Field test to demonstrate a smart market platform via smart meter infrastructure

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Abstract — **The deployment of smart market approaches as well as the implementation of smart meter infrastructure are tools to face the challenges which come along with the continuing transition of the energy system. This paper describes a field test of the application and use of smart markets and smart meter infrastructure in combination with one another, and points out constraints limiting their implementation. Besides the technical perspective, the importance of user participation in the field test to obtain findings regarding the usability of the concept is discussed**

Keywords— Smart market, smart metering, intelligent metering systems, field test, performance evaluation, participation

I. Introduction and Motivation

The transformation of the energy system away from central supply structures towards a renewable energy future is not only a technical challenge that requires the integration of millions of renewable generation plants and new consumers, but also leads to a redesign of the coordination between electric markets and the available capacity of the electric grids. Today´s curtailment and redispatch mechanisms in most European countries rely on cost-based pricing and were designed as emergency measures. The increasing frequency of grid congestion (73.7 GWh in 2009; 5,518 GWh in 2017 [1]) has led to the development of the principles and processes necessary to integrate small-scale flexibility (esp. loads) into congestion management. Therefore, so called smart market platforms, often market based, are seen as an answer to the rising complexity in grid operation. This is supported by European regulation 2019/943: "*The management of congestion problems should provide correct economic signals to transmission system operators and market participants and should be based on market mechanisms*". [1]

In recent years, several versions of such platforms have been developed and demonstrated. A meta-study of similar concepts was conducted to identify basic design principles and necessary attributes of a smart market platform, and can be found in /FFE-37 19/

Besides the encouragement of smart market approaches, the implementation of intelligent metering systems (iMSys or smart meter) is another goal of the European Union (EU). According to directive 2009/72/EC, 80 % of consumers shall be equipped with iMSys by 2020. The iMSys shall enable, for example, an active participation of consumers in the energy market and support energy-efficient behavior. A prerequisite for the EU to require a member state to implement the rollout of iMSys is a cost-benefit analysis, to be performed by the member state, with a positive result.

This analysis was required to be completed no later than September 2012, with a 10-year timetable regarding the implementation of iMSys to be provided afterwards. [2]

According to the goal set in directive 2009/72/EC, the current rate of iMSys implementation should now have reached a considerable level. At the end of 2017, nine member states had a rollout level of more than 50 %. Another seven countries have at least started with the rollout of iMSys but have not reached a considerable implementation rate. Besides the rollout rate, the functionalities of the intelligent metering systems vary from one member state to another. In most cases, the capability for the remote reading of power consumption is required, and secure data communication must be guaranteed. In-Home Display as well as the possibility to change the billing intervals is only required in a few member states. Along with the different functionalities, the time granularity differs from 15 minutes (14 member states), 30 minutes (3 member states), or up to one hour (3 member states). [3]

With regard to the execution of directive 2009/72/EC, Germany is a notable case. Deviating from the expressed EU goal, the official rollout of iMSys has not started in Germany yet. The implementation will begin as soon as three independent companies offer an iMSys (respectively a smart meter gateway) on the market and the Federal Office for Information Security (BSI) confirms its suitability in accordance with the legal requirements. According to [4] just one product has received all needed certifications, while a further eight products are in the certification process. The overall goal regarding iMSys is to equip 95 % of certain measuring points until 2032. These measuring points are consumers with annual consumption greater than 6.000 kWh, generation plants with an installed capacity greater than 7 kW, and measuring points which take part in a flexibility mechanism like § 14a EnWG. The implementation of iMSys at the remaining measuring points is optional and not included at the 95 % goal. [5], [6]

The infrastructure of intelligent measuring systems provides in general the functionality to transmit values as well as control signals. In particular the ability to use the iMSys as an interoperable infrastructure to vary the operation point of technical units is a basic requirement for a smart market platform. Therefore, the results of the field test should show if the iMSys infrastructure, incl. the involved market roles, is suitable for the implementation of a smart market platform, and where the potential bottlenecks are. In addition to the technical and functional analysis, the design of the field test must consider the current state of technical units (like PV-plants or heat pumps), which are already implemented.

