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Subject: **FLECH Fundamental Demonstration Platform Documentation**

Contents

1 Scope and Content

The purpose of this document is to describe the interactions between FLECH and participants and the implementation of FLECH. The aim of this document is to provide guidance to partners implementing FLECH clients and provide an overview of the implementation of the FLECH platform.

The following services are candidates to be included in this document. Depending on the need these will be added when the need arises.

Service	**State**	**Report describing the service**
PowerMax	Included in this version	FLECH PowerMax Service Requirement Specification, September 12, 2014
PowerCutPlanned		FLECH – Technical Requirement Specification, October 11, 2013
PowerCap		FLECH Power Cap Service Requirement Specification, May 12, 2014
FastFrequenceReserve		FLECH TSO Service – Fast Frequence Reserve, June 27, 2014

Table 1. List of potential services in FLECH.

The document is structured into a first part that describes the use-cases of FLECH with a separate section on each service and into a second part that explain the actual implementation.

2 Basic Use Cases

This section lists use-cases that describe how buyers of flexibility create a new market and how sellers place offers. Whenever the actor field of a use-case lists 'participant', it refers to either a buyer or a seller.

2.1 Participant Authentication

Name	Use-Case Participant Authentication
Description	Authenticates a participant at the FLECH. The participant's credentials are verified against the information stored at the FLECH's user database. FLECH checks whether the participant is allowed to send a message of this type depending on his role.
Actors	FLECH, Participant
Pre-Condition	
Post-Condition	• If the authentication succeeds, the message is approved to be processed by FLECH.
Trigger	A new message arrived at FLECH
Basic Flow	1. A participant includes his credentials in the request sent to FLECH. 2. In case of a failed authentication, no further processing of the request will be done.
Alternate Flow	
Comments	This process is invoked whenever a new message arrives at the FLECH and the information necessary for authentication is part of every message.

3 PowerMax – Use Cases

This section lists use-cases that describe the communication process depicted in figure 2 between buyers of flexibility, sellers of flexibility and the clearing house (FLECH) in more detail. Whenever the actor field of a use-case lists 'participant', it refers to either a buyer or a seller.

3.1 Open Market

Name	Use-Case Open Market
Description	To reserve a reduction in maximum power in the future, a DSO opens a new market in FLECH. All participants are informed by FLECH that a new market is opened.
Actors	Buyer, FLECH, Seller
Pre-Condition	• Successful Participant Authentication
Post-Condition	• FLECH has stored the information for the market and notified all the participants. • The buyer that opened the market has been notified about the success/failure of opening the market.
Trigger	Buyer demand
Basic Flow	1. The Buyer sends a request to FLECH specifying the new market and conditions. 2. All participants receive a notification with all information necessary to place offers, including market ID. 3. The Buyer receives an acknowledgement with the status and market ID of the new market.
Alternate Flow	• If opening the capacity market is not possible, the Buyer receives a negative acknowledgement and no sellers are notified.
Comments	

3.2 Placing Offer

Name	Use-Case Placing Offer
Description	For an open market sellers can submit any number of offers.
Actors	Seller, FLECH
Pre-Condition	• Successful Participant Authentication • An existing market has been opened by a buyer and the seller has been informed about the conditions and the market ID.
Post-Condition	• The FLECH has stored the information for the offer. • The seller that placed the offer has been notified about the success/failure of the placement.
Trigger	Available flexibility of an aggregator after a new market has been opened.

Basic Flow	1. The Seller submits an offer to FLECH. 2. FLECH acknowledges the offer with the status.
Alternate Flow	
Comments	

