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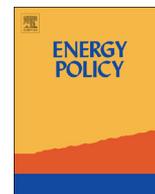
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A system perspective to the deployment of flexibility through aggregator companies in the Netherlands

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ABSTRACT

Recent developments in distribution grids, environmental policy, and the energy market liberalisation process, have resulted in a quest for flexibility in power systems operation, with the focus increasingly placed on the aggregation of distributed resources. A generic method is proposed for the identification of opportunities, barriers and potential solutions in developing flexibility mechanisms through aggregator companies by concentrating on the market integration aspects. The method is applied to the Netherlands as a case study, and the outcome is a state-of-the-art review of the electricity market development concerning all relevant issues for advancing the market integration of aggregator companies within the Dutch system and in line with the new European grid codes. Opportunities were framed among six categories which outline the potential for the provision of market-based products and services in the Dutch system, whereas barriers were decomposed into market, regulatory, technical and social issues. A set of recommended actions is provided to facilitate the market integration of aggregator companies in the Netherlands, which point out the need for policy interventions and follow-up research activities.

1. Introduction

The increasing integration of intermittent renewable energy sources (RES) in power systems and the ongoing deregulation of electricity markets have resulted in a quest for flexibility (van Hout et al., 2014). Flexibility is defined as a “general concept of elasticity of resource deployment providing ancillary services (AS) for the grid stability and/or market optimisation” (CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012). Until now, flexibility was mainly sourced from large power plants at the supply-side. However, with the increasing electrification of the transport and heating systems, the further integration of distributed generation, flexible loads and energy storage at the distribution level, the gradual decommissioning of thermal power plants due to environmental reasons, and the liberalisation of the energy market, the focus of enabling flexibility is increasingly placed at the demand-side in the industry, commercial, and residential sectors. Furthermore, technological developments in electrochemical energy storage are expected to result into significant decrease of technology cost in the coming years, and drive the adoption of battery systems by electricity

customers. Especially, lithium-ion stationary battery systems are expected to become economically viable for electricity bill management applications, from the customers’ perspective, by 2020 (Telaretti et al., 2016). Unlocking the flexibility at the demand-side is considered a key factor for an effective energy transition, which requires not only the development of technology but also the active participation and empowerment of customers (Expert Group 3 Regulatory Recommendations for Smart Grids Deployment, 2015). In most cases, individual distributed resources cannot contribute to flexibility services on their own because of limited capacity and controllability. Aggregator companies¹ are organisations that can combine these distributed resources into a single system resource which can be utilised for the provision of flexibility services. Demand-side flexibility can be used by various actors to serve several purposes and provide multiple benefits and sources of revenues (Expert Group 3 Regulatory Recommendations for Smart Grids Deployment, 2015). Once a flexible portfolio of distributed resources has been constructed, an aggregator can employ optimisation approaches to address different objectives, such as the participation in load-frequency control (Lampropoulos et al., 2013a), or

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¹ Also called aggregation service providers but referred to as simply ‘aggregator’ in the remaining part of this paper.

the scheduling of resources considering economic and environmental objectives (Di Somma et al., 2018). An aggregator might utilise flexibility to take advantage of price differences in wholesale and retail markets for electricity, to participate in markets for AS, and to provide over-the-counter services to other market parties. According to the European Energy Efficiency Directive (E.U., 2012), E.U. Member States shall ensure that Transmission System Operators (TSOs) and Distribution System Operators (DSOs), in meeting requirements for balancing and AS, treat demand response (DR) providers, including aggregators, in a non-discriminatory manner, on the basis of their technical capabilities. To unlock the full potential of demand-side response² there is a need for new rules, as an enabling policy, and to remove regulatory obstacles including barriers related to the relationship between independent aggregators and suppliers (ENTSO-E, 2015a).

A generic method is lacking with which stakeholders can identify in a systematic and consistent way barriers and associated solutions for developing flexibility mechanisms through aggregators. As a consequence, current overviews cannot be strictly comparable within the context of different countries (Pause and Caneva, 2016), and consist of an ad hoc set of barriers (Cappers et al., 2013). For this purpose, a generic method is developed which integrates elements from relevant approaches, and further contains a measure to account for country-specific preconditions. A country-specific precondition, e.g. consistency with the market model under question, sets boundaries to the search of potential solutions. Another novel contribution of this paper is a framework for categorising identified barriers. Cappers et al. have proposed a framework for a typology of barriers to DR participation but with sole focus on AS (Cappers et al., 2013). In our proposed framework, barriers are categorised among different areas of identified opportunities for the provision of market-based products and services through aggregators, whereas AS markets only address part of these opportunities. Such a framework has the advantage of making clear which barriers stand in the way for these opportunities to be realised. Furthermore, in the proposed framework, identified barriers are decomposed into their elements which provides clarity for stakeholders on the causes of its existence, and supports the process of identifying solutions to overcome them. The proposed method and framework are applied to the Netherlands as a case study and result in a systematic overview of all relevant issues for advancing the market integration of aggregator companies within the Dutch system.

The main objective of this research is to identify opportunities and barriers and propose solutions and actions for enabling flexibility through aggregators in power systems operations, from scheduling and operations, to verification and settlement within the current systems of programme responsibility (TenneT TSO B.V., 2014), and imbalance settlement in the Netherlands (TenneT TSO B.V., 2015). The research thus addresses the feasibility of new concepts for the provision of flexibility in the energy system by focusing on the market integration aspects. Note that issues related directly to the viability of particular business models of aggregators (e.g. revenue availability and capture for certain applications, cost of enabling technology and control infrastructure at the customer's side, customers' acceptance to certain DR programmes) are left outside of the research scope as those can differ significantly for each business case. The outcome is a set of recommended actions to progress the market integration of aggregators without major changes to the roles and responsibilities of market parties and grid operators, while remaining in line with the new European grid codes. The results are primarily meant to support the Dutch TSO to systematically structure its approach on the market integration of demand-side resources for flexibility services through aggregators in the Netherlands. However, the method as well as most of the findings are applicable and relevant in the broader European context of energy policy. This work aims to create more knowledge and better

understanding of the trends at the demand-side, the impact of flexibility deployment through aggregators from a system perspective, and how the envisioned opportunities can be exploited.

In order to identify opportunities, barriers and potential solutions for enabling flexibility through aggregators, this research focused on consistently answering the following questions:

- Which are the **opportunities** for the deployment of flexibility in the energy system through aggregators?
- What stands (**barriers**) in the way for these opportunities to be realised?
- How can the identified barriers be removed (**potential solutions**)?
- Which actions the Dutch TSO and/or the regulator might take to promote the proposed solutions (**recommendations**)?
- What is the importance of the identified barriers and proposed solutions (**priority level**)? Priorities were determined in terms of system impact and ease of implementation.

The paper is structured as follows: The research method is presented in Section 2, whereas the results follow in Section 3. The paper is concluded in Section 4, where also the policy implications are discussed.

2. Research method

The research involved a qualitative approach for identifying opportunities and barriers for developing flexibility mechanisms through aggregators, and determining potential solutions and a plan with prioritised actions. Previous research on the identification of barriers for the deployment and operations of business models for aggregators in several European Member States,³ employed desk research and questionnaire-based surveys including rankings to determine the most relevant barriers (Pause and Caneva, 2016). Painuly (2001) has proposed a framework for identifying barriers to the deployment of renewable energy technologies and for suggesting measures to overcome them, which is based on literature review, the study of existing projects, and interaction with stakeholders through interviews and/or questionnaires. Our proposed method follows a similar approach where opportunities and barriers were identified, and potential solutions were explored based on the review of the relevant literature and documentation, and interviews with experts and relevant stakeholders in the electricity sector.⁴ Rankings performed by the interviewees and the project partners were used to prioritise the identified barriers and proposed solutions. The research method is outlined in two steps (i.e. problem space formulation and development phase) and is graphically illustrated in Fig. 1.