The implementation, demonstration and evaluation of a smart market platform via the use of the iMSys infrastructure is part of the activities of Forschungsstelle für Energiewirtschaft (FfE) in the project C/sells. The FfE is funded by the Federal Ministry of Economics and Energy (BMWi) as part of the "Schaufenster intelligente Energie - Digitale Agenda für die Energiewende" (SINTEG) funding programme (funding code: 03SIN121). [7]

II. Framework of the Field Test

A. Description of the project area

The area considered for the field test are medium and low voltage levels (MV/LV) in Bavaria, Germany. Located around the municipality of Altdorf near Landshut, it is a rural region encompassing eight municipalities in total. Fig. 1 illustrates the MV network of the considered project area whereby this 20 kV voltage level is supplied by one substation.

The area comprises around 30,600 inhabitants of 8,650 residential units. [8] The area has a total renewable energy sources (RES) power of around 60 MW, 49 MW of which is contributed by PV installations, primarily from residential installations. [9] The project region has a high PV-density with 1,6 kW/inhabitant. Compared to the total PV-power in Germany of 45 GW, PV-installations represent only 0,50 kW/inhabitant nationwide [10], [11]. Despite today's high PV-density in this area, the entire PV-potential (rooftop installations) in the project area is around 116 MW. [12], [13] TABLE I. compromises key data on the network area, loads and installed capacities.

Within the project area, there is still potential for additional PV-installations, both rooftop and open ground, as well as other loads, e.g. electromobility, heat pumps or storage systems. In [15] different scenarios for the development within the project area are developed. The choice of the project region for the field trail is, besides today's high PV-density, further influenced by pre-studies conducted by the distribution system operator (DSO) within the same area and the resulting availability of relevant data. Along with these pre-studies, contact to local stakeholders like the local council, energy working groups etc. is already established and can be used for the smart market field test.

TABLE I. KEY DATA OF THE PROJECT NETWORK AREA

Parameter	***Amount***
Installed PV-capacity[a]	around 49 MW
Other installed RES[a, b]	around 11 MW
Consumer power for grid load (MV/LV)[c]	2.2 MW / 12.3 MW
Number of medium-voltage radiation net [c]	8
Number of local network stations[c]	232
Grid network length MV (overhead lines/ cable) [c]	around 99 km / 75 km

a. Data from [9]

b. EEG-based; incl. CHP, biomass, wind and hydro

c. Data from [14]

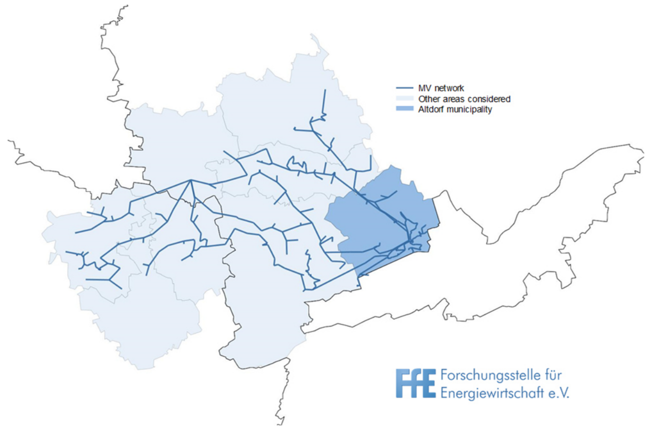


Fig. 1. Medium voltage network of the project area (based on [14])

B. Application of iMSys infrastructure

The German approach to implement intelligent measuring systems essentially consists of two main hardware components: A modern measuring unit (mME) and a smart meter gateway (SMGW). A mME is "a measuring system that reflects the actual electricity consumption and the actual time of use and can be securely integrated into a communication network via an SMGW" [6]. The mME primarily replaces the common Ferraris meter, which was previously predominantly used, and assumes its basic function - the calibrated measurement of consumed energy. In addition to the modern measuring equipment, the smart meter gateway is the second and main component of the iMSys. The key features are the collection, time stamping, processing, transmission and storage of values and data, whereby data protection, data security and interoperability must be guaranteed. [6] The combination of mME and SMGW provides the basic function to collect, sort, and transmit metered values. Besides consumed energy, [16] describes further minimum requirements for the smart meter gateway. There are 13 so called "Tarifanwendungsfälle - TAF" (tariff application cases), which can be categorized as follows (further information in TABLE III.): [5]

- TAF 1 – 8: Pricing and balancing
- TAF 9: Control of technical units
- TAF 10 – 13: Network survey

As already mentioned, the iMSys should be used to vary the operation point of technical units in Germany. Therefore the transmission of control signals (driven by market or grid issues) is another possibility for the application of the intelligent measuring system. In this case, the primary task is to replace the existing unidirectional radio ripple control with a more reliable, bidirectional system. The new technical solution must therefore be compatible with both existing and new technical units (like PV inverter). To connect existing technical units to the new iMSys, another component (control box) is needed to ensure the conversion of switching commands according to current technical standard. Fig. 2 shows the functional connection between the hardware components and the link of involved market roles.

