the system I want to be able to

- Locate the Contract to be reinstated via a set of search criteria (that includes the retrieval of deleted areas).
- Mark the Contract as Active (by Setting its entity status to active).
- When reactivating a Contract, the normal validation that is applied on adding/editing an area will be verified.

Roles

FO decides if to reactive a Contract.

Preconditions and Assumptions

None

Acceptance Criteria

On supply of valid data, the Contract is persisted to the systems data repository (with entity status Active), else get an appropriate error message.

3.1.2.17 User interfaces

User interface	Short description
Legal Entity	Provides a single screen for the management of Legal Entities (create, update, delete and undelete)
Contract Product	Provides a single screen for the management of Contract Product (create, update, delete and undelete), including <ul style="list-style-type: none"> ▪ its properties ▪ its entity status (Active, deleted) ▪ its flexibility parameters to contract optimization
Contract	Provides a single screen for the management of Contract (create, update, delete and undelete), including <ul style="list-style-type: none"> ▪ its properties ▪ its entity status (Active, deleted) ▪ its parameters to Contract Assets

3.2 Meter values management

3.2.1 Overview

Meter values are imported through API methods described in D7.2 Specification of the CP-API, either as meter readings or energy values and stored to assets in the form of time series.

Meter readings may be received with unstructured or unaligned time stamps. On arrival the readings are first aligned to fixed time resolution of 15 minute. Any missing values in intervals between meter readings will be estimated by interpolating between the existing values.

The delta between meter readings are then calculated and stored as the energy consumed or produced in the time interval. Values received as different phases will be aggregated to one energy value for the resource.

The main process is split into sub-processes as illustrated in Figure 3.

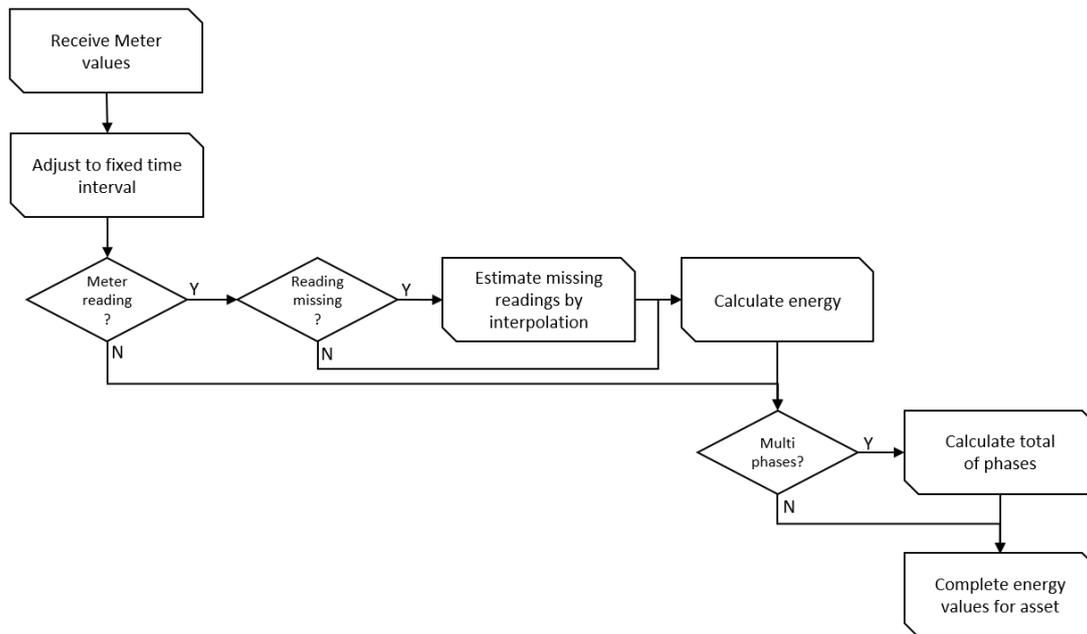


Figure 3. Main process and sub-processes for Meter values management

3.2.2 Receive Meter Values

3.2.2.1 Purpose

The purpose of this process is to handle values imported to resources, transformation to energy in usable time segments and estimation of missing values.

3.2.2.2 Involved roles

All processes are automated and hence involve only system roles.

3.2.2.3 Preconditions

The input-data that are going to be input must be ready at a pre-defined format.

3.2.2.4 Main steps/list of user stories

The automated process of receiving meter values will be like this:

1. An external System or FO (outside the IIP) sends all necessary parameters for meter values.
2. The external System or FO calls the IIP Data Management API providing meter values to an asset or list of assets and all necessary parameters to save the meter values.
3. The meter value and it's time stamp are validated and stored.

4. The system returns to the caller details about the data saved and any error information related to the supplied meter values if the meter value could not be stored.

The following user stories are covered:

1. Receive meter values as energy values and align to fixed time intervals.
2. Receive meter values as meter reading.
3. Receive meter values as 3 phased meter readings.
4. Receive meter values as energy values when value in previous time segment is missing.

3.2.2.5 Receive meter values as energy values and align to fixed time intervals

Purpose

To capture new energy values, or updates to existing energy values, when values are received with start time and end time different from the time series fixed time intervals.

Description

As a supplier of meter values of the system I want to be able to

- Align meter values to fixed time intervals
- Add or update energy values to a prosumer resource

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

The prosumer resource and its topology have already been defined in the system.

Acceptance Criteria

On supply of valid data, the energy values are stored to the systems time series repository.

3.2.2.6 Receive meter values as meter reading

Purpose

To capture new energy values or updates to existing energy values from meter readings.

Description

As a supplier of meter values of the system I want to be able to

- Add or update energy values to a prosumer resource as delta from meter readings.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

The prosumer resource and its topology have already been defined in the system.

Acceptance Criteria

On supply of valid data, the energy values are calculated as delta from current and previous meter reading and stored to the systems time series repository.

3.2.2.7 Receive meter values as 3 phased meter readings

Purpose

To capture new energy values or updates to existing energy values from 3 phased meter readings.

Description

As a supplier of meter values of the system I want to be able to

- Add or update energy values to a prosumer resource calculated as the delta for each of the three phases.
- Add or update energy values to a prosumer as the sum of energy for the three phases.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

The prosumer resource and its topology have already been defined in the system.

Acceptance Criteria

On supply of valid data, the energy values are calculated as delta from current and previous meter reading and stored to the systems time series repository for each of the three phases, and total energy as a sum of the three phases.