2.1. Problem space formulation

The problem space is a representation of the problems in which the phenomena of interest reside, i.e. opportunities and barriers, and in which the search for potential solutions can take place.

An extensive *literature review* was performed to identify opportunities, barriers and potential solutions for enabling flexibility through aggregators in Europe, and particularly in the Netherlands. The relevance of a barrier should also be addressed in the context of each Member State separately since the status of the market deregulation

³ The study focused on Austria, Belgium, Germany, France, Italy, Cyprus, Portugal, Spain and the United Kingdom.

⁴ The approach followed during the interviews has some similarities with the Delphi method (i.e. the facilitator managed the interactions among the interviewees by collecting their input and filtering out irrelevant information, whereas the interviewees were asked to comment on their own viewpoints as well as on the responses of others), but also a main difference (i.e. the role of the facilitator was not to establish consensus among the interviewees but to reveal option items, including contradictory viewpoints).

² Equivalent to the term Demand Response (DR).



Fig. 1. Graphical illustration of the developed research method.
Source: Own elaboration, partly based on [Pause and Caneva \(2016\)](#), [Painuly \(2001\)](#).

process and the market design differ for each country ([Pause and Caneva, 2016](#)). Therefore, barriers can also be identified through a comparative analysis by framing the participation of aggregators in comparison to traditional service providers, based on the established national regulations and market rules. Thus, the literature review covered the procedures and requirements regarding the current systems of programme responsibility and imbalance settlement, and different options for contributing to balancing in the Netherlands. For the convenience of the reader, an overview of the main actors (including roles and tasks) in the Dutch electricity system is provided in the appendix (see [Table A.1](#)). The literature review covered the following topics:

- Historical and emerging cases of DR implementations through aggregators in Europe ([Lampropoulos et al., 2017, 2013b](#); [Universal Smart Energy Framework \(USEF\) Foundation, 2015](#); [Universal Smart Energy Framework \(USEF\) Foundation, 2016](#); [Smart Energy Demand Coalition \(SEDC\), 2015](#); [Verhaegen and Caneva, 2016](#)).
- Policy papers and regulatory recommendations for the deployment of flexibility ([Expert Group 3 Regulatory Recommendations for Smart Grids Deployment, 2015](#)), data management ([CEDEC 2016](#)), market rules ([The European parliament and the council of the European Union, 2009](#)), and developments at the demand-side and at the distribution level ([ENTSO-E, 2015a](#); [AF-Mercados 2015](#)).
- Barriers for the deployment and operations of current business models for aggregators ([Pause and Caneva, 2016](#)), the deployment of renewable energy technologies ([Painuly, 2001](#)), and DR providing AS ([Cappers et al., 2013](#)).
- Procedures and requirements regarding the current systems of programme responsibility and imbalance settlement in the Netherlands, i.e. operational planning (nomination and scheduling of exchange, bidding for regulating, reserve and incident reserve power), operations (request for upward and/or downward power, and dispatch), and settlement (verification and financial settlement) ([TenneT TSO B.V., 2005, 2010, 2012, 2014](#)).
- Different options for contributing to balancing in the Dutch system, i.e. reserves for frequency containment, reserves for frequency restoration through the bid price ladder (active contribution), voluntary response (passive contribution), emergency power (contracted capacity for incident reserves), and flexibility exchange through aggregators between market parties ([TenneT TSO B.V., 2016a](#); [ENTSO-E Ancillary Services Working Group, 2014](#); [Ophuis, 2015](#); [ENTSO-E, 2016](#)).

The interaction approach with stakeholders is considered as crucial for the identification of barriers, as their knowledge and perception may reveal gaps in existing procedures and policies, but also assist in identifying measures for overcoming identified barriers ([Painuly,](#)

[2001](#)). A number of *interviews* with experts and relevant stakeholders were conducted in person and by telephone. The interviews were recorded and subsequently transcribed. The approach was based on semi-structured interviews, which made it possible not only to validate the outcome of the literature review but also to incorporate additional input based on the interviewees' expertise regarding opportunities, barriers, and potential solutions. The eight (8) interviewees were selected to encompass a wide range of expertise and experiences, from multiple organisations, which also reflect different perspectives. The interviewees included five experts from the Dutch TSO, TenneT (departments of system management, system operations, AS procurement, customers and markets), two representatives of commercial parties (Balance Responsible Parties (BRPs), suppliers, aggregators) and a business process consultant from the Universal Smart Energy Framework (USEF) foundation, i.e. an association promoting the aggregator concept and the development of flexibility services. The questionnaire used during the interviews was structured on the basis of the five research questions (see [Section 1](#)). Questions were also framed around a number of preliminary opportunities and barriers which were identified through the literature review. Based on these preliminary identified barriers, measures to overcome these barriers were also included in the questionnaire to elicit the viewpoints of the interviewees on potential solutions, as suggested in [Painuly \(2001\)](#). The questionnaire was complemented by supplementary questions to address the position of the system operator and relevant stakeholders on the identified issues, the expected impact at system level by exploring the identified opportunities, any relevant developments that could add in the contextual knowledge, and any prerequisites and/or conditions before the potential solutions could be realised.

Currently, there is a debate both in the Netherlands and at the European level about positioning the aggregator concept as a new role in the energy system. Different countries approach this topic in different ways in terms of laws and regulations. The market design and principles can vary significantly among countries, therefore, it is important to account for any country-specific preconditions that set boundaries to the search of potential solutions. In the Netherlands, the positioning of the aggregator concept is currently undertaken in the context of the revision of the contractual agreements on emergency power⁵ ([TenneT TSO B.V., 2016a](#); [de Geus, 2016](#)), the Task Force Flex ([Flexiblepower Alliance Network, 2016](#)), the Energy Consultation Table ([van Ingen and Spaans, 2016](#)), and within the USEF foundation that promotes an international common standard for smart energy technologies and

⁵ The introduction of a tender for emergency power by the Dutch system operator in 2013, draw the attention of aggregators and this situation intensified the need for adapting the market rules and the model agreement on manual Frequency Restoration Reserves directly activated (mFRRda) between the system operator and service providers.

projects (Universal Smart Energy Framework (USEF) Foundation, 2015; Universal Smart Energy Framework (USEF) Foundation, 2016). USEF has provided a list of all the different implementation models of the aggregator concept (USEF, 2016), however, the applicability of each of these models to a specific context is dependent on the country's market design. The Dutch market model is based on the four basic principles of freedom of connection, transaction, dispatch, and choice in resource (EURELECTRIC, 2016), coupled with a system of Program Responsibility (TenneT TSO B.V., 2014), which is supported by the prominent BRP role, i.e. a party that has a contract proving financial security and balance responsibility (ENTSO-E, 2015b). Therefore, for the integration of the aggregator concept in the Dutch market, potential solutions for overcoming identified barriers shall comply with the following country-specific preconditions which are consistent with the current market model:

- The solutions should encourage market forces.
- The solutions should fit as much as possible in the current processes (including data exchange) in the energy market.
- The process must not be ambiguous in determining the energy balance, both at national level and at the level of individual parties, thus the imbalance of a connection must be clearly determined and assigned to the involved BRP(s).
- The process must be in line with the freedom of dispatch per connection and provide freedoms for the customers of a connection on exploiting their flexibility capabilities in a market-based environment.
- The prices should arise in the market and not be determined or influenced by the TSO.