3.3 Close Market

Name	Use-Case Close Market
Description	The market closes and FLECH clears the market by selecting the minimum cost combination of offers based on the desired volume and other pre-conditions of the market.
Actors	FLECH, Seller, Buyer
Pre-Condition	• An existing open market
Post-Condition	• The market is closed and is not accepting any more offers. • The buyer has been informed about the offers that got accepted and therefore bought by the buyer. • The sellers know if their offers got accepted or rejected. • Information on acceptance/rejection is stored in FLECH for future use.
Trigger	Trigger at the time when the market is scheduled to close.
Basic Flow	1. After the closing time FLECH acknowledge incoming offers with the information that the market is closed. 2. FLECH requests and receives historical data for all offers from the Buyer 3. FLECH verifies that the offer corresponds to the baseline determined from meter data. 4. FLECH clears the market and labels all offers with accept or reject. 5. Sellers are notified with the status of their offer 6. The Buyer is notified with the details of the accepted offers.
Alternate Flow	
Comments	

3.4 Activation

Name	Use-Case Activation
Description	The Buyer and the Sellers that have accepted offers are notified about the delivery
Actors	Buyer, FLECH, Seller
Pre-Condition	• At least one accepted offer for a market
Post-Condition	• Buyer and Sellers have received a notification that activation is expected.
Trigger	Time trigger based on conditions set in the market opening phase

Basic Flow	1. FLECH informs Buyer and Seller about expected activation
Alternate Flow	
Comments	This use-case is not necessary and can be seen as redundant. The Buyer and Sellers are informed at market closing and should be aware that activation is expected.

3.5 Settlement of Market

Name	Use-Case Settlement of Capacity Reservation Market
Description	The necessary information to settle the market is collected by FLECH and information of invoices and payments are communicated to the participants
Actors	Buyer, FLECH, Sellers (with accepted offers)
Pre-Condition	• An existing market reservation period has passed
Post-Condition	• Buyer and Seller have the information about payments and invoices
Trigger	Triggered after market period has passed
Basic Flow	1. Request to get historical meter data is sent from FLECH to the Buyer 2. Buyer provides historical meter data for all accepted offers 3. FLECH determines if each accepted offer has been successfully delivered 4. Payment information is sent to Sellers with accepted and delivered offers 5. Invoice information is sent to Buyer 6. Buyer confirms that invoice has been received and paid
Alternate Flow	
Comments	

5 General Implementation

The implementation of FLECH to handle the use-cases described in the previous section uses message based communication between participants and FLECH. The messaging is handled using a message broker that is available with a public URL to both FLECH and the participants. The components in the system are shown in Figure 1. The message broker relays messages between FLECH and the participants. The FLECH Message Handler handles all the messages sent by the participants and broadcasts notification events. The FLECH HTTP Server includes a public user interface where participants can see relevant information about their markets and offers. Both the Message Handler and the HTTP Server share a common database where information is stored.