3.2.2.8 Receive meter values as energy values when value in previous time segment is missing**Purpose**

To capture new energy values or updates to existing energy values as an interpolation between current and previous value.

Description

As a supplier of meter values of the system I want to be able to

- Add or update energy values to a prosumer resource as an interpolation between current and last known value when previous energy values are missing.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

The prosumer resource and its topology have already been defined in the system.

Acceptance Criteria

On supply of valid data, the energy values are calculated as delta from current and last known energy value and stored to the systems time series repository.

3.3 Events and external information

3.3.1 Overview

The purpose with Events and external information is to capture additional data as parameters for predictions and optimization. Weather, prices and charge point connections are imported for IIP version 1, but additional parameters may easily be added later. Charge point meter values are imported in Meter Values Management, but the derived status saying that a charger is connected is treated as an event and thus, described in this section.

Weather data is requested from third-party supplier of weather services as observations and forecasts. Weather observation history is, together with resource asset energy values history, used for training predictions models. This trained model is then, together with weather forecasts, used for prediction of future energy values to resource assets.

Weather observations and forecasts include:

- Temperature
- Wind speed
- Wind direction
- Cloudiness

Prices are imported from the pilots or as a request from a third-party supplier of day ahead prices. Additional prices may have to be added in IIP version 2.

Third-party data is requested on a configurable schedule. E.g. on the 5th minute of every 15 minute. In IIP version 1 the schedules are configured by eSmart. Typically, the day ahead prices will be requested once a day, but the weather information will be requested on a schedule with higher frequency, e.g. every hour or every 15 minutes. These schedules are configurable per system tenant and will be discussed with each pilot separately.

Charge point connection history is a status time series derived from the arrival of Charge point energy values. Charge points will deliver values when a charger is connected to an EV and values will be blank when a charger is not connected. Status will have the value 1 when charge point is connected and the value 0 when not connected.

When new information is stored to the above-mentioned time series the prediction service for that series will be triggered automatically.

The process is illustrated in Figure 4.

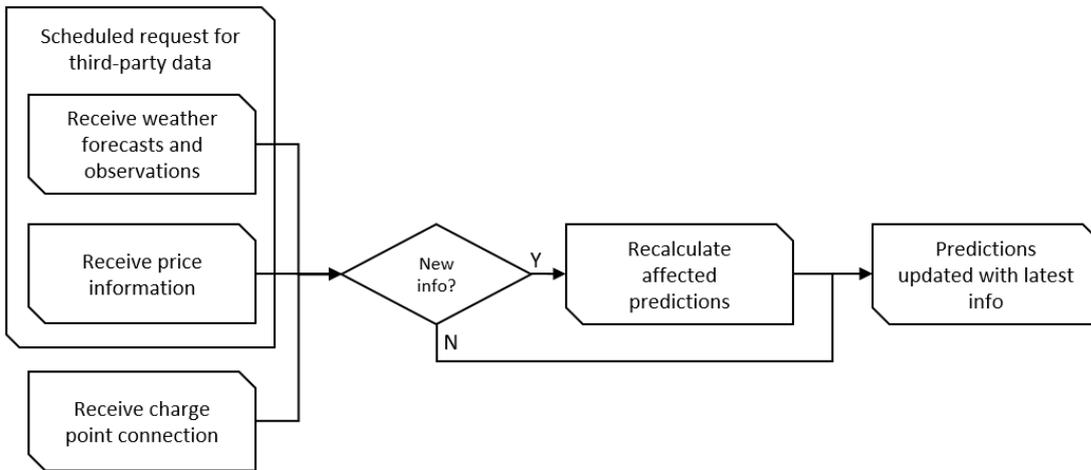


Figure 4: Events and external information process

3.3.2 Events and external information user stories

3.3.2.1 Purpose

The purpose of this process is to handle values imported as weather in the form of forecasts and observations, prices and to derive charge point status from charge point energy values.

3.3.2.2 Involved roles

All processes are automated and hence involve only system roles.

3.3.2.3 Preconditions

The input-data must be ready at a pre-defined format.

End points for suppliers of third-party data is configured and ready for scheduled requests.

3.3.2.4 Main steps/list of user stories

The automated process of requesting third-party data will be like this:

1. A schedule triggers a request for third-party data when the specified time in the series of fixed time intervals occur.
2. The System requests data from the third-party system from a configured end point in the correct format.

3. The external data elements and time stamps are validated and stored to the correct time series in the system.

The process of charge point status derived from arrival of charge point energy values will be like this:

1. A charge point delivers energy values, as described in section 3.2.2 Receive Meter Values.
2. Charge points status will be stored with the value 1 when an energy value exists on the charge point energy values time series, and the value 0 if the energy value does not exist.

The following user stories are covered:

1. Scheduled request for weather observations and forecasts.
2. Scheduled request for day ahead prices.
3. Derive charge point status from charge point energy values.

3.3.2.5 Scheduled request for weather observations and forecasts

Purpose

To capture new weather observations and forecasts from third-party supplier of weather services.

Description

As an FO I want the system to

- Request weather observations and forecasts to the system.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

End points for suppliers of third-party data is configured and ready for scheduled requests.

Acceptance Criteria

Weather observations and forecasts are stored to the system's time series repository.

3.3.2.6 Scheduled request for day ahead prices

Purpose

To capture new day ahead prices from third-party supplier of day ahead prices.

Description

As an FO I want the system to

- Request weather observations and forecasts to the system.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

End points for suppliers of third-party data is configured and ready for scheduled requests.

Acceptance Criteria

Day ahead prices are stored to the system's time series repository.

3.3.2.7 Derive charge point status from charge point energy values

Purpose

To derive charge point status from charge point energy values as input to charge point predictions.

Description

As an FO I want the system to

- Derive charge point status from charge point energy values as input to charge point predictions.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

New energy values for charge point have arrived in the system.

Acceptance Criteria

Charge point status is stored to the system's time series repository.

3.4 Calculator and scheduling

3.4.1 Overview

This section describes how to support IIP processes with calculations and schedules.

In general, all arriving values stored to time series will trigger a mechanism starting any dependent calculations.

Some processes are time dependent and will be triggered at specified intervals.