2.2. Development phase

During the *development phase*, an action plan is developed with potential solutions and/or recommendations to overcome identified barriers and seize the opportunities. First, the identified opportunities are categorised into a number of areas for the provision of market-based products and services through aggregators, and the identified elements of barriers are framed among these areas. This process makes it possible to distinguish which issues stand as barriers for realising an identified opportunity. Subsequently, the identified elements of barriers are grouped under different types of barriers, and further organised into a number of main categories (i.e. market, regulatory, technical and social barriers) in a bottom-up approach. This results into a three-level hierarchical structure, i.e. the first level as a main category of barriers, the second level with different types of barriers within a category, and the third level with various elements of these types of barriers. An overview of considered types of barriers is provided in Table 1. The advantage of decomposing a barrier into its elements is clarity for stakeholders on the causes of its existence, and supports the process of identifying solutions

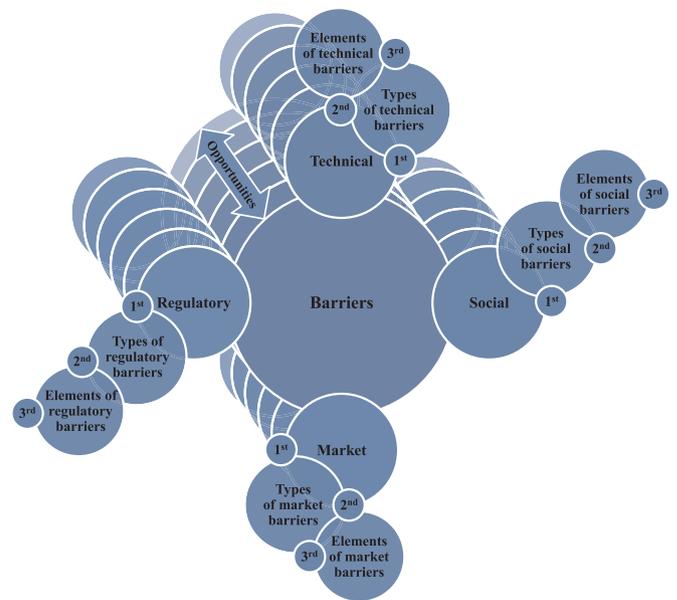


Fig. 2. Conceptual framework for the categorisation of barriers. Barriers are decomposed into three levels and framed among the areas with identified opportunities for the provision of market-based products and services through aggregators.

Source: Own elaboration, partly based on Painuly (2001).

to overcome them (Painuly, 2001). The conceptual framework which was used for the categorisation of barriers is illustrated in Fig. 2.

The approach of semi-structured interviews allowed the inclusion of additional issues addressed by the stakeholders that were beyond the issues covered through the literature review and the structured questions. Thus, the list of identified barriers and potential solutions was also expanded based on the input provided by the interviewees. Then, during the development phase a number of reiterations with the interviewees was performed to complement any missing information, to request for clarifications wherever necessary, and to give them the opportunity to comment on contradictory viewpoints which were provided by the other interviewees.

Subsequently, a plan was determined with prioritised actions for the Dutch TSO and National Regulatory Authority (NRA) to support the development of flexibility services and the market integration of aggregators. For each of the identified barriers and potential solutions, the project partners and the interviewees were asked to indicate the priority level in terms of two criteria, i.e. system impact and ease of implementation. The 'system impact' criterion refers to the opportunities that can be realised and/or the benefits that can be derived at system level by implementing a measure to overcome an identified

Table 1

Main categories and types of barriers.

Source: Own elaboration, partly based on Painuly (2001).

| Main categories of barriers | Types of barriers | Remarks |
|-----------------------------|--------------------------------------|---|
| Market | Design barriers | Certain market design characteristics might create barriers for participation and/or efficient market operations |
| | Entry thresholds | Entry requirements act as a barrier for market participation |
| | Lack of transparency | Barriers related to non-transparency and access to market information |
| | Process related barriers | Barriers related to the processes of tendering and/or forming contractual agreements |
| Regulatory | Lack of standards | Lack of institutions and/or initiatives to establish standards |
| | Market imperfections and distortions | Market imperfections and distortions refer to conditions and/or deliberate actions that might distort perfect competition |
| Technical | Metering and data exchange barriers | High technical requirements act as barriers for market participation |
| | Data access barriers | Difficulties in accessing metered data might impact the quality of service provision |
| Social | Lack of consumer acceptance | Lack of consumer acceptance to certain measures and/or technologies might impact the development of a market service |

barrier. The ‘ease of implementation’ criterion refers to the level of required effort and changes in the system for realising a proposed solution, e.g. a response indicating a high ease of implementation corresponds to a solution which can be implemented without major changes to the roles and responsibilities of market parties and grid operators and extensive modifications in the existing system. The priority levels were presented on the basis of the following options: Urgent/Semi-urgent/Nice to have.

3. Results

In this section, the identified opportunities, barriers and potential solutions for the deployment of flexibility in the Dutch energy system through aggregators are presented. This section is concluded with an action plan with priorities, where the most urgent barriers are listed.

3.1. Identification of opportunities, barriers and potential solutions

Based on the literature review and the interviews, six areas with opportunities for the deployment of flexibility through aggregators in the Dutch power system were identified. Opportunities were determined in terms of participation within the deregulated and market-based segments of the electricity sector, i.e. wholesale trade in spot markets, AS markets, over-the-counter trade of flexibility services, retail markets and other miscellaneous issues related to the provision of data services such as the roll-out status of smart metering systems and access to metered data. In the following sub-sections, the identified barriers, potential solutions and/or recommendations for the Dutch TSO and NRA are systematically presented for each of the areas with identified opportunities.

An overview of all identified barriers is provided in Table 2, listed among the six areas where opportunities for the provision of market-based products and services were identified. Identified barriers were categorised under four main categories, i.e. market, regulatory, technical and social, and further decomposed into types of barriers and their elements. A three-level numbering format is applied to the identified elements of barriers, in line with the hierarchical structure used for the decomposition of barriers. In total, there were thirty-one (31) identified elements of barriers which are discussed in the following sub-sections.

3.1.1. Spot markets

In the spot markets of the European Power Exchange (EPEX) Netherlands,⁶ i.e. day-ahead and (EPEX Netherlands, 2017), intra-day auctions (EPEX SPOT, 2017), market members can trade hourly instruments. The long settlement period can be seen as a market design barrier (1.1.1) as one hour is a relatively long time period for exchanging flexibility options, especially for aggregators that deal with relatively small capacities. Furthermore, market parties cannot effectively structure their e-programmes⁷ on an hourly basis since the imbalance settlement system is based on Imbalance Settlement Periods (ISPs) of 15 min. A solution would be to implement a settlement period of 15 min in the day-ahead and/or intra-day markets. This would require considerable time, but it is recommended to start considering it as it can support a more efficient use of operating reserves.

A second barrier (1.1.2) related to market design is the early timing of the Gate Closure Time (GCT), i.e. the closure of the day-ahead bidding. The EPEX day-ahead market (DAM) GCT (at 12:00 a.m. for the next full day from 00:00 to 24:00) is too early to support the forecast process and the integration of intermittent RES. A solution would be to move the DAM GCT closer to real-time operations.

⁶ Formerly Amsterdam Power eXchange (APX) Power NL.

⁷ All trades in EPEX Netherlands are notified to the Dutch TSO by double-sided nominations sent by both the exchange and the trading participants in the form of energy schedules (e-programmes).

A barrier (1.2.1) for relatively small market parties, including aggregators, to access the EPEX spot markets relates to high entry thresholds. The required fixed fees⁸ for participation at the EPEX spot markets (APX, 2014), can be too high for small size market parties. A light-membership option does not yet solve this problem, because the light-member still requires a full-member to process its orders, which incurs additional costs for light-members. The EPEX board could investigate the entry requirements and possible ways for lowering and standardising those.