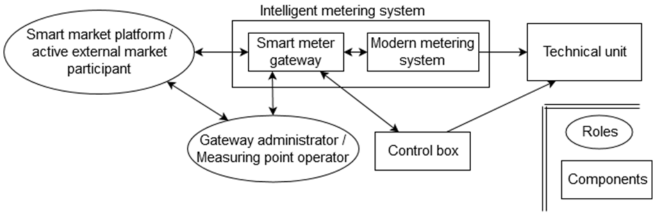


Fig. 2. Functional relationship between components and roles regarding iMSys infrastructure

For the usage of the iMSys infrastructure (transmit control signals or collect measured values) two market roles must be integrated into the process: The SMGW administrator is responsible for the technical operation of the intelligent measuring system. This includes for example the communication between an active external market participant (aEMT) and a technical unit or receive and deliver of measured values. Any issues regarding communication via SMGW, the administrator must be included. The responsibility for this administration lies with the measuring point operator or a third party commissioned by them. The second important market role is the external market participant. There is a passive (receive data only) and active (receive data and transmit control signals) version. The implementation of a smart market platform requires data and generate control signals whereby the role of an aEMT ist needed. This can be fulfilled by the platform itself or the use of a third party service [5].

C. *Overview about smart market platform*

The described market and coordination platform serves as an interface between the grid operator and the supplier of flexibility. The following parties are involved in the platform process:

The operator of flexibility primarily interacts with the platform when registering the technical unit to provide flexibility. They place so-called “Flex offers” on the platform or release their unit for use if they themselves do not actively market their plant. If the bid is accepted, the operator is obligated to provide flexibility to the buyer. In case of the field test, the test persons in the project region are the operator and provide flexibility to the smart market platform.

Once the technical unit has been registered, it will be topologically located by the grid operator and stored on the platform with its network effectiveness. This functionality is carried out initially or after topological changes. In addition, the grid operator acts as an operator for plants according to EnWG §14a and StromNEV §19 and converts the control signal if required. In principle, the grid operators act as demanders on the platform. For this purpose, they transmit their flexibility requirements and possible grid limitations. An interaction between the network operators can take place both in the network security calculation to determine the flexibility requirement and in the setting of limits. Several forecast services (temperature, solar radiation) are used as input to execute the network security calculation.

The smart market platform is the central mediator with the core functions of the planning process (matching, frontend/backend) and the execution or flexibility call. The system is divided into a backend, in which all internal platform processes and functions take place, and a frontend, via which the participating actors have interfaces for interaction and visualization at their disposal.

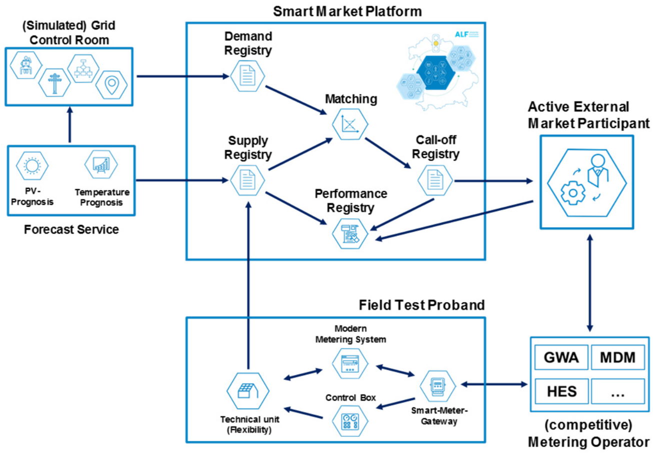


Fig. 3. System landscape of the connection between smart market platform and iMSys infrsturcutre

III. Methodological Approach

The iMSys infrastructure is the linkage between technical units owned test persons, such as photovoltaic plants, and the smart market platform. Therefore, several use cases are needed to cover a wide range of different types of technical units with individual properties. Besides the technical point of view, (active) participation of test persons is in general useful and needful to demonstrate a smart market platform at the chosen project area (see section II).