3.4.1.1 Calculations

All transformation, alignment, aggregation or events to time series values are made by calculations. Main types of calculations are:

- Delta derived as energy between current and previous meter reading.
 - Any missing meter time interval in between two existing readings will be estimated by interpolating the existing values.
- Observation time will be aligned to fixed intervals
- Accumulated sub-meters to resource. E.g. 3 phased meter readings
- Prediction service triggered by new values via prediction model. Models are described in 3.5 Predictions Management.

Each type of time series can have a list of calculation linked. The calculation meta data for a time series type will contain:

- QueueName
- ResultTimeSeriesType
- ResultTimeSeriesResolution

When a value is imported or stored to the time series repository, the change will trigger the new value to put an item in the specified queue(s) defined in the time series type.

In IIP version 1 these configurations are setup by eSmart. More calculations will be added in IIP version 2.

The main process is split into sub-processes as illustrated in Figure 5.

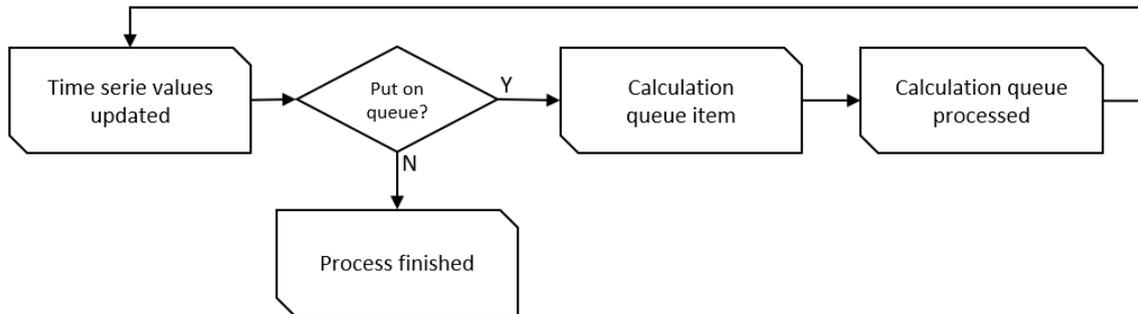


Figure 5. Main process of calculations to updated time series values

The calculations required in IIP version 1 are listed in **Error! Reference source not found.**

Source time series type	Queue Name	Result time series type	Via Model (for predictions)
Consumption Meter Reading	DeltaFromMeterReading	Consumption	
Production Meter Reading	DeltaFromMeterReading	Production	
Consumption	AccumulateTimeSeries	Net Energy	
Production	AccumulateTimeSeries	Net Energy	
Energy Level Meter Reading	ConvertTimeSeriesToResolution	Energy Level	
Charging Meter Reading	DeltaFrom MeterReading	Charging Energy	
Discharging Meter Reading	DeltaFromMeterReading	Discharging Energy	
Consumption Phase1 Meter Reading	DeltaFromMeterReading	Consumption Phase1	
Consumption Phase2 Meter Reading	DeltaFromMeterReading	Consumption Phase2	

Consumption Phase3 Meter Reading	DeltaFromMeterReading	Consumption Phase3	
Charging Meter Reading	DeltaFromMeterReading	Charging Energy	
Production Phase1 Meter Reading	DeltaFromMeterReading	Production Phase1	
Production Phase2 Meter Reading	DeltaFromMeterReading	Production Phase2	
Production Phase3 Meter Reading	DeltaFromMeterReading	Production Phase3	
Charging Phase1 Meter Reading	DeltaFromMeterReading	Charging Energy Phase1	
Charging Phase2 Meter Reading	DeltaFromMeterReading	Charging Energy Phase2	
Charging Phase3 Meter Reading	DeltaFromMeterReading	Charging Energy Phase3	
Discharging Phase1 Meter Reading	DeltaFromMeterReading	Discharging Energy Phase1	
Discharging Phase2 Meter Reading	DeltaFromMeterReading	Discharging Energy Phase2	
Discharging Phase3 Meter Reading	DeltaFromMeterReading	Discharging Energy Phase3	
Discharging Meter Reading	DeltaFromMeterReading	Discharging Energy	
Consumption Phase1	AccumulateTimeSeries	Consumption	
Consumption Phase2	AccumulateTimeSeries	Consumption	
Consumption Phase3	AccumulateTimeSeries	Consumption	
Production Phase1	AccumulateTimeSeries	Production	
Production Phase2	AccumulateTimeSeries	Production	
Production Phase3	AccumulateTimeSeries	Production	
Discharging Energy Phase1	AccumulateTimeSeries	Discharging Energy	

Discharging Energy Phase2	AccumulateTimeSeries	Discharging Energy	
Discharging Energy Phase3	AccumulateTimeSeries	Discharging Energy	
Charging Energy Phase1	AccumulateTimeSeries	Charging Energy	
Charging Energy Phase2	AccumulateTimeSeries	Charging Energy	
Charging Energy Phase3	AccumulateTimeSeries	Charging Energy	
Consumption	ModelForecast	Forecasted Consumption	Via Model
Production	ModelForecast	Forecasted Production	Via Model
Charging Energy	ModelForecast	Forecasted Charging Energy	Via Model
Charging Energy	ModelForecast	Forecasted Charging Point State	Via Model
Charging Point State	ModelForecast	Forecasted Charging Point State	Via Model
Spot Price	ModelForecast	Forecasted Spot Price	Via Model

Table 2: List of calculations in the IIP version 1

3.4.1.2 Schedules

A schedule is a triggering mechanism which fire at pre-defined times at pre-defined time intervals. Frequency and Time in the interval are configurable and may be altered for each pilot individually. In IIP version 1 these configurations are setup by eSmart.

All schedules are mentioned in other processes but are listed in Table 3.

Process	Frequency	Time in the interval
Request weather forecast and observations	Every hour	Start of hour
Request day ahead prices	Every day	When prices are available. Usually around 13:00
Prediction model training	Every day	At 00:00 (midnight)
Optimization service	Every 15 minutes	10 minutes before the regulating period starts.

Table 3 - Processes triggered by schedule

3.4.2 Calculations

Calculation user stories are described in other sections in this delivery:

- 4
- Receive meter values as energy values and align to fixed time intervals
- 3.2.2.6 Receive meter values as meter reading
- 3.2.2.7 Receive meter values as 3 phased meter readings
- 3.2.2.8 Receive meter values as energy values when value in previous time segment is missing.