A lack of transparency issue is the non-disclosure of the mathematical formula used by EPEX for calculating the amount of a collateral⁹ for a given transaction. This can be seen as a market barrier (1.3.1), and making transparent the formula could support especially small market participants with limited financial capacity in defining their market strategies.

Another market barrier (1.4.1) relates to EPEX market processes, such as long contracts, and long time periods to bring the contract into effect. The EPEX board could investigate ways to simplify the contractual procedures and accelerate the process of bringing a contract into effect.

TenneT TSO could have communicated and perhaps influence the above-mentioned issues in the past. However, since April 2015, APX and EPEX SPOT have integrated their businesses and TenneT does not hold shares in APX anymore (EPEX SPOT, 2015), thus its influence towards the board has been diminished. TenneT performs a number of non-regulated activities for supporting the proper and efficient operation of the energy market. The Energy Trading Platform Amsterdam (ETPA) is a recent development, started in April 2016, which lowers the market entry thresholds.¹⁰ Furthermore, ETPA enables market parties to trade energy in blocks of 15 min, one hour, one day, one weekend, or one week. TenneT has a share of about 40% in ETPA (TenneT TSO B.V., 2016b), and it is recommended to continue supporting this development which provides an alternative marketplace for relatively small market parties.

3.1.2. Ancillary services markets for operating reserves

The focus in this section is on market-based AS related to the provision of operating reserves. The European Network of Transmission System Operators for Electricity (ENTSO-E) defines operating reserves for balancing actions in three categories (ENTSO-E, 2013): Frequency Containment Reserves (FCR), Frequency Restoration Reserves (FRR), and replacement reserves (RR), which are comparable with the formerly defined primary, secondary and tertiary reserves.¹¹ The issues related to FCR and FRR are addressed in respectively, whereas the provision of RR, i.e. slow tertiary reserves, is not applicable in the Dutch system. A state-of-the-art overview of the operating reserves for balancing that are currently traded in the Netherlands is presented in the appendix (see Table B.1). Other AS which are currently traded in the Netherlands but are not treated in this paper, due to low relevance for aggregators,¹² are presented in Table B.2. This information is relevant for aggregators and other service providers for exploring

⁸ Fixed fees include a market entrance fee, membership fee (per annum), and technology fee (per annum).

⁹ Contracts on the EPEX Netherlands are fully collateralised, i.e. secured against the condition that a market participant might fail to meet its obligations.

¹⁰ ETPA enables the participation of small customers with distributed resources around 0.5 MW.

¹¹ The alignment of former and contemporary definitions for reserves is non-rigid, e.g. in the Dutch system, RR are not applicable, whereas the former tertiary reserves are categorised under FRR.

¹² Other types of ancillary services such as black start capability, provision of reactive power and compensation for network losses are not treated in this paper due to their low relevance for aggregators as these services require significant level of aggregation and are currently offered solely by large power plants. Nevertheless, with the further integration of distributed inverter-based systems, such as photovoltaics and storage technologies, these services might become relevant for aggregators in the future.

opportunities with respect to the provision of operating reserves for balancing and other AS in the Netherlands.

3.1.2.1. Provision of frequency containment reserves. The provision of FCR does not require a compensation for the activated energy and that makes it an interesting potential application for aggregators since there are no requirements for settling energy imbalances with other market parties such as suppliers and BRPs. However, there are relatively high requirements for metering and data exchange. Each unit that delivers FCR requires a metering system with a 4 s resolution. This technical requirement is a barrier (3.1.1) for aggregators to provide FCR through the aggregation of small scale resources because it would require to equip every single resource with a costly metering and data communication system. Since January 2016, TenneT is involved in pilot projects, with an end date in January 2018, to identify new solutions for the provision of FCR (TenneT TSO B.V., 2017a). In the course of 2017, TenneT is expected to start with another pilot about contracting of regulating (aFRR) and reserve capacity (mFRR). Continuous involvement of TenneT in Research and Development (R&D) activities and pilot projects together with research institutions and commercial parties can support the design of new technical rules for metering and data exchange to enable the participation of aggregators in FCR provision.

3.1.2.2. Provision of frequency restoration reserves. Standardised market processes, between suppliers, BRPs and aggregators, are lacking with respect to the provision of FRR, specifically regarding metering, allocation, billing, reconciliation, and data exchange, which can be seen as a regulatory barrier (2.1.1). In order to support the process of establishing proper arrangements and market rules that allow customers to access any service provider (including aggregators) of their choice, there is a prime need to develop standardised market processes for enabling the proper information exchange between market parties, and indisputable methods for metering and defining the allocation of imbalances, billing figures and reconciliation issues. It is recommended to TenneT to investigate through R&D activities whether the Central register system (C-AR) system¹³ could be used for facilitating the communication and commercial activities between market parties that are associated with connections with the same EANs.

A major regulatory barrier for further developing commercial DR for the provision of operating reserves is the lack of standards for settling energy imbalances between the customers (or their aggregator) and their suppliers. This barrier element (2.1.2) relates to the *transfer of energy* issue i.e. an energy settlement between the aggregator's BRP and the supplier (and/or its BRP), and currently concerns mFRRda. However, in the future, it is relevant to consider also other balancing products and services. Apparently, there is a need for supporting the design of a standardised solution that enables the proper communication and interaction between market parties. The solution should enable that aggregators can facilitate these transactions on behalf of their customers (the connected parties). The solution must also include a baseline method to quantify the performance of flexibility service providers and provide a basis for the *transfer of energy*. Currently, TenneT is in discussions with market parties about a new concept proposal for the provision of emergency power (de Geus, 2016). It is recommended to continue this dialogue and to initiate a research project for investigating the optimal solution.

The technical requirements for aFRR provision are very high (e.g.

¹³ The C-AR system contains all grid connections, registered in terms of European Article Numbers (EANs), with information about the associated Supplier, BRP and metering responsible party for each connection. The C-AR is currently administered by Energie Data Services Nederland (EDSN) which is owned by the grid operators (including TenneT & Gas Transport Services). More info about the C-AR system, e.g. detailed C-AR attributes list, can be found in Energie Data Services Nederland (EDSN) (2013).

with respect to the delta signal exchange from the TSO to a Balancing Service Provider (BSP), and the response signal from a BSP to the TSO¹⁴). Furthermore, the rule is such that each unit that delivers aFRR requires a metering system with a 4 s resolution similar to the case of FCR provision. This can be seen as a technical barrier (3.1.2), especially for aggregators that deal with large numbers of distributed resources. Research can be conducted to investigate how aggregators can provide aFRR without major modifications in the existing system. A balance needs to be found between expensive technical solutions and adaptation of rules.

The verification of aFRR is based on a visual inspection which is performed manually by TenneT staff. This can be seen as a lack of standards barrier (2.1.3) as it would be too time intensive for a large number of market parties participating in aFRR provision. The current verification process with visual inspection could be replaced by an automated process (Lampropoulos et al., 2012).

The time period between bidding and activation of aFRR is currently one full clock hour. Thus the lead time (i.e. the period between bidding and activation of a bid) is between 4 and 7 ISPs. This lead time is too long for effectively integrating DR in aFRR provision and supporting the integration of intermittent RES into the system, and can be seen as a market design barrier (1.1.3). The lead time applies also to mFRRsa but not to mFRRda. A first improvement could be to make the lead time for aFRR constant (equal to 4 ISPs), whereas an even shorter lead time can be facilitated by automation. It is recommended to TenneT to initiate a discussion between the IT department and the department of Markets about a possible reduction of the lead time, and associated implementation requirements.

The tenders for the provision of aFRR require products that are symmetric for upward and downward capacity. However, most demand-side resources cannot be regulated in a symmetric way, which is a barrier (1.4.2) for participation. It is recommended to TenneT to continue the ongoing efforts in enabling separate contracts for upwards and downwards aFRR capacity in the tender phase.