A. *Systemic overview*

For the demonstration of a smart market platform by using the iMSys infrastructure, various restrictions have to be considered. These issues already have to be taken into account while designing the field test: Regarding the technical units, there is a large number of different flexibility types [17], which in general can participate in a smart market platform. The pool of possible systems is limited by the considered voltage levels (e.g. no large thermal or renewable power plants), customer comfort (e.g. no white goods) and the necessary compatibility with the used iMSys (control box) infrastructure (e.g. no battery storages). The focus of the field test is therefore on generation plants, which can be regulated in certain stages in accordance to § 9 EEG. Furthermore, loads currently able to participate in the flexibility mechanism § 14a EnWG can also be integrated. By referring to these two paragraphs, it can be ensured that the individual technical unit is basically compatible with the iMSys infrastructure and thus with the smart market platform.

In order to reach the target number of around 50 test persons for the field test, two different strategies are used: The participation approach involves advertising the project through various measures in the region and thus convincing test persons to participate. The disadvantage regarding this approach is the lack of certainty that the technical units of the interested persons meet the requirements mentioned above. Therefore, a functional approach is being developed in parallel, in which specific plants are selected which meet the technical requirements. It is assumed that after the first implementations additional people want be integrated in the smart market platform (see section IV.B). Final restrictions can result from the on-site inspection. For example, lack of mobile signal can be a further exclusion criterion.

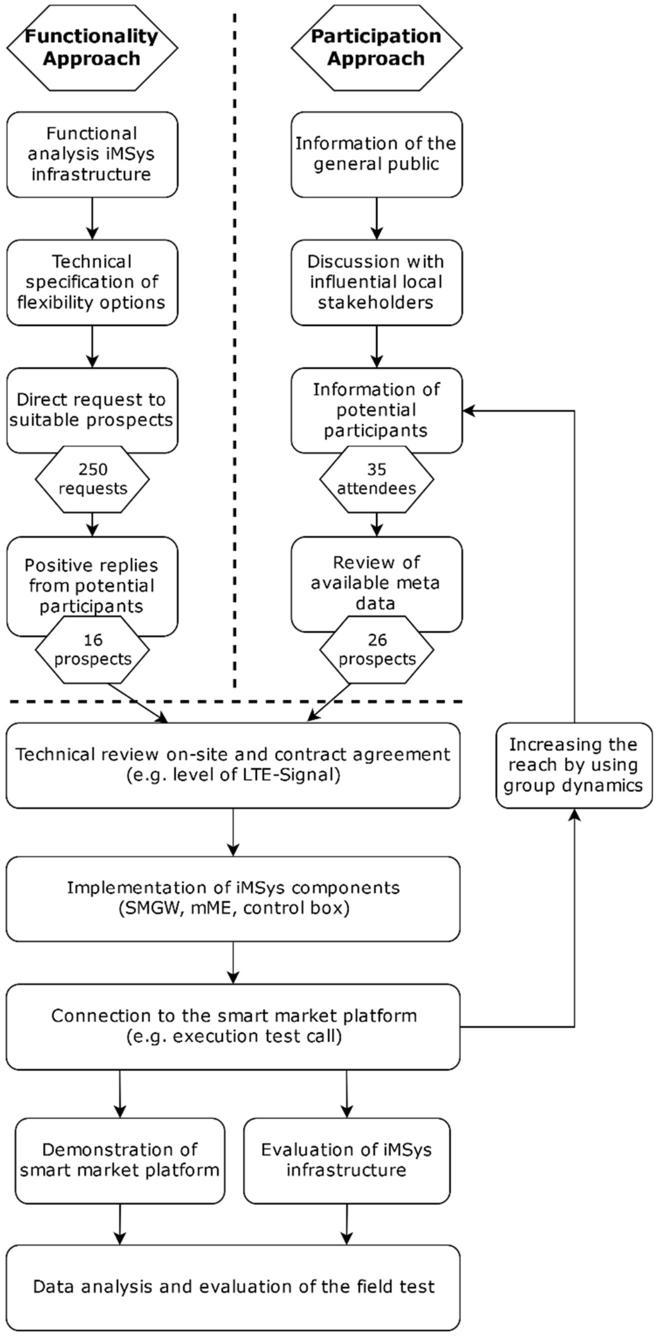


Fig. 4. Systemic overview of the workflow of the field test

After the technical implementation of an iMSys & control box, the connection to the smart Market platform takes place. Simple switching tests are used to check whether the system can be reached and whether data communication is working. During the field test period, various data are collected to enable an evaluation of the iMSys infrastructure within this field test framework.