3.4.3 Schedules

Schedule user stories are described in other sections in this delivery:

- 3.5.2.5 Schedule training of prediction model
- 3.3.2.5 Scheduled request for weather observations and forecasts
- 3.3.2.6 Scheduled request for day ahead prices
- 3.6.2.5 Calculate optimal flexibility schedule

3.5 Predictions Management

3.5.1 Overview

The IIP prediction service has two separate services for training prediction models and calculate predictions. The main aim is to develop a generic training and prediction service for each appliance group.

The Prediction model training uses full history of metered values and weather, while the prediction service uses shorter history along with the trained models.

The main process of predictions management is split into sub-processes in Figure 6.

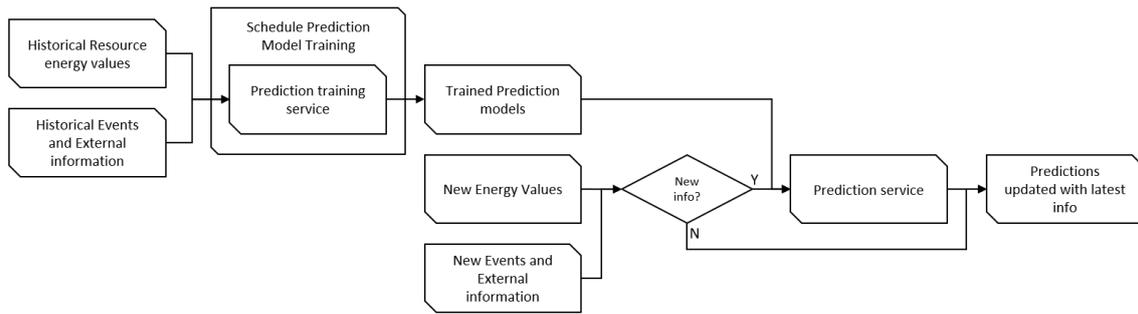


Figure 6: Predictions Management overview

3.5.1.1 Prediction training service

Prediction models are trained using sci-kit learn library available in python on a Kubernetes cluster built on Azure platform. Training and prediction web services are developed for each resource group. As the training process takes more time, it is done offline on scheduled time intervals. The prediction models need to be retrained periodically.

3.5.1.2 Prediction service

In the IIP version 1 all predictions will be triggered event-based when new values are imported to the metered time series. The input to the data-driven techniques are the features extracted from the historical data. The machine learning models predict the future values from input time series. Each resource group needs different features combinations for making predictions. The feature combinations are selected after analyzing the load consumption/generation times series.

3.5.1.3 Prediction and training input data

The prevailing parameters for training and prediction services for all the assets present in all the pilot areas, and the output time series from each model, is described in Table 4. This list will however be refined during the project.

Source	Input time series	Output time series
None controllable consumption	None controllable consumption Charge Point Status GUID of the nearest weather station Temperature Windspeed Wind Direction Cloudiness	Predicted none controllable consumption
Charge Point status	Consumption Charge Point Status GUID of the nearest weather station Temperature Windspeed Wind Direction Cloudiness	Predicted Charge Point Status (connect and disconnect times)
Electric vehicle	Consumption Charge Point Status GUID of the nearest weather station Temperature Windspeed Wind Direction Cloudiness	Predicted Consumption (required charging)
Generation	Production GUID of the nearest weather station Temperature Windspeed Wind Direction Cloudiness	Predicted Production
Load (Electric space heating and water heaters)	Consumption GUID of the nearest weather station Temperature Windspeed Wind Direction Cloudiness	Predicted Consumption

Table 4 - Input and output parameters to prediction service

3.5.2 Predictions management user stories

3.5.2.1 Purpose

The purpose of this process is to train the prediction models and recalculate affected predictions based on new energy values or events and external information.

3.5.2.2 Involved roles

All processes are automated and hence involve only system roles.

3.5.2.3 Preconditions

Historical Resource energy values and historical Events and external information exists.

Prediction model training schedule is configured in the system.

New energy values or Events and external information are received.

3.5.2.4 Main steps/list of user stories

The automated process of training prediction models will be like this:

1. A schedule triggers the model training service with the correct parameters for the specified model.
2. The prediction model training service runs the training process from updated input values to the model.
3. The trained model is stored to the prediction model Azure blob storage.

The automated process of recalculating affected predictions is like this:

1. New values to Energy values and Events and external information will trigger the prediction service for the relevant resource.
2. The recalculated prediction is returned from the prediction service and stored to the correct time series in the system.

The following user stories are covered:

1. Schedule training of prediction model.
2. Calculate Load prediction for water heater prediction.
3. Calculate PV prediction.
4. Calculate Charge point status prediction.
5. Calculate None controllable consumption.

3.5.2.5 Schedule training of prediction model

Purpose

To train prediction model as basis for predictions.

Description

As an FO I want the system to

- Train prediction model on configured time intervals.

Roles

The IIP

Preconditions and Assumptions

Historical Resource energy values and historical Events and external information exists.

Prediction model training schedule is configured in the system.

Acceptance Criteria

Trained prediction model stored to the prediction service Azure blob storage.

3.5.2.6 Calculate None controllable consumption prediction

Purpose

To calculate None controllable consumption prediction as basis for Flexibility Optimization.

Description

As an FO I want the system to

- Trigger calculation of None controllable consumption prediction from the arrival of new energy values.
- Prediction service returns the calculated None controllable consumption prediction.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

Required parameters to the prediction model of None controllable consumption all have values.

Acceptance Criteria

None controllable consumption predicted values are stored to the systems time series repository.

3.5.2.7 Calculate PV prediction**Purpose**

To calculate PV prediction as basis for Flexibility Optimization.

Description

As an FO I want the system to

- Trigger calculation of PV prediction from the arrival of new energy values.
- Prediction service returns the calculated PV prediction.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

Required parameters to the prediction model of PV all have values.

Acceptance Criteria

PV predicted values are stored to the systems time series repository.

3.5.2.8 Calculate Charge point status prediction**Purpose**

To calculate Charge point prediction as basis for Flexibility Optimization.

Description

As an FO I want the system to

- Trigger calculation of Charge point prediction from the arrival of new energy values.
- Prediction service returns the calculated Charge point prediction.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

Required parameters to the prediction model of Charge point all have values.

Acceptance Criteria

Charge point values are stored to the systems time series repository.

3.5.2.9 Calculate Load prediction for water heater**Purpose**

To calculate Load prediction for water heater as basis for Flexibility Optimization.