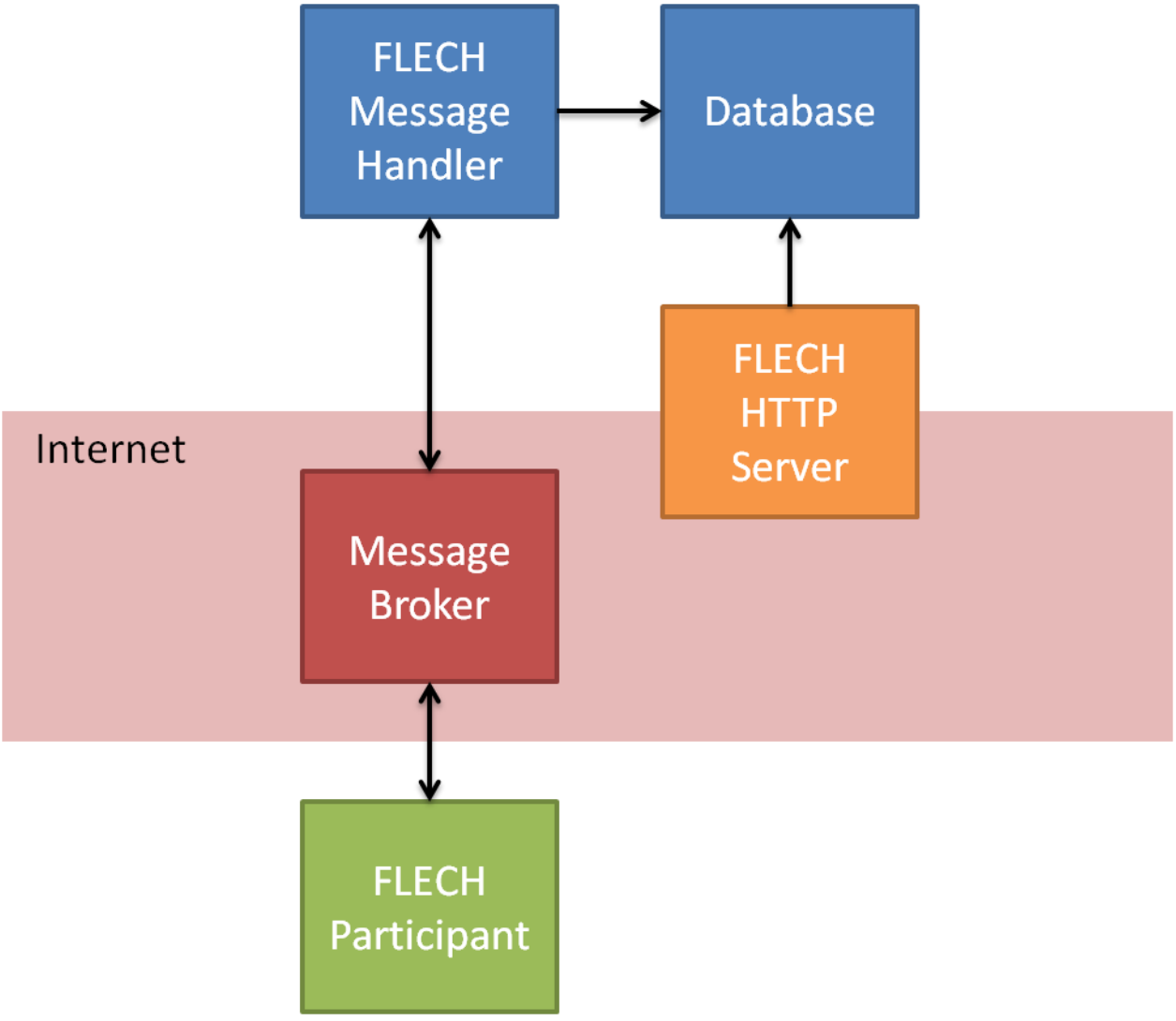


Figure 1. Components of the FLECH implementation

5.1 Messaging

FLECH relies on the Java Messaging Service (JMS) which the Message Broker implementation also supports. JMS can also be used with non-Java clients such as .NET and information and tutorials are available online.

5.1.1 Sequences

The communication between FLECH and the participants can be separated into three different types. The first type is a request by participant that is sent to FLECH. If the participant is authorized a response is created in FLECH and sent only to the participant that sent the request.

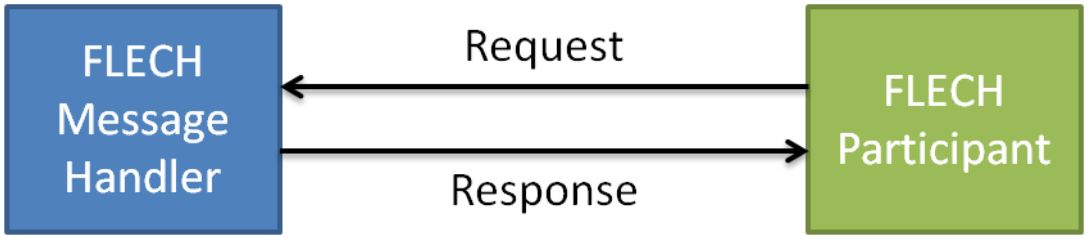


Figure 2. Request by participant to FLECH.

The second type is a request by FLECH that is sent to an individual participant. This request must be handled by the participant and a response is expected by FLECH. To handle failing participants the request will be repeated for a fixed number of times and if no response is supplied within a certain time the participant will be considered unable to participate. Consequences of such failures are not the scope of this document.