B. Technical use cases

Due to the application of the iMSys infrastructure, restrictions exist regarding the connection of technical units (see section III.A), from which a selection of technical use cases flows (see TABLE II.). Each of the listed use cases can contain different editions of units, only the technical type of flexibility service is identical within a use case: The most common case is the *curtailment of RES*.

TABLE II. OVERVIEW ABOUT THE TECHNICAL USE CASES

Use Case	*Description*
Curtailment of RES	Limitation of the feed-in power of RES to the steps 0/30/60/100 %[d]
Curtailment of loads	Switching off of heat pumps, electrical storage heaters or electric vehicles[e]
Activation of loads	Forced activation of heat pumps[f]
Integration of schedule plants	Transmission of a (modified) schedule
Evaluation of iMSys infrastructure	Performance (latency, data volume, reliability etc.) of components resp. process groups

[d] According to § 9 EEG

[e] According to § 14a EnWG

[f] According to Requirements of "Smart-Grid-Ready" label

This contains the stepwise feed-in limitation to 60/30/0 % in relation to the feed-in power. The duration of the call-off is theoretically unlimited and therefore only dependent on the requester. In addition to curtailing feed-in systems, the iMSys infrastructure can also be used for the *curtailment of loads*. This includes systems which are managed as interruptible consumption devices according to §14a EnWG. Besides heat pumps, these can also be electric vehicles or electrical storage heaters. The maximum time for this retrieval is limited to 2 h, due to none or only minor restrictions on comfort for the customer [18]. From a technical point of view, the *activation of loads* is only possible to a limited extent. Heat pumps with the "Smart Grid Ready" label currently offer a corresponding (standardized) function [18]. These three technical use cases use the iMSys infrastructure to collect measurement data and transmit control signals. Another use case is the *integration of schedule plants*. These describe flexible units of professional marketers that are capable of actively providing offer bids consisting of a day-ahead timeseries in 15 min steps including available power, price and potential constraints. After being contracted for flexibility a modified schedule is sent to them via e-mail. The proof of provision is then conducted by ex-post measurement via iMSys. The implementation of the use cases are the basis for the evaluation of the iMSys infrastructure. Various performance data are collected for all switching processes (see also section IV.A), which in turn provide the opportunity to name the feasibility of a smart market platform using the iMSys infrastructure. The implementation of these technical use cases require several metering data.

TABLE III. OVERVIEW ABOUT THE USED TAF

TAF name	*Availability [4]*	*Use for smart market platform*
TAF 7: Meter reading	G 1	Energy values must be evaluated for settlement, performance verification and documentation
TAF 9[g]: Call of the actual power	G 1b	Current power value is queried before and after the actual retrieval
TAF 10: Call of network status data	G 1b	Threshold values at neuralgic points in the network are defined in order to detect overloads
TAF 1, 2, 3, 4, 5, 6, 8, 12 and 13	TAF 1, 2 and 6 would be available in G1 but are not necessary for the smart market platform	

[g] Contrary to the directive, this TAF is used for generation and consumption plants.

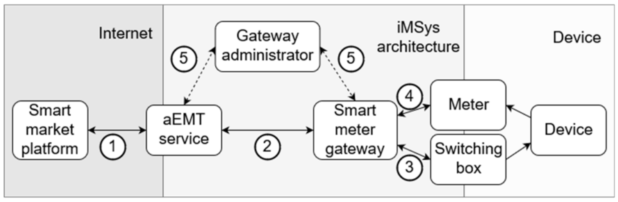
As already mentioned in section II.B, there are in sum thirteen tariff application cases, which describe the minimum requirements towards the smart meter gateway. The application of the smart market platform requires several data which can be provided by the SMGW respectively whose three certain tariff application cases (see TABLE III.): Before and after switching, the actual power value of the technical unit is transmitted near real-time (TAF 9) in order to provide technical proof of the switching action. The meter reading of the unit (TAF 7) is evaluated on a daily basis (resolution 15 min) in order to be able to prove that the service offered has been provided. In addition, network status data is transmitted to the platform as soon as defined threshold (e.g. net voltage) values are exceeded or fallen below (TAF 10). Just one TAF is available with the current generation of SMGW, which are part of the running certification process [4]. The implementation of further TAF will be part of coming device generations. Therefore, non-certified SMGW will be used during the field test to meet the requirements of the smart market platform. This restriction means that the SMGW may not be used to carry out payroll processes for regular operations.