Description

As an FO I want the system to

- Trigger calculation of Load prediction for water heater from the arrival of new energy values.
- Prediction service returns the calculated Load prediction for water heater.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

Required parameters to the prediction model of Load prediction for water heater all have values.

Acceptance Criteria

Load prediction for water heater values are stored to the systems time series repository.

3.6 Flexibility Management Optimization

3.6.1 Overview

The optimization models are developed as part of T5.4 and integrated as a part of the optimization service in the IIP. The optimization service is designed to handle the flexibility services at prosumer level in the first version of the IIP. In IIP version 2, the Balance responsible party (BRP) and DSO flexibility services will also be handled. The service is developed in Python and use Pyomo package developed by Sandia Lab to build optimization model. The optimization model is then solved using standard solvers such as open source GLPK or commercial Gurobi. The optimization service is expected to trigger every 15 minutes (time-based triggering) and require the inputs explained in detailed in section 3.6.1.1.

The main process is split into sub-processes as illustrated in Figure 7.

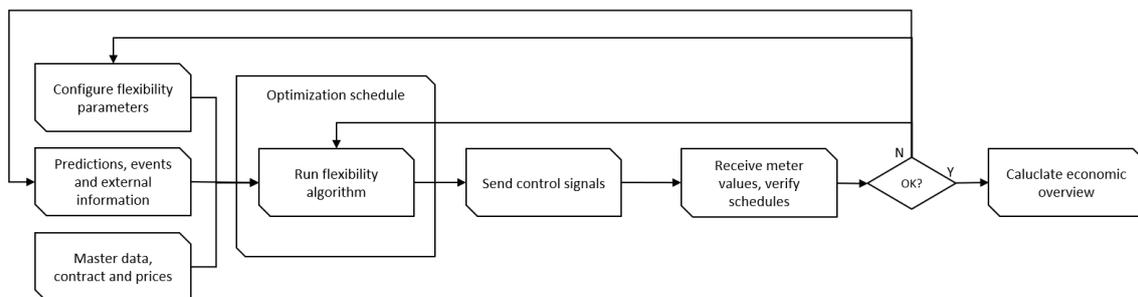


Figure 7: Flexibility Management Optimization process

The output of the optimization service gives a control schedule for configured horizon and intervals for all the flexible devices present in the site and for the whole site. In the Netherlands pilot, an optimal EV charging capacity will be returned in levels where a capacity constraint is sent as parameter to the optimization service. ElaadNL and Greenflux will then distribute the charging between individual charging points within the limits set by the optimal EV charging capacity

The optimization for DSO and BRP will be exposed through separate APIs in IIP version 2.

3.6.1.1 Optimization input parameters

In this section, the input parameters required for the optimization service are listed. The required input parameters are divided into five categories: predictions data, metered data, fixed technical characteristics, flexibility contracts and contract prices.

Parameter name	Unit	Description
Predictions Data		
Generation (PV panels)	kWh	Predicted production
Load (water heaters, space heating)	kWh	Predicted consumption
Charging (EV)	kWh	Predicted consumption
Charge point status	Int	Predicted status
Inflexible load	kWh	Predicted site total consumption – (minus) Predicted total of flexible devices consumption
Metered Data		
Generation (PV panels)	kWh	Received meter data
Load (water heaters, space heating)	kWh	Received meter data
Charging (EV)	kWh	Received meter data
Charge point status	kWh	Received meter data
Charge point status	Int	Derived from received meter data
Inflexible load	kWh	Site total consumption - (minus) flexible devices consumption
Battery	kWh	Received state of Charge
Fixed Technical Characteristics		
Generation (PV panels)		
InstalledMaxCapacity	kWh	Max production from resource
Load (water heaters, space heating)		
InstalledMaxCapacity	kWh	Max consumption in resource
Charging (EV)		
InstalledMaxCapacity	kWh	Max consumption in resource
Battery technical parameter sheet		

MaximumChargingPower	kW	Maximum charging power allowed for battery
MaximumDischargingPower	kW	Maximum discharging power allowed for battery
maxCapacity	kWh	Maximum state of charge allowed for battery
minCapacity	kWh	Minimum state of charge allowed for battery
EfficiencyOfCharging	p.u.	Efficiency parameter for charging storage unit
EfficiencyOfDischarging	p.u.	Efficiency parameter for discharging storage unit
ThresholdCharge	p.u.	Threshold in battery unit b charging process
ThresholdDischarge	p.u.	Threshold in battery unit b discharging process
ThresholdStoredEndPH	p.u.	Threshold in battery unit b of stored energy at the end of the planning horizon
Battery economical parameter sheet		
CostCharging	€/kWh	Technical parameter from the battery manual
CostDischarging	€/kWh	Technical parameter from the battery manual
Flexibility contracts		
Generation (PV panels)		
ActivationFeeNoneWorkdays /ActivationFeeWorkdays	€/NOK	Price of reducing generation output of the unit
MaxActivationTime	Minutes	Max activation time for resource
RestTime	Minutes	Minimum rest time between activations
MaxNumberOfActivations	Times per day	Max number of Activations per day
Load (space heating, water heaters)		
ActivationFeeNoneWorkdays /ActivationFeeWorkdays	€/NOK	Price for disconnecting the load unit
MaxActivationTime	Minutes	Max activation time for resource
RestTime	Minutes	Minimum rest time between activations
MaxNumberOfActivations	Times per day	Max number of Activations per day

Charging (EV)		
ActivationFeeNoneWorkdays /ActivationFeeWorkdays	€/NOK	Price for disconnecting the load unit
MaxActivationTime	Minutes	Max activation time for resource
RestTime	Minutes	Minimum rest time between activations
MaxNumberOfActivations	Times per day	Max number of Activations per day
Battery technical parameter		
ActivationFeeNoneWorkdays /ActivationFeeWorkdays	€/NOK	Price for disconnecting the load unit
MaxActivationTime	Minutes	Max activation time for resource
RestTime	Minutes	Minimum rest time between activations
MaxNumberOfActivations	Times per day	Max number of Activations per day
Prices		
Retail Buy (imported spot prices)	€/kWh	Price at energy part of retail contract for buying electricity in period
Retail Sell (imported spot prices)	€/kWh	Price at energy part of retail contract for selling electricity in period
Retail Buy (predicted spot prices)	€/kWh	Predicted price at energy part of retail contract for buying electricity in period
Retail Sell (predicted spot prices)	€/kWh	Predicted price at energy part of retail contract for selling electricity in period
Grid Sell	€/kWh	Price at energy part of grid contract for selling electricity in period t
Grid Buy	€/kWh	Price at energy part of grid contract for buying electricity in period t
Grid Buy Low	€/kWh	Price at energy part of grid contract for buying electricity in cases with subscribed power in period if bought electricity is below subscribed level