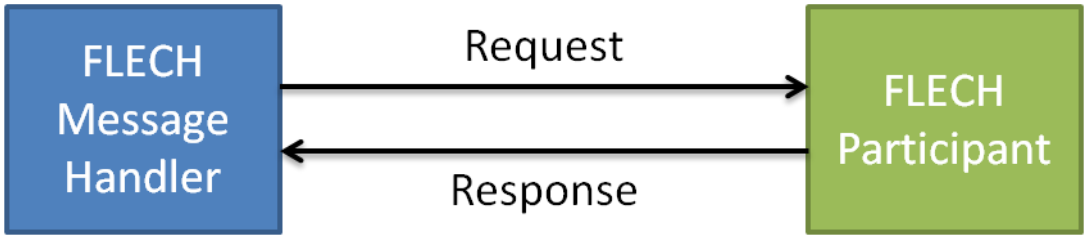


Figure 3. Request by FLECH to participant.

The third type of sequence is a notification by FLECH that is sent to one or more participants. There is no response expected in this sequence and the message is only an information message.

Figure 4. Notification by FLECH to one or more participants.

5.1.2 Topics and Queues

There are three main destinations that are relevant for a participant. The first is the FLECH request queue. This is the queue where participants place requests to FLECH. Participants have write access to this queue but no read access since it is only FLECH that is authorized to de-queue such requests. The second destination is the individual participant request queue. This is the queue where FLECH places requests to the individual participant. Each participant has its own unique queue and the participant has read access to this queue. A response by FLECH to a request by a participant is placed on the participant's individual queue. A response by a participant to a request by FLECH is assumed to be sent on FLECH's incoming queue. The third destination is the publish/subscribe topic that is used by FLECH to broadcast notifications to all participants. Participants are required to subscribe to this topic. Figure 5 shows these three destinations in detail.

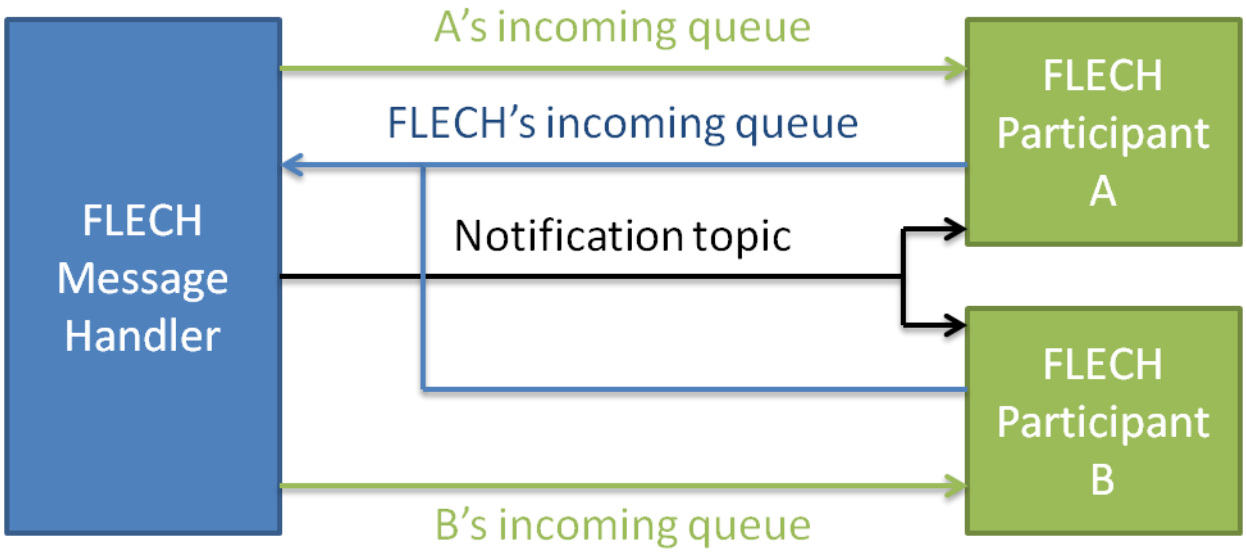


Figure 5. An example of the three different destinations that are used in the communication between FLECH and a single participant.