The periods for which the aFRR contracts apply, are still too long (i.e. annual/quarterly contracts) which can be seen as a market barrier (1.4.3). By enabling shorter contract periods (e.g. from quarterly to weekly), providers can better plan their resources (e.g. due to weather dependencies). It is recommended to TenneT to start considering the possibility of weekly contracts for aFRR.

Aggregators have started entering into contractual agreements with the Dutch TSO for the provision of mFRRda. In 2016, TenneT had to activate mFRRda but these reserves are not visible in the merit order list for FRR. Non-transparency in the market is a barrier (1.3.2) for aggregators and other market parties in order to effectively perform their activities. The process of making the mFRRda capacity supplementary to the FRR merit order list is on-going, and this item is part of the new concept proposal for the provision of mFRRda (ENTSO-E Ancillary Services Working Group, 2014). It is recommended to TenneT to continue this planned implementation in close cooperation with market parties.

A market barrier (1.3.3) related to non-transparency concerns the provision of mFRRsa. In some cases, TenneT might bypass the bids for mFRRsa in the merit order list by calling mFRRda in order to effectively deal with considerable system imbalances. Whether to bypass mFRRsa bids from the merit order list or not is a decision of the human operator, but the exact criteria are not disclosed. Market parties are concerned about it, especially since mFRRsa receive only payments for the energy component (capacity payments are not applicable). A potential solution could be to inform the market parties and allow them to withdraw their mFRRsa bids once there is an activation of mFRRda. In this way, the providers of mFRRsa capacity can use it for other purposes (own

¹⁴ The response signal is required by the TSO to verify the compliance with the dispatch signal (i.e. the delta signal).

imbalances or passive contribution).

After several postponements, the tender for contracting also downwards mFFRda capacity,¹⁵ was official announced (TenneT TSO B.V., 2016c), and published in TenderNed.¹⁶ Still, TenneT does not allow parties to provide both upwards and downwards mFFRda because there may be situations where the TSO would like to use both types of mFFRda at a given time in a particular area. This can be seen as a market barrier (1.4.4). TenneT is currently investigating whether any adjustments can be made, to enable companies to provide both services in 2017/2018 (Duijnsmayer, 2017). It is recommended to TenneT to continue with this implementation and to ensure that all relevant system data are available and accessible since there were no registrations for downwards mFFRda in the online portal of historical data for the first semester of 2017 (TenneT TSO B.V., 2017b).

The economic incentives for the provision of mFFRda are reducing, whereas the requirements for contributions are increasing. Market parties have claimed that the capacity fees are relatively low and are decreasing over the past years, whereas the activation times of mFFRda is increasing. Even though the decreasing capacity fees for mFFRda is a result of the competitive market, the actual characteristics for activation of mFFRda can be seen as a barrier (2.2.1) and could be revised. The issue regarding the frequency of activations for mFFRda could be further investigated through research activities.

A market entry barrier (1.2.2) in the provision of aFRR and mFRR is about the requirements for minimum bid sizes (see Table B.1), which might prevent small-scale aggregators to offer these services. A potential solution would be either to lower these thresholds or remove the bid size constraints for all products. However, the reduction or removal of the minimum bid sizes would require an automated system to process the bids, otherwise the system will become too complex with an increasing number of smaller bids.

A regulatory barrier (2.1.4) which obscures aggregators from cross border exchange of FRR is that balancing markets and products are not harmonised in Europe. Currently, only TSO-TSO cooperation for the exchange of mFFRda is possible which entails the inter-TSO cooperation for procuring reserves solely from BSPs within their own Load Frequency Control (LFC) Block.¹⁷ Integrating markets for FRR through a common merit order list requires to tackle the differences in pricing schemes among countries/systems (pay-as-bid, or pay-marginal schemes as in the Netherlands), in accordance with the development of the ENTSO-E Network Code on Electricity Balancing.

Aggregators that carry the BRP role can provide passive contribution in system balancing which is considered a low-key business model, i.e. a BRP that faces an own imbalance which alleviates the system imbalance during an ISP will subsequently receive financial benefits. Its simplicity is considered an advantage, but aggregators and other market parties face high risks when system state 2 occurs,¹⁸ especially at the end of the ISP when there is little room for adjustments. The definition of state 2 and the associated financial risks can be perceived as a market design barrier (1.1.4). Research activities could contribute in revising the market design, specifically with respect to the definition of system state 2.

3.1.3. Regional network and congestion management services

The provision of AS at the distribution level is a topic that is getting increasing attention with the further decarbonisation of heating systems in buildings and the transport system, as well as with the further

integration of distributed generation and energy storage at the distribution level. Distributed energy resources have the potential to provide AS to grid operators (both at the transmission and distribution level), possibly with competing objectives. With the development of active distribution grid management, it becomes essential to establish procedures to identify and solve possible TSO/DSO conflicts that take place when requesting and/or procuring AS from flexible distributed resources (Zecchino et al., 2017). Currently there is no available platform to enable the provision of AS at the regional distribution level and the proper communication between system users, market parties and grid operators, which can be seen as a regulatory barrier (2.1.5). The regulatory framework and subsequent data management model should support the data exchange, taking into account the needs of TSOs and DSOs to receive relevant information (CEDEC et al., 2016). It is recommended to start a dialogue on whether (and how) a common platform can accommodate transactions of flexibility for different purposes and actors on a level playing field. Solutions could be developed on top of existing platforms, e.g. the ETPA could facilitate location-specific services by attributing location tags to the submitted bids, whereas R&D activities could address future concepts. Relevant aspects are about defining administrative areas to handle congestion, and exact criteria for coordinating the interaction between the TSO and DSOs, and market parties. Relevant developments that could contribute in this direction are the USEF common reference model for communicating congestion incidents and congestion areas in the distribution grid, and the C-AR system.

A market barrier (1.4.5) related to the flexibility provision at the distribution level, in the Netherlands, is about the limited available options in terms of differentiated components in the distribution tariff (AF-Mercados et al., 2015). Specifically, there is no time of use differentiation in electricity distributions tariff for all consumer groups. Furthermore, there is a disproportionate share of costs borne by residential customers, and to a lesser extent by commercial customers, based on their consumption. Finally, regarding connection charges, only shallow charges are in effect for consumers and embedded generators and there are no targets and/or incentive schemes in place to enhance hosting capacity. The voltage level and the contractual power are the main variables for identifying tariff categories in the Netherlands. The distribution tariff for residential customers includes a fixed charge, a capacity charge¹⁹ and a charge for metering.²⁰ Usually in the countries where the system users pay for a capacity charge, they do not pay for a fixed charge.²¹ DSOs have full responsibility for managing and owning the meters for small customers. Suppliers are responsible for the collection and validation of the data. Possible improvement could address the implementation of differentiated tariffs for grid connections by the DSOs (in a bottom-up approach), e.g. during certain time periods would provide a price incentive for customers' responsiveness, and considerations for reducing the disproportionate share of costs borne by residential customers based on their energy consumption by revising the components of fixed charges and/or capacity charges. Furthermore, more sophisticated methods for calculating the connection charges, e.g. offering different options to customers based on their capacity, may provide incentives for the deployment of smart grid technologies at the customers' side in order to benefit from lower connection charges. In the Netherlands the main responsible parties in setting distribution tariffs are the DSO and the NRA.²²

¹⁹ The capacity charge depends on the maximum power contracted and billed to end-users in €/kW.

²⁰ The metering charge is only applied to small customers.

²¹ In the Netherlands, the fixed charge is 215 € (in the average distribution network cost for the year 2013) for households (AF-Mercados et al., 2015). Household consumer are typically defined as having a 3 × 25A connection with an annual average consumption of 3500 kWh connected to the low voltage grid and a contracted capacity of 6 kW.