C. Evaluation approaches of the iMSys infrastructure

After the closure of trading at the smart market platform, switching commands for the participating technical units are generated from the market result. Those commands are then executed and monitored by the iMSys infrastructure. In the following, approaches to evaluate performance and reliability are shown by using this infrastructure.

Latency times: In general, the goal is to quantify latency times / delays between the sending of switching commands from the smart market platform via the aEMT-service and their actual reception at the device (see Fig. 5). Latency occurs between the smart market platform and the aEMT-service, which is internet-based. Much more latency emerges within the iMSys architecture when establishing a connection to the SMGW via the gateway administrator. During the field test, four switch measurement categories, further described in Fig. 5 and section IV.A, were performed. Latency data for evaluation is provided by the aEMT-service for the iMSys architecture and an additional measurement between smart market platform and the aEMT-service. A first evaluation for switching command runtimes is given in section IV.A. To minimize latency times of the total process, it seems advisable to establish the channel to the smart meter gateway well beforehand in order to send the switching command at the desired switching time.

Data volume: When measuring latency, one can thereby measure data volumes sent through the iMSys infrastructure and evaluate approaches to minimize transferred data. Typically, when communicating with a smart meter gateway, a connection is established, communication carried out, and the connection is closed again. The process of establishing a connection creates extra data volume to be sent. Another approach is to keep the communication channel open, which demands regular, but low volume, data traffic. Which method causes less data volume can be determined after a data volume measurement is integrated at the technical process.



	S open	***MSM open***	***S closed***	***MSM closed***
Description	Switch with opened channel	Measure-switch-measure with opened channel	Switch with closed channel	Measure-switch-measure with closed channel
Order of comm-unication processes	1	1	1	1
	2, 3	2, 4	5	5
		2, 3	2, 3	2, 4
		2, 4		2, 3
				2, 4

Fig. 5. Scheme of the iMSys architecture and the communication processes used

Reliability of execution: The iMSys infrastructure enables to immediate verification of the conduction of switching operations by measuring the current power of the corresponding devices. Performing measurements Allows operators to assess the reliability of flexibility options and the consideration of this for future switching operations. One can furthermore take immediate counter-measures if measurement is conducted directly after switching operations: if a switching operation is not successful, another flexibility option from backup may be switched, instead.

Fulfillment of offered flexibility: The smart market platform enables devices without any ability to schedule power production/usage, such as domestic photovoltaic systems or heat pumps, to take part in the market. For such units, flexibility offers are forecasted and issued automatically by the platform. Small devices with little electrical power are aggregated as a collective offer. Those offers are prognosticated based on the number and type of flexibility options, plus further parameters, due to their unpredictable commitment. Countermeasures, like switching further flexibility options from backup, can compensate for unfulfilled calls in the short-term. In the long run, aggregation and prognosis of offers can be optimized to reduce the amount of immediate countermeasures.

D. Participation

The project gained attention in the public through local events and through communication to municipal bodies during summer 2018. During a public citizen dialogue and during meetings with a local energy group in early 2019, the project team informed potential participants and consulted them for their suggestions and ideas. Additionally, participants' experiences as market players in the field test could later play a role for further developments of smart market platforms. With the evolving energy transition, citizen participation is increasingly discussed as one pillar for its success [19], [20], [21]. Innovations such as digitalization require users to adapt and change their behaviour. Furthermore, citizens can bring in innovative ideas for the design of future energy systems.

TABLE IV. ARNSTEIN'S LADDER OF PARTICIPATION AND IMPLEMENTATION IN THE FIELD TEST (BASED ON [22])

Step	*Form of participation*	*Implementation field test*
8	Citizen control	-
7	Delegated power	-
6	Partnership	Players on market platform
5	Placation	-
4	Consultation	Citizen dialogue, meetings
3	Information	Local events, news media
2	Therapy	-
1	Manipulation	-

As acceptance is significant for successful implementation of innovations, early participation can create a feeling of valuation and integration for users. [19] Generally, participation can rank from passive participation such as information and consultation to active forms such as cooperation or citizen control. Arnstein's ladder of participation [22] first described these different layers (see TABLE IV.). The presented smart market platform covers the steps 3, 4 and 6. First information of the general public and suitable prospects took place in an early project stage.