5.1.3 Formats

The body of the text messages should contain a JSON object. In addition to the types available for JSON the implementation uses additional types to represent certain information. The full list of types used in the messages is shown in Table 2.

Type	Field format / available values	Example
STRING		"this is a string"
FLOAT		10.0
INTEGER		10
BOOLEAN		true

TOD (time of day)	"yyyy-MM-ddTHH:mm:ss.SSSZ"	"2014-08-01T00:00:00.000Z"
TIME (time)	"HH:mm:ss.SSS"	"14:00:00.000"

TODPERIOD (time of day period)	{
	"from": "HH:mm:ss.SSS",
	"to": "HH:mm:ss.SSS"
	}
		{
		"from":"14:00:00.000",
		"to":"16:00:00.000"
		}

TIMEPERIOD (time period)	{
	"from": "yyyy-MM-ddTHH:mm:ss.SSSZ",
	"to": "yyyy-MM-ddTHH:mm:ss.SSSZ"
	}
		{
		"from":"2014-08-01T00:00:00.000Z",
		"to":"2014-08-31T23:59:59.999Z"
		}

METERVALUE (meter value, the unit is assumed to be kWh)	{
	"time": "yyyy-MM-ddTHH:mm:ss.SSSZ",
	"value": FLOAT
	}
		{
		"time": "2014-08-01T00:00:00.000Z",
		"value": 1000.0
		}

STATUS (status values)	"SUCCESS" | "FAILURE" | "DUPLICATE"	"SUCCESS"

Table 2. Formats and types in the JSON objects for the body of the messages.

5.1.4 FLECH Acknowledgements

Requests sent by participants are always acknowledged. Such requests can be to open a new market or placing a new offer. An acknowledgement sent from FLECH always contains two fields: a status code and a human readable message. Table 3 shows the mandatory fields in an response to a request sent to FLECH.

Field description	Field name	Field type
The status of the request, where DUPLICATE indicates that the request has already been handled by FLECH	status	STATUS
A human readable message that can provide more information about the request handling.	message	STRING

Table 3. Mandatory fields in responses created by FLECH to a request by a participant.

5.2 Security

Secure communication is crucial for the security of the whole system. Secure Sockets Layer (SSL) secures the JMS communication from the participants and the FLECH to the broker. While the broker has to be available from the internet, the FLECH server, Participant and the database can operate from a subnet that is not accessible directly from the internet. The Message Broker has its own access control and participants needs to have appropriate credentials to send and receive messages from the message broker.

6 Basic Use-Case Implementation

This section shows the implementation of the basic use-cases in section 2.

6.1 Participant Authentication

All messages that are sent by participants to FLECH must contain the FLECH credentials as part of the message headers/properties.

Description	Header name	Header value	Header type
FLECH username	user	(your FLECH username)	String
FLECH password	password	(your FLECH password)	String

Table 4. The message headers that are mandatory when communicating with FLECH

7 PowerMax – Use-Case Implementation

This section shows the implementation of the basic use-cases in section 3. Figure 6 shows a schematic view of the time periods for the services. The open market request is sent at 1, only offers that are placed between 2 and 3 are considered in the clearing of the market, the assets behind accepted offers are reserved in the period between 4 and 8 and activated daily for the period defined as 5 and 6. The settlement sequence starts at 8 when the reservation period expoires.

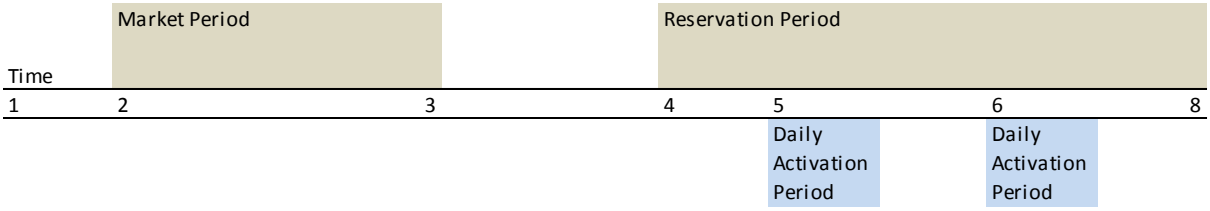


Figure 6. Timeline of a typical market lifetime.