²² First, the DSOs propose tariffs (and allocations of total income) to the NRA, then the minister of Economic Affairs sets the principal tariff structure, and finally the NRA makes

¹⁵ The Tender for both upwards (350 MW) and downwards (200 MW) mFFRda capacity for the first semester of 2017 was announced in late September 2016.

¹⁶ TenderNed is the procurement system of the Dutch government.

¹⁷ The TSO-TSO cooperation concept is considered as straightforward with least prerequisites, transparent and socio-economic benefits (de Haan, 2016). No foreign BSP-TSO communication is present in this cooperation concept.

¹⁸ System state 2 corresponds to both upward and downward regulation during an ISP (TenneT TSO B.V., 2015).

3.1.4. Flexibility service provision between market parties

Enabling the provision of flexibility services between market parties is an issue within the commercial domain. In general, it should be possible for different market parties (including aggregators) to be active behind a single connection, so that market parties can define their business cases without the need for extensive regulation. Existing arrangements are based on contractual agreements between market parties and/or relationships between parent companies and their subsidiaries. The lack of standards for additional sub-metering behind a point of connection to support the settlement process between collaborating market parties can be seen as a regulatory barrier (2.1.6). The ETPA could provide a potential solution as a trading platform capable of providing access to flexible capacity with opportunities to conclude short-term intra-day contracts.

3.1.5. Retail market for energy supply and demand response

In the Netherlands, the ‘Vangnet’ regulation²³ is a guarantee scheme to ensure that reasonable rates are charged to retail customers for the supply of electricity and gas (Janssen, 2011). Suppliers have to negotiate with the NRA which retail tariffs they may apply. According to the Ministry of Economic Affairs there are no regulated prices for energy supply in the Netherlands, and the ‘Vangnet’ regulation is a ‘last resort’ regulation to protect customers. However, the way this legislation is interpreted and executed by the NRA can be seen as a regulatory barrier (2.2.2) for developing DR programmes. The NRA has many requirements for suppliers that would like to offer DR programmes to their customers, such as variable pricing schemes and also ‘threatens’ suppliers who are charging their customers too much, according to the secret calculation method of the NRA, Authority for Consumers and Markets (ACM), with public disclosure and an official warning. Public disclosure of such a decision means by definition major reputational damage for the involved supplier (Janssen, 2011). Suppliers are concerned with receiving such an official warning because customers would probably switch in bulk to others and that could lead them to bankruptcy. This situation might result into a very conservative behaviour of suppliers and can be interpreted as a barrier for the development of DR mechanisms. The ‘Vangnet’ regulation has been criticised as an unnecessary administrative burden, and its abolition has been recommended since public interests can be safeguarded with more targeted, less extensive and less controversial measures (Janssen, 2011). The NRA could start promoting DR by publishing the secret calculation method that is used for regulating the supply prices. Adjustments in the regulation or even abolishment of the ‘Vangnet’ regulation in communication with the NRA, ACM, could be a way forward in stimulating DR but this would require the change of the law. However, even if the ministry could be convinced, then they most probably would not initiate the necessary change of the law because of concerns that there will be no sufficient political support for abolishment in the parliament. A mainstream perception among politicians is that suppliers are making big profits at the expense of their customers.

A regulatory barrier (2.1.7) that can hinder the development of DR is the lack of standard baseline methods to support verification and settlement procedures, and the lack of methods to account for the ‘rebound’ effect, e.g. the load increase following the activation of a DR measure, and its impact on the positions of BRPs and suppliers. The deployment of electronic meters can support the development of more sophisticated methods for establishing baselines. Depending on the DR resource in question and its operational characteristics, appropriate models for estimating the ‘rebound’ effect can be developed through R&D activities. Such models can be used for adjusting the positions of involved market parties and determining compensation measures.

(footnote continued)

the decision on proposed tariffs (AF-Mercados et al., 2015).

²³ English translation: Safety net regulation.

New market entrants such as aggregators or small suppliers should be able to compete at a level playing field with incumbent market players in attracting new customers. This could increase the competition in the electricity market. However, in some cases, small suppliers have difficulties to attract customers that ask for long-term fixed-price contracts, because the suppliers have to ask for a collateral in return, pledged as security to be forfeited in the event of a default. Large suppliers have the financial capacity to provide long-term contracts at fixed prices without asking for a collateral. This situation can distort the level playing and create a barrier (2.2.3) for small suppliers and aggregators. Furthermore, another obstruction for relatively small suppliers with low financial capacity is that large suppliers might even offer energy retail prices to their customers that are below the market prices. The NRA, ACM, should investigate whether such incidents actually distort the competition and establish a level playing field with incumbent utilities by taking appropriate measures, e.g. the creation of a niche environment for new market entrants. Though, such measures should be implemented in a manner that does not obscure the free market development.

3.1.6. Data services

Other barriers are related to the roll-out of smart metering systems and access to metered data. Aggregators can gather data from smart meters of associated customers and/or other sources (e.g. weather data, market data), create data analytics, and provide consultancy services to various parties (e.g. their customers, grid operators).

Currently, customers in the Netherlands can access their consumption data via a DSO web portal, with quarter-hourly readings available one day after consumption. The resolution of 15 min readings can be seen as a technical barrier (3.1.3) as it is too long to support contributions within an ISP (e.g. provision of aFRR), whereas the one day delay can be seen as a data access barrier (3.2.1) which might hinder the provision of services close to real-time operations. Enabling the access to high resolution smart meter data, and closer to real-time operations can support the development of new services around the aggregator concept.

The slow deployment of smart meters due to low acceptance, especially from relatively small consumers, is hindering the participation of the demand-side in smart grid applications and can be seen as a social barrier (4.1.1). The TSO and the NRA could support the process of customers’ empowerment through education and by promoting adequate representation of the customers’ perspectives in relevant working groups.

The profile-based allocation system²⁴ actually obscures BRPs/suppliers from reaping the full benefits of DR measures and can be seen as a regulatory barrier (2.1.8). Apparently, there is a need for establishing official solutions for smart meter data access (standard metering procedures and exchange messages), so that market parties and customers can define their business cases. The Dutch TSO could act as facilitator in such a development or even as the operator of a central data hub as the Danish TSO (energinet.dk) that is managing the data hub in Denmark. Another example is the data hub owned and controlled by national industry associations in Sweden (van den Oosterkamp et al., 2014). TenneT has the ambition to play a bigger role in the area of smart meter data access. The Association of Dutch Energy Data Exchange, NEDU, is also involved in this discussion, as well as the Ministry of Economic Affairs. In the Netherlands, the market reference model on options of handling smart meter data is that of a (regulated) independent central communication platform, i.e. the EDSN central data platform owned by network operators. EDSN ensures that only authorized parties receive

²⁴ Profile-based allocation means that the BRP/supplier buys the energy at wholesale level based on a predetermined profile of its customers and that the settlement is also based on this profile followed by a reconciliation process at the end of the year where the market parties have to settle the differences between them based on the annual metered values.

and send data. EDSN certifies measuring technology Independent Services Providers.²⁵

Aggregators can benefit from having access to a central data hub with information about the characteristics of their customers (e.g. the associated BRPs and/or suppliers, registration of local generation units). Such a data centre could support market operations (e.g. support a simple and straightforward switching process for customers to another BRP/supplier), support system operations (e.g. support quality control by the TSO for balancing contributions), and facilitate aggregators in managing their new customers and developing new proposition for retail customers by getting access in registered information which would not be available otherwise. The absence of a registration system with the associated connections of a BRP and/or BSP can be seen as a regulatory barrier (2.1.9). Every connection has a unique EAN, but these are not mentioned in the e-programmes of the BRPs²⁶ which are portfolio-based. Without this information, it is difficult for the TSO to exercise a quality control on (some) connections that provide balancing services (e.g. aFRR or mFRRda), which creates a barrier for the development of new (portfolio-based) flexibility services through aggregator companies (e.g. aggregators acting as BSPs). A potential solution could be to establish a central data hub where each unique EAN code is linked to a unique address, and an associated BRP and supplier, including information about local generation, flexible demand and storage, e.g. by merging the C-AR with the Production Installation Registry (PIR).²⁷ That would require the cooperation between the TSO and DSOs who operate the grids below 110/150 kV since each DSO institution has its own database about the connected parties to their operating grids.