Grid Buy High	€/kWh	Price at energy part of grid contract for buying electricity in cases with subscribed power in period if bought electricity is above subscribed level
Capacity Constraint Consumption	kW	Maximum import capacity. If given as parameter it will trigger the calculation of optimal capacity constraint as the sum of charge point schedules in the flexibility area.
Capacity Constraint Production	kW	Maximum export capacity
Tax	€/kWh	Sum price for all taxes that are related to buying electricity in period
VAT	p.u.	Parameter that adds Value Added Tax to the amount bought
Grid Buy Peak	€/kW/month	Price at grid contract for peak fee
Grid Buy Low - Volume Limit	kW	Limitation of basis for peak fee
Optimization Frequency	#	Periods per hour

Table 5: Optimization Management input parameters

Updates may have to be made to the list of parameters in later deliveries, both for additional parameters and changes to existing.

3.6.2 Calculate optimal flexibility schedule

3.6.2.1 Purpose

The purpose of this process is to generate an optimal flexibility schedule and an optimal capacity regulation schedule for the Netherlands pilot.

3.6.2.2 Involved roles

All processes are automated and hence involve only system roles.

3.6.2.3 Preconditions

Historical Resource energy values and historical Events and external information exists.

Predicted energy values and charge point status exists.

Flexibility contract, contract product and contract asset parameters exist.

3.6.2.4 Main steps/list of user stories

The automated process of prosumer optimization will be like this:

1. A schedule triggers the optimization service with the correct parameters for each of the flexibility areas.
2. The optimization service calculates an optimal flexibility schedule and an optimal capacity regulation schedule.
3. The calculated schedules are returned from the optimization service and stored to the correct time series in the system.

The following user stories are covered:

1. Calculate optimal flexibility schedule.
2. Calculate optimal flexibility schedule and optimal capacity schedule.

3.6.2.5 Calculate optimal flexibility schedule

Purpose

To calculate an optimal flexibility schedule for the resources at a prosumer site.

Description

As an FO I want the system to

- Trigger optimization service at a scheduled time.
- Store the optimization schedule to time series.

Roles

The IIP.

Preconditions and Assumptions

Required parameters to the optimization service exists.

Acceptance Criteria

Optimal flexibility schedule stored to the systems time series repository.

3.6.2.6 Calculate optimal flexibility schedule and optimal capacity schedule

Purpose

To calculate an optimal flexibility schedule and an optimal capacity schedule for the resources at a prosumer site.

Description

As an FO I want the system to

- Trigger optimization service at a scheduled time.
- Store the optimal flexibility schedule and the optimal capacity schedule to time series.

Roles

The IIP.

Preconditions and Assumptions

Required parameters to the optimization service exists.

Capacity constraint exists as input parameter to the optimization service.

Acceptance Criteria

Optimal flexibility schedule and optimal capacity schedule are stored to the systems time series repository.

3.7 Follow up and reporting

3.7.1 Overview

This section will describe in general the follow up and reporting of base time series and calculated time series in the IIP. Base time series includes the received meter values for prosumer resources and charge point status, in addition to the requested weather and prices described in section 3.2 Meter values management. Calculated time series include results from IIP calculations, prediction services and flexibility optimization.

A set of search criteria enables the user to combine energy, predictions, flexibility schedules to make overview of the status of the optimization process with a prosumer.

Data may be viewed as a chart or as meter values in numbers for a single resource or all the resources and areas connected to a site. Meter values may even be edited by user with sufficient access.

The links between different data objects in Follow up and reporting is described in Figure 8.

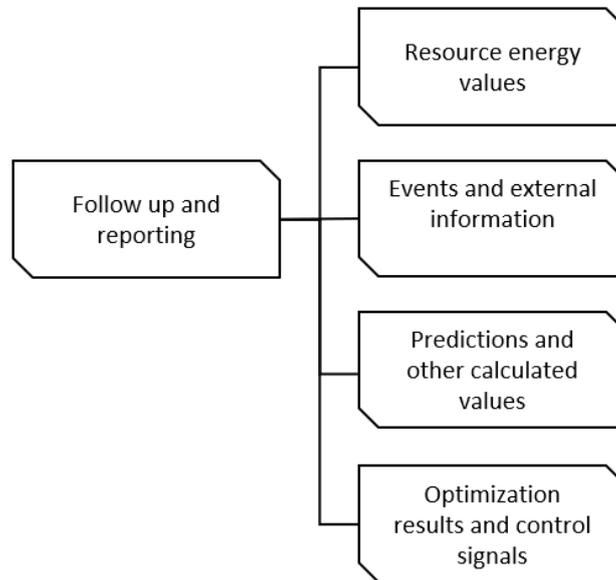


Figure 8: How data is linked in the Value Reporting screen

3.7.2 Follow up and reporting user stories

3.7.2.1 Purpose

The purpose of this process is to view and if necessary edit, all the time series values involved in the process of prosumer flexibility in the IIP.

3.7.2.2 Involved roles

FO follow up on time series values.

3.7.2.3 Preconditions

Resources, sites and areas are defined in the system and relevant time series in each topology level have been imported or calculated.

Predictions are calculated.

Flexibility optimization have been executed.

3.7.2.4 Main steps/list of user stories

The manual process of follow up in value reporting will be like this:

1. The FO opens the Value Reporting UI and enters search criteria.
2. The FO chooses to view the values in a chart view or as meter values as numbers.

The following user stories are covered:

1. View time series as chart and values for a Charge point.
2. View time series as chart and values for a Site.
3. Edit time series values for estimated energy values for a resource.
4. View multiple time series as chart for the optimization process for a prosumer.

3.7.2.5 View time series as chart and values for a Charge point

Purpose

To examine all time series of a Charge point as a manual validation of imported energy values, predictions and the optimization schedule.

Description

As an operator of the system I want the system to

- Enter search criteria for a specific charge point.
- View all time series values for a prosumers charge point.

Roles

FO examine the time series values of a charge point.

Preconditions and Assumptions

Charge point and its connection to flexibility area is defined in the system.

Charge point energy value and status time series exist in the system.

Charge point predictions and optimization schedule exist in the system.