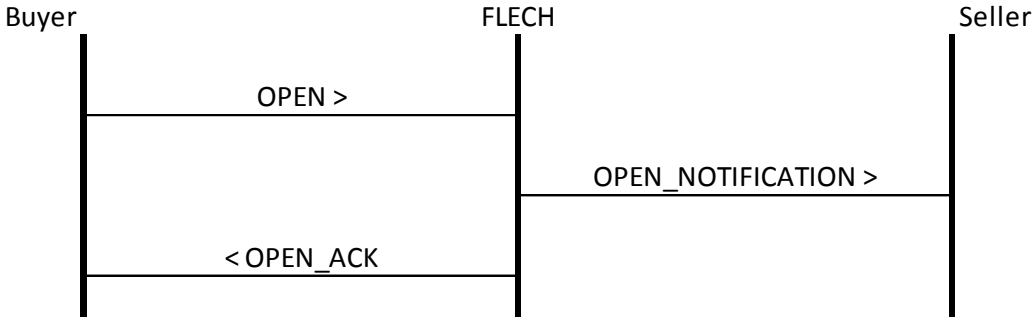
In addition to the message headers for use-case 6.1 the product and the message type must also be specified in the message headers/properties. Table 4 shows the necessary properties for the PowerMax service.

Description	**Header name**	**Header value**	**Header type**
This is the name of the service. Different message handling is necessary for different services and this header help redirecting the message to the correct handler before parsing the content.	product	POWER_MAX	String
The type of the message, this helps in handling the message correctly without parsing the content.	messageType	(see individual messages in the user-case implementation sections)	String

Table 4. Additional message headers required to interact with FLECH for the PowerMax service.

7.1 Open Market

To open a new market a buyer needs to send an open market message to FLECH. If properly formatted the market will be persisted in FLECH and an open market notification is sent to all participants (this is done on the notification topic). A successful open market process will also schedule a closing of the market at the end of the market period (at the time specified in the marketPeriod.to field). The message flow is shown in detail in the figure below.

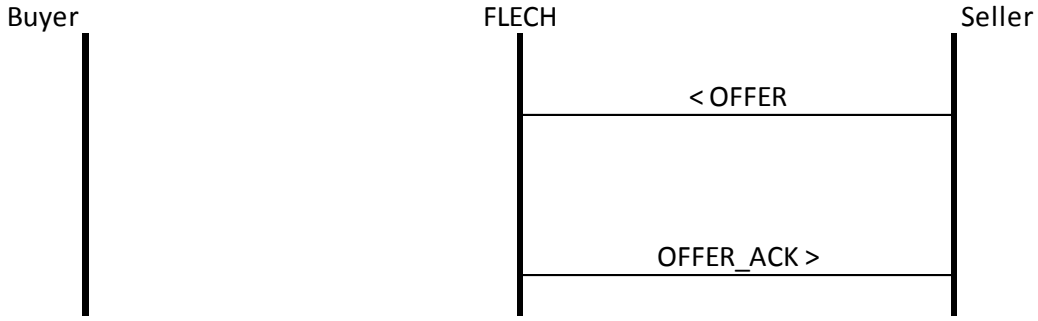


The formats of the messages are shown in detail in the table below.