3.2. Action plan with priorities

Based on our analysis, a number of opportunities, barriers, and potential solutions were identified, and recommendations were accordingly drawn up to stimulate the market integration of demand-side resources through aggregators in the Netherlands.

By reviewing the identified issues in the previous section, a number of barriers and potential solutions are prioritised for progressing the market integration of aggregators within the current systems of programme responsibility and imbalance settlement in the Netherlands. Priorities were determined through the interviews with the experts and relevant stakeholders. The responses were averaged and are presented in Table 3 on the basis of the following options: Urgent/Semi-urgent/Nice to have. Even though the sample (11 responses²⁸) was relatively small, a trend was empirically observed. Note that many of the prioritised items point out to the need for policy interventions and/or follow-up research activities. Specifically, the prioritised items point out to the need for review and adaptation of the rules for the provision of operating reserves, the need to support the roll-out of smart metering systems and to develop standardised solutions for smart meter data access, including solutions for sub-metering, lowering the entry requirements in spot markets for relatively small market parties, and the development of a framework for the provision of services at the distribution level.

3.3. Market development and expected system impact

The propositions presented in the previous sub-sections are meant

²⁵ The Dutch term for these Independent Services Providers is Onafhankelijke Diensten Aanbieder (ODA).

²⁶ For becoming acknowledged as BRP, there are two options, only trade or fully acknowledged, but in both cases it is not necessary to mention which are the associated EAN connections.

²⁷ The PIR (www.energieleveren.nl) is an initiative of the association of network operators (Netbeheer Nederland). The customers that own/operate local generation units can register their plants in PIR, through which the DSOs can be informed and act accordingly to ensure the security of the network.

²⁸ The sample consisted of the responses of the eight selected interviewees, and the three academic partners.

to facilitate the participation of aggregators and demand-side resources in the electricity market, by recommending actions for increasing market transparency, establishing standards, revising the market design and processes. Recent experience shows that the participation of aggregators in the electricity market is contributing to increased competition and liquidity, and this trend is expected to continue with the further integration of demand-side resources. In this section, we present facts and figures about the potential system impact and the market development in the Netherlands by focusing on two developed markets: the spot and balancing markets.

3.3.1. Spot markets

Price volatility in spot markets is expected to be an important driver for the development of flexibility options through aggregators. However, computer simulations utilising historical data of the day-ahead market have shown that the potential revenues from energy arbitrage are declining, and were about 2.8 times less in 2015 compared to 2000, mainly due to a decrease in price volatility in the APX day-ahead market over the years (Lampropoulos et al., 2017). In 2016, overall price differences became smaller in the CWE region.²⁹ The average monthly price in Germany dropped to a record low of 22 €/MWh in February 2016. The volatility of hourly day-ahead prices for the Netherlands remained comparable to 2015, i.e. a slight increase of less than 1 €/MWh between 2015 and 2016. The low prices, especially in the first two thirds of 2016, are mainly due to low generation costs associated with low prices for fuels and CO₂ emission allowances (TenneT TSO B.V., 2017c). One study has attempted to determine volumes and prices of flexibility on the future day-ahead market in the Netherlands given a scenario with increasing levels of intermittent RES, and the results show that next to an increase in the demand for flexibility, there will also be an increase in price volatility, and the average price in the year 2023 will be considerably higher (~ 82 €) compared to 2012 (~ 46 €) and 2017 (~ 35 €), given the assumptions for higher coal and gas prices in 2023 (van Hout et al., 2014).

The hourly product resolution in spot markets is a restricting factor for load serving participants in purchasing energy volumes that match the load profiles of their customers (TenneT TSO B.V., 2017c). The proposition of implementing a settlement period of 15 min in the EPEX day-ahead and/or intra-day market is expected to result in increased market liquidity. In 2016, the intra-day trading volumes increased in Germany, especially for 15 min products, whereas the trading volumes decreased in the Netherlands where the product resolution is one hour (TenneT TSO B.V., 2017c). Overall, the volumes on the intra-day market in the Netherlands are considerable less than those in Germany. This is due to the smaller size of the Dutch market, a lower integration of intermittent RES, and the design of the balancing market which allows the passive contribution in system balancing thus taking advantage of a market opportunity which is otherwise realised by intra-day trade (TenneT TSO B.V., 2017c). In the Netherlands, the intra-day trading volumes were about 1.8% of the day-ahead volumes for EPEX Spot in 2016 (TenneT TSO B.V., 2017c). An increase in traded volumes from 2013 to 2014 was followed by a decrease in both 2015 and 2016, mainly due to the decreasing trading volumes at Nord Pool.³⁰

3.3.2. Balancing markets

The traded capacities in the common German tender process for FCR increased in 2016/2017, with more international TSOs joining the

²⁹ Central Western European (CWE) market region formed by Austria, Belgium, France, Germany, Luxembourg and the Netherlands.

³⁰ The intra-day trading volume at Nord Pool in 2016 was 25% of the volume in 2014. This is mainly due to the migration of the APX Power NL and Belpex intra-day markets from the trading platform Elbas to Eurolight in September 2015, whereas intra-day trade between Norway and the Netherlands continued on the Elbas platform, thus leading to a division in liquidity over these platforms (TenneT TSO B.V., 2017c).

Table 3

Priorities for overcoming identified barriers to support the development of flexibility services and the market integration of aggregators in the Netherlands.
Source: Own elaboration.

| Rank | Barrier element | Identifier | Priority level |
|------|---|------------|--------------------------|
| 1 | Regulatory – Lack of standards: Determination of transfer of energy for mFRRda | 2.1.2 | Urgent |
| 2 | Market – Lack of transparency: Non-visibility of mFRRda in the FRR merit order list | 1.3.2 | Urgent |
| 3 | Regulatory – Lack of standards: Metering, allocation, billing, reconciliation and data exchange | 2.1.1 | Urgent/Semi-urgent |
| 4 | Market – Design: Length of lead time for aFRR | 1.1.3 | Urgent/Semi-urgent |
| 5 | Regulatory – Lack of standards: Solution for smart meter data access | 2.1.8 | Semi-urgent |
| 6 | Regulatory – Lack of standards: Register of connections | 2.1.9 | Semi-urgent |
| 7 | Regulatory – Lack of standards: Sub-metering to support settlement processes | 2.1.6 | Semi-urgent |
| 8 | Market – Process: Separate provision of upwards and downwards mFRRda | 1.4.4 | Semi-urgent/Nice to have |
| 9 | Market – Design: Length of settlement period | 1.1.1 | Semi-urgent/Nice to have |
| 10 | Technical – Metering and data exchange: Requirements for FCR | 3.1.1 | Semi-urgent/Nice to have |
| 11 | Technical – Metering and data exchange: Requirements for aFRR | 3.1.2 | Semi-urgent/Nice to have |
| 12 | Market – Process: Duration of contracts for aFRR | 1.4.3 | Semi-urgent/Nice to have |
| 13 | Market – Process: Requirement for symmetric bids for aFRR | 1.4.2 | Semi-urgent/Nice to have |
| 14 | Regulatory – Market imperfections and distortions: Activation characteristics for mFRRda | 2.2.1 | Semi-urgent/Nice to have |
| 15 | Regulatory – Lack of standards: Platform for regional congestion management | 2.1.5 | Semi-urgent/Nice to have |