Acceptance Criteria

Charge point time series are presented in the system.

3.7.2.6 View time series as chart and values for a Site

Purpose

To examine time series of a Site as a manual validation of aggregated values to the site.

Description

As an operator of the system I want the system to

- Enter search criteria for a specific site.
- View time series values for the site.

Roles

FO examine the time series values of a site.

Preconditions and Assumptions

Site and connected resources are defined in the system.

Site time aggregated time series exist in the system.

Acceptance Criteria

Site time series are presented in the system.

3.7.2.7 Edit time series values for estimated energy values for a resource

Purpose

To update estimated energy values when a time interval has been missing.

Description

As an operator of the system I want to

- Enter search criteria for a specific resource.
- Update energy values to replace estimated values.

Roles

FO updates estimated energy values.

Preconditions and Assumptions

Energy values have been estimated as a result of missing previous value when receiving new energy values.

Acceptance Criteria

Estimated energy values have been replaced manually and stored to the systems time series repository.

3.7.2.8 View multiple time series as chart for the optimization process for a prosumer**Purpose**

To investigate the status of the optimization process at a prosumer site.

Description

As an operator of the system I want to

- Enter search criteria for a prosumer site.
- Investigate the meter values, predictions and optimization schedules in a combined view.

Roles

FO investigates the optimization process.

Preconditions and Assumptions

Prosumer site and flexibility contract and all parameters are defined in the system.

Predictions have been calculated.

Optimization service have returned optimization schedules for the prosumer site.

Acceptance Criteria

FO have an overview of the optimization process at the prosumer site.

3.7.2.9 User interfaces

User interface	Short description
Value Reporting	Provides a single screen for presentation of time series in the system as chart or value numbers. Search criteria must be entered as filter for required data.

3.8 Control signals management

3.8.1 Overview

The purpose with Control signals management is to determine where and how to send the optimized schedule generated by the optimization management. The process is triggered at specified times by the Control signal management schedule.

End points will be configured for each pilot company specifying the input to the pilot system.

Control signals management have three main types of messages. These are:

- Asset Control On/Off message – for resources having controllable type OnOff
- Control Regulation Message – for resources having controllable type Continuous
- Optimal Capacity Regulation Message – for flexibility areas providing capacity constraint as input to optimization

The management system at pilot sites have the responsibility to execute the schedules to the resources according to the received schedules.

The main process is split into sub-processes as illustrated in Figure 9.

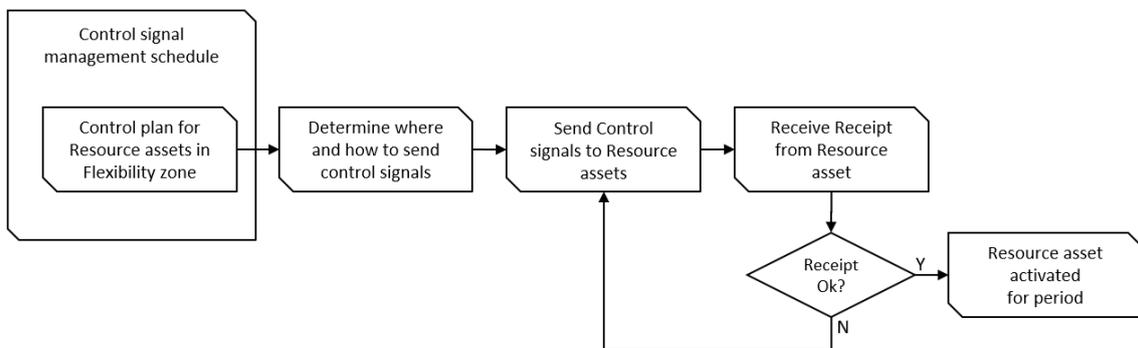


Figure 9. Main process and sub-processes for Control signals management

3.8.2 Control signals management user stories

3.8.2.1 Purpose

The purpose of this process is to send control signals and schedules to end points defined in the system.

3.8.2.2 Involved roles

All processes are automated and hence involve only system roles.

3.8.2.3 Preconditions

Optimal flexibility schedule and optimal capacity schedule exists.

Flexibility resources and areas have end points defined in the system.

3.8.2.4 Main steps/list of user stories

The automated process of control signals management will be like this:

1. A schedule triggers the control signal management.
2. The end point parameters are fetched from the tenant configuration.
4. Optimal schedules are sent at the defined format to the pilot system.

The following user stories are covered:

1. Send optimal flexibility schedule to the pilot system.
2. Send optimal capacity schedule to the pilot system.

3.8.2.5 Send optimal flexibility schedule to the pilot system

Purpose

To send the optimal flexibility schedule to the pilot system.

Description

As a system integrator want the system to

- Call the pilot system with an optimized flexibility schedule.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

Optimal flexibility schedule exists.

Flexibility resources and areas have end points defined in the system.

Acceptance Criteria

Optimal flexibility schedule is received and stored in the pilot system.

3.8.2.6 Send optimal capacity schedule to the pilot system**Purpose**

To send the optimal capacity schedule to the pilot system.

Description

As a system integrator want the system to

- Call the pilot system with an optimized capacity schedule.

Roles

Fully automated process, only system roles involved.

Preconditions and Assumptions

Optimal capacity schedule exists.

Flexibility resources and areas have end points defined in the system.

Acceptance Criteria

Optimal capacity schedule is received and stored in the pilot system.

4 Integrated INVADE Platform - Web UI

4.1 Overview

All user interfaces in the IIP are released as one common installation for all pilots and is accessed from a web browser with a URL provided by eSmart. Google Chrome have been selected as the preferred browser. Thus, all users should have this browser available and strive to update regularly to latest version.