Message Type	**Correlation ID**	**Message Body**	
OPEN	Must be provided by the participant	**Field name**	**Field type**
		maxPrice	FLOAT
		volume	FLOAT
		area	STRING ARRAY
		reservationPeriod	TIMEPERIOD
		dailyActivationPeriod	TODPERIOD
		marketPeriod	TIMEPERIOD
OPEN_NOTIFICATION		**Field name**	**Field type**
		marketID	STRING
		volume	FLOAT
		area	STRING ARRAY
		reservationPeriod	TIMEPERIOD
		dailyActivationPeriod	TODPERIOD
		marketPeriod	TIMEPERIOD
OPEN_ACK	The same as in the OPEN message	**Field name**	**Field type**
		status	STATUS
		marketID	STRING
		message	INTEGER

7.2 Placing Offer

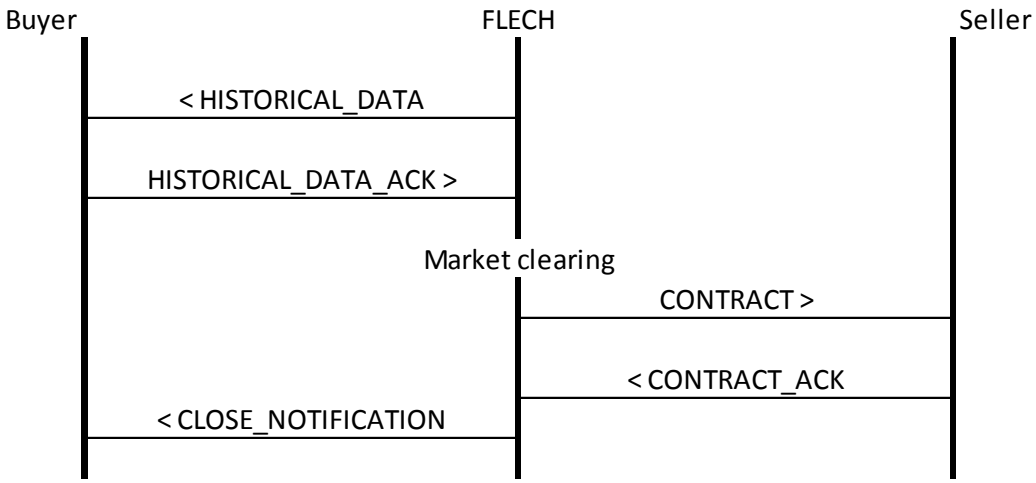
A participant can place an offer in a market by sending an offer message. The offer message must therefore contain the ID of the market to target. Only offers that are delivered to the broker during the market period will be used in the clearing of the market. There is therefore no point in placing offers outside of the market period because they will be automatically rejected. The response sent by FLECH will contain the ID of the offer which is created by FLECH. To avoid duplicate offers the offer message must contain a correlation ID. This correlation ID will be used by FLECH in the response. By using this concept a participant can be sure that if the offer is sent twice (potentially by retrying if no response is received) only a single offer is recorded in the market.



Message Type	**Correlation ID**	**Message Body**	
OFFER	Must be provided by the Seller	**Field name**	**Field type**
		marketID	STRING
		maxPower	FLOAT
		volume	FLOAT
		area	STRING ARRAY
		reservationPrice	FLOAT
OFFER_ACK	The same as in the OFFER message	**Field name**	**Field type**
		status	STATUS
		offerID	STRING
		message	INTEGER

7.3 Close Market

When the market closes FLECH will send requests to the buyer opening the market to get historical meter values for all the offers. The meter values are then used to determine the baseline of the maximum power that sellers offer a reduction from.

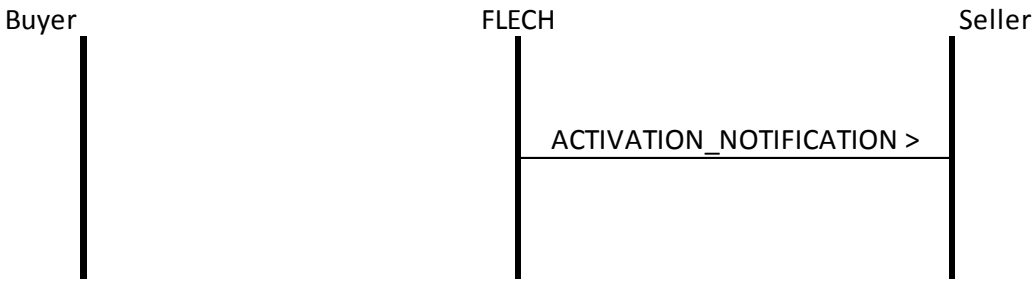


Once the market is closed the settlement is triggered at the end of the reservation period (at the time specified in the reservationPeriod.to field at the opening of the market)