A project-specific participation approach ought to cover recruitment and support of participants before and during the field test [23]. A survey on the acceptance towards the digitalization of the energy system helped identify citizens' motivations for participation. An extensive literature meta-review of other projects' best-practice examples as well as theories from participation, marketing and communications science served as input for the development of strategies for recruitment and support. These strategies were then adapted to the project region's specifications, the project goals and the target group. The latter consisted of forerunners and followers, i.e. those who stated their interest early on and those who stated their interest later. The core strategy of the participation concept included the usage of three types of appeals: emotional, social and rational. Emotional appeals consider personal values and beliefs, social appeals can be group dynamics or peer influence, and rational appeals include additional value, often in the form of financial advantages.

IV. RESULTS

The field test to demonstrate a smart market platform consists of three clusters: The smart market platform itself, iMSys and technical units along with the test persons.

A. *Use of iMSys infrastructure*

To get some detailed information about the iMSys infrastructure an isolated technical field study has been carried out by E.ON Metering GmbH, Bayernwerk Netz and FfE. During this preceding field test, twelve smart meter gateways and control boxes were implemented at photovoltaic plants to reduce their feed-in power. In sum, more than 2,000 accesses were performed for the switch respectively measurement categories (see also Fig. 5). [24] The goal was to collect data about the signal runtime, reliability of the system, possible correlations regarding time of day, location of the plant and day of the week. Fig. 6 shows the signal runtime (median) of each category.

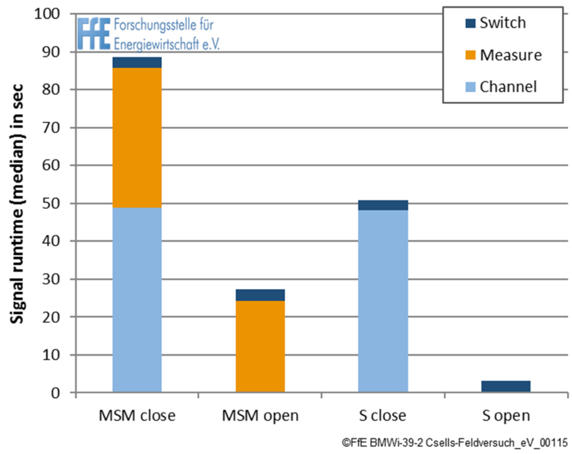


Fig. 6. Signal runtime of different categories regarding measurement, switch and channel

The results of this preceding technical analysis show that the implementation of feed-in management measures (curtailment) of PV plants within the framework of the iMSys infrastructure is possible. The total runtime varies between around 90 and 3 seconds and depends on the used process steps. According to VDE-AR-N 4140, the grid operator has in sum twelve minutes to prepare and execute feed-in management measurements. The execution time has a range between six and twelve minutes due to the limitation of the preparation time to a maximum of six minutes. [26] Although the runtime of the signal is just one part of the entire feed-in management process, this result allows a technical assessment about the suitability of the iMSys infrastructure for this issue.

In this field test design, the system architecture was created by using components from one manufacturer and some communication steps between market roles were performed only by simulation. In further investigations the use of different manufacturers is being considered in order to examine and evaluate the transferability of the results. Further components such as heat pumps must be connected in addition to PV systems. This is particularly important for the C/sells activities to evaluate the infrastructure for the implementation of switching and measurement issues as an interface between smart market platform and a wide range of technical units.

B. *Proof of concept of the smart market platform*

The field test consists of a proof of concept of the smart market, its matching algorithm and the usage of the iMSys infrastructure. TABLE V. gives overview of the development state of selected topics/features.

The simulation runs lead to the requirement of a web platform to manage flexibility offers and demands. Test users access the platform via a developed app to deliver and communicate their flexibility to the market. After the close of trading, an algorithm matches demand and offers, minimizing costs whilst maximizing coverage of demands. The platform is furthermore used to conduct simulations. The flexibility demands are provided by a virtual control room of the grid from the project area which is used as input data for simulations. For actual switching and measurement operations via the iMSys architecture, the smart market platform applies a web-based aEMT-interface.