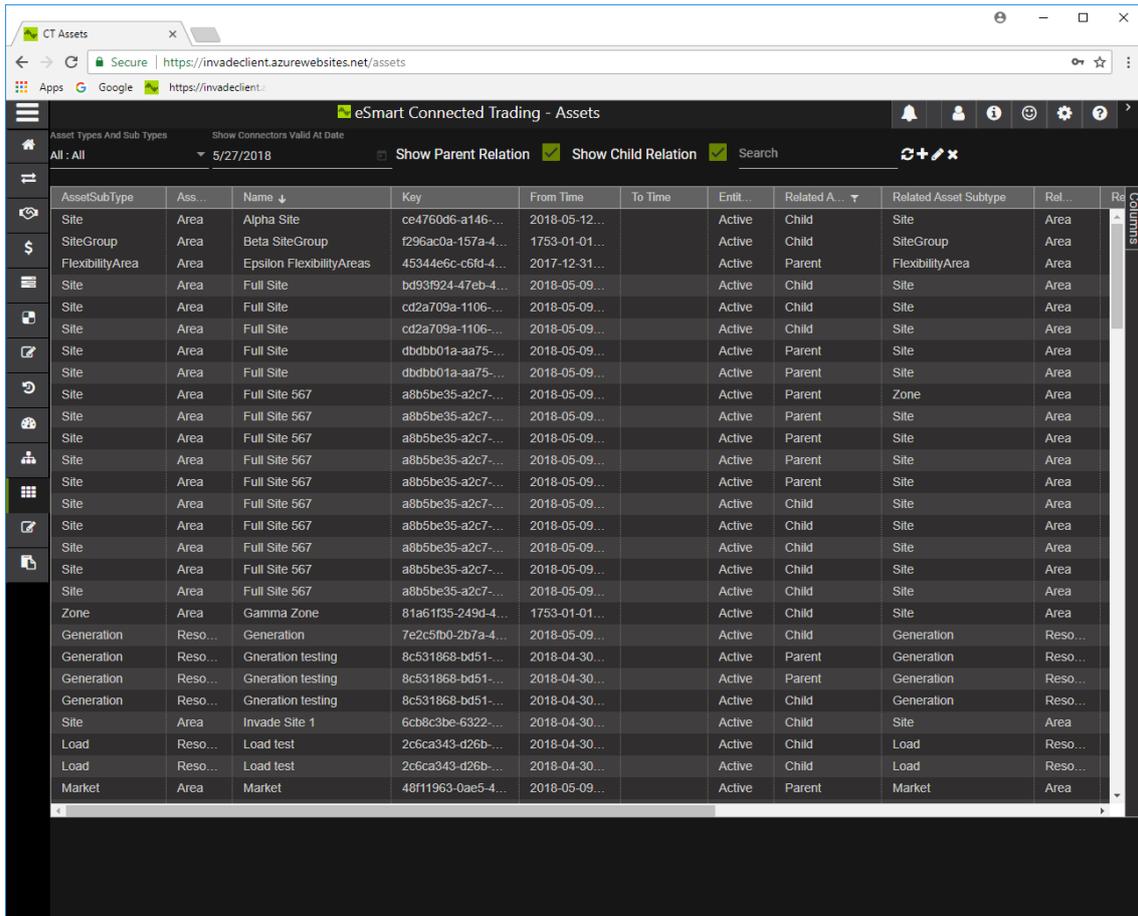


Figure 10 – Example IIP screen: UI where assets can be configured.

New version will be installed by eSmart to maintain compatibility between client and data repositories.

4.2 Security

4.2.1 Tenants

Each pilot will be setup as a separate tenant in Microsoft Azure to ensure no data is visible across pilot companies. GreenFlux and ElaadNL will be setup with separate tenants since these are separate companies within the Netherland pilot.

4.2.2 User configuration

Login to the IIP is handled with Microsoft Azure Active Directory B2C security.

Pilots will be asked for a list of users containing name and a valid e-mail address, per company. User name could be an anonymous user code to maintain user anonymity which could be completed with a matching anonymous e-mail address.

Users will be configured by eSmart in IIP version 1.

The first time a user logs in with the provided password, he or she will be asked to change password.

Login screen will look like this:

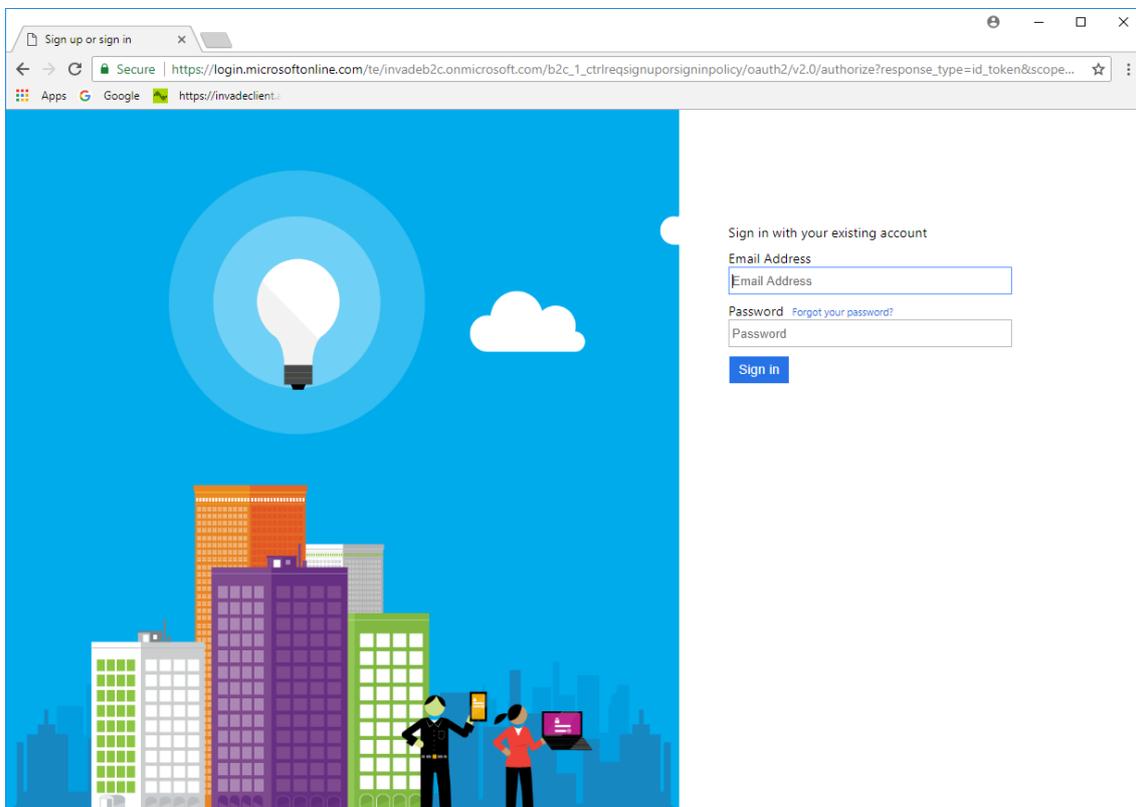


Figure 11 - B2C login screen