Message Type	**Correlation ID**	**Message Body**	
HISTORICAL_DATA	Provided by FLECH	**Field name** area reservationPeriod dailyActivationPeriod	**Field type** STRING ARRAY TIMEPERIOD TODPERIOD
HISTORICAL_DATA_ACK	The same as in the HISTORICAL_DATA message	**Field name** area values	**Field type** STRING ARRAY METERDATA
CONTRACT	Provided by FLECH	**Field name** offerID accepted	**Field type** STRING BOOLEAN
CONTRACT_ACK	The same as in the CONTRACT message	**Field name** offerID accepted	**Field type** STRING BOOLEAN
CLOSE_NOTIFICATION		**Field name** marketID volume offerIDs	**Field type** STRING FLOAT STRING ARRAY

7.4 Activation

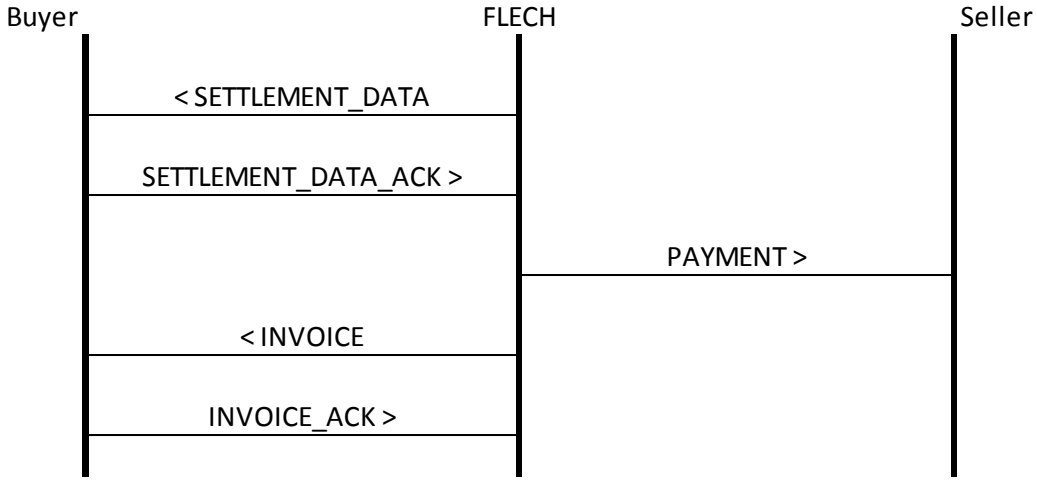
For all accepted offers a message is sent from FLECH to the participants as a reminder that activation is expected. This is done as close to the real activation time as possible.



Message Type	**Correlation ID**	**Message Body**	
ACTIVATION_NOTIFICATION		**Field name**	**Field type**
		offerID	STRING

7.5 Settlement of Market

The settlement is performed for all accepted offers in a market and is triggered at the end of the reservation period of the market. In a first step, meter data is requested from the Buyer by FLECH for each accepted offer. The meter data is then verified and if meter data shows that the service was delivered a payment notification is sent to the Seller. Once all accepted offers are verified and paid for an invoice is sent to the Buyer. This invoice must be acknowledged by the buyer.



Message Type	**Correlation ID**	**Message Body**	
SETTLEMENT_DATA	Provided by FLECH	**Field name** area reservationPeriod dailyActivationPeriod	**Field type** STRING ARRAY TIMEPERIOD TODPERIOD
SETTLEMENT_DATA_ACK	The same as in the SETTLEMENT_DATA message	**Field name** area values	**Field type** STRING ARRAY METERDATA
PAYMENT		**Field name** offerID amount	**Field type** STRING FLOAT
INVOICE	Provided by FLECH	**Field name** marketID amount	**Field type** STRING FLOAT
INVOICE_ACK	The same as in the INVOICE message	**Field name**	**Field type**