TABLE V. CURRENT DEVELOPMENT STATE OF THE SMART MARKET PLATFORM

Topic	Concep-tion	Implemen-tation	Demons-tration
Matching algorithm	✓	✓	✗
Website and app for test users	✓	✓	✓
Curtailment of RES	✓	✓	✓
Curtailment of loads	✓	✓	✗
Activation of loads	✓	✗	✗
Cyclic TAF 9: Actual power	✓	✓	✗
TAF 7: Meter reading	✓	✓	✓
TAF 10: Call of network status data	✗	✗	✗
Virtual control room for the grid	✓	✓	✓

C. *Participation*

Based on Roger's Theory of Diffusion of Innovations [25] and personal communication with citizens, the decision for participation is based on emotional, rational or social appeals, depending on the target group (see Fig. 7).

Survey results and discussions with prospects showed that emotional values such as the desire to support the energy transition and the project's regional character are key for motivating forerunners. To reach a higher number of followers, however, financial appeals are further included. Interestingly, while 85% of survey respondents stated the wish to support the energy transition actively, most respondents did not want to sacrifice their comfort or routines for participation. [23]

In total, 26 people stated their willingness to participate based on the participation approach. Unforeseen difficulties in the connection of technical units, namely non-compatible RES, occurred during data review and thus hindered most of these prospects from actually participating. Consequently, by accessing network databases, the DSO sent out around 250 requests to prospects regarded as technically eligible to participate (see also Fig. 4). A technical review of the prospects' units will take place on-site, before finally connecting them as a technical unit to provide their flexibility to the smart market platform.

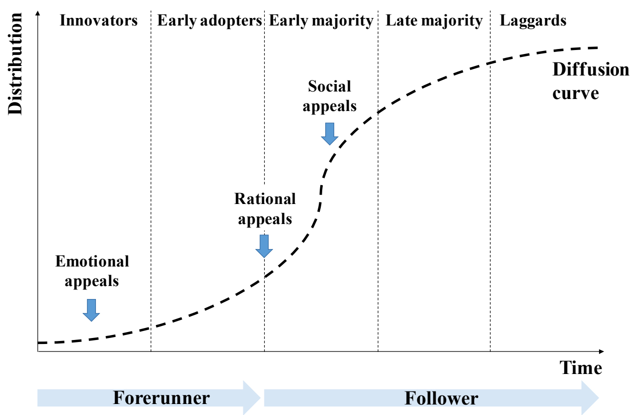


Fig. 7. The project's target group and according appeals (based on [25])

V. DISCUSSION AND OUTLOOK

A. *Critical review*

The focus on the exclusive application and use of the iMSys infrastructure means a considerable procedural and technical effort. In addition, the current technical capability of iMSys limits the connection of potential technical units, leaving a potential for flexibility untapped (e.g. battery storage). These disadvantages could be simplified by using a proprietary technical solution. The application of iMSys, however, has the advantage that, in addition to safety aspects, access to the components is standardized which are installed across the board. In the long run, especially small scale flexibility could be integrated more efficiently and new solutions such as smart market platforms could be scaled to larger areas.

Even though the participation approach was overall successful with 26 prospects resulting from the participation activities, the project also showed technological limits to this approach. Due to technical constraints, some of the interested prospects are not eligible for participation. Thus, the combination with a functionality approach seems to be promising. Furthermore, the question remains whether the integration of citizens in such a field test can be regarded as participation. Here, the use of passive participation in the form of information dominated. To achieve active participation, increased inclusion of citizens in the development process, for example through design thinking, is necessary. A frequent hurdle for active participation is the unwillingness to change current routines and to invest time and work for participation. As large-scale application of a smart market platform requires a high number of participants, the investigation of drivers and appeals for participation gains in importance. The open question remains, which level of participation is needed to implement approaches like smart market beyond research projects like C/sells.

B. *Outlook*

As soon as the target number of 50 test persons has been reached and a corresponding number of technical units are connected to the smart market platform, various test phases will be carried out. These test phases concern the use of the smart market platform and are planned for late summer, autumn and winter. This enables the different operating behavior of components such as PV systems or heat pumps to be investigated and their effect on the power grid to be taken into account. Each of these test phases is scheduled for approx. 4 weeks with a subsequent 4-week break. During the breaks, adjustments will be made to the iMSys infrastructure and the smart market platform and, if necessary, additional test persons will be integrated. Furthermore, the deactivation of the smart market platform is used to carry out special switching and communication sequences, which allow a technical evaluation of the iMSys architecture and finally the feasibility of a smart market platform with iMSys. During the field test, several activities and analysis with the test persons are planned to evaluate the smart market approach form the persons view.

VI. References

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