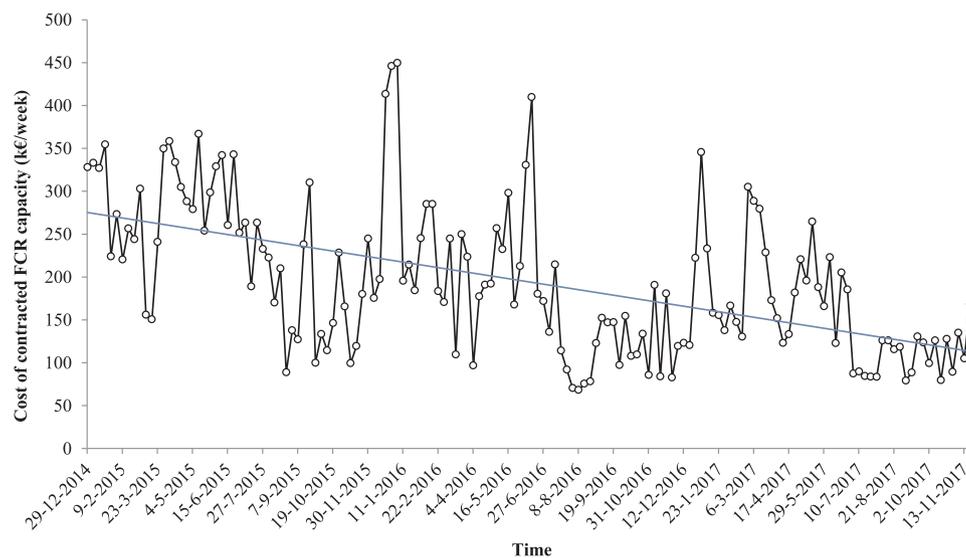


Fig. 3. Cost development of contracted Frequency Containment Reserve (FCR) capacity in the Netherlands from 2014 to 2017 based on the weekly auctions in the German platform (ENTSO-E, 2017). The blue line illustrates the linear trend of decreasing weekly cost.

process.³¹ As a result of to the higher liquidity of in the FCR tender process, the prices for contracted FCR capacity are decreasing and the maximum contracted prices are converging towards the average contracted prices (TenneT TSO B.V., 2017c). This convergence is likely due to a more competitive market, where all market players place bids with similar prices, an assumption that is also supported by the fact that FCR prices have fallen over the past six years (TenneT TSO B.V., 2017c). The Dutch TSO, TenneT, joined the German platform of weekly auctions for primary reserves in 2014. In Fig. 3, the cost development of contracted FCR capacity in the Netherlands is illustrated based on the clearing of the weekly auctions in the German platform (Regelleistung, 2017). The trend of decreasing cost is also attributed to the increase of auctioned capacity via the German platform, and a more competitive market, and reflects the cost savings at system level for the Dutch TSO.

The further integration of the FCR market results into commercial

³¹ The demand for FCR capacity in the auction organised by the four TSOs in Germany increased between 2014 and 2017. TenneT NL (the Dutch TSO) joined the call for tenders in 2014, increasing the demand from 583 MW to 628 MW. In 2015, APG (the Austrian TSO) and Swissgrid (the Swiss TSO) joined the call for tenders, resulting in an auctioned demand of about 793 MW. On August 1st, 2016, Elia (the Belgian TSO) joined the process, resulting into a procured amount around 830 MW. At the beginning of 2017, RTE (the French TSO) joined the coordinated tender, increasing the volume further to 1400 MW (TenneT TSO B.V., 2017c).

opportunities for new providers, including battery operators. In the Netherlands, AES Corp. installed a 10 MW lithium-ion battery system providing FCR from the Zeeland Province, whereas a company called ‘The New Motion’ has aggregated more than 19,000 electric vehicle (EV) charging stations starting from January 2016 to provide FCR by adjusting the charging process of EVs. Due to the low operating costs of batteries, the new systems being installed are expected to have an impact on the FCR market (TenneT TSO B.V., 2017c).

Another relevant development, with significant efficiency gains on the side of TSOs, is about the avoidance of counteracting activation of aFRR through the International Grid Control Cooperation (IGCC).³² The total volume of netted imbalances through IGCC is steadily increasing since its initiation in 2011. On February 2016, the French TSO, RTE, joined the IGCC, and the inclusion of this large LFC block has resulted in a significant increase of the netted volumes. In certain months of 2016 the netted volumes were doubled in comparison to the previous year (TenneT TSO B.V., 2017c). This development results into significant economic savings for TSOs.

³² The IGCC currently consists of 11 TSOs, and is the largest imbalance netting cooperation in Continental Europe. The ENTSO-E is following this project as part of the implementation of the Electricity Balancing Guideline (EBGL) which is expected to enter into force in late 2017 (TenneT TSO B.V., 2017c).

3.4. Relevance to the European context

In this section the applicability of the developed method and key findings achieved for the Dutch system to the broader European context of energy policy are further discussed.

The developed method is generic in the sense that it can be applied to different systems for the identification of opportunities, barriers and potential solutions in developing flexibility mechanisms through aggregator companies. Within the broader European context of energy policy, the relevance of a barrier and associated solutions should be addressed in each Member State separately due to the differences in market models and principles. The proposed method contains a measure to account for country-specific preconditions which set boundaries to the search of potential solutions. Such an approach can unveil similarities among market models at national-level and support the replication of solutions from one Member State to another.

Key findings for the Dutch system in further unlocking flexibility, and integrating the aggregator concept in the market, are about the need of establishing standards for metering, allocation, billing, reconciliation and data exchange, shortening the lead time for aFRR and the length of the settlement period in spot markets, and enabling the provision of ancillary services at the regional distribution level. These issues have also been identified as barriers in other Member States (Pause and Caneva, 2016). Standards are necessary for overcoming the *transfer of energy* issue in the case that the portfolio of an aggregator consists of customers that belong to several suppliers and BRPs. Smart meter data should be easily accessible so that market parties can complete commercial deals with each other, ensuring that energy positions can be established beyond doubt and imbalance volumes can be attributed to the correct market parties. Such a complication was already observed in France in 2011 (Lampropoulos et al., 2013b). The different approaches in dealing with this issue also reveals the different market principles and requirements among Member States. For instance, in France the TSO compensates the associated suppliers for the *transfer of energy*, whereas in the Netherlands the TSO facilitates the exchange of data and info and let the market parties solve any dispute, without taking a commercial position in-between. These different approaches at national-level, also indicate the lack of clear guidelines to facilitate aggregators in the E.U. (Pause and Caneva, 2016). The application of the proposed method can reveal differences among national market designs, and this knowledge is relevant for the E.C. in defining guidelines towards the integration of the energy market and for reaching the E.U. energy policy objectives, while taking into account the deployment of national-level policies.

4. Conclusions and policy implications

In recent years, the concept of the aggregator has emerged in Europe, in response to a general quest for flexibility in power systems driven by the increasing integration of RES and the ongoing deregulation of electricity markets. The main contribution of this work is a new method to map opportunities, barriers and possible solutions for enabling flexibility through aggregators, in order to support the process of developing new flexibility services and appropriate regulatory frameworks. The barriers have to be identified and overcome before the opportunities for aggregators can be realised. The proposed method is based on literature review and interaction with stakeholders through semi-structured interviews. Even though the method is applied to the Netherlands as a case study, it is applicable and relevant in the broader European context.

Unlocking the potential of flexibility in the energy market on the basis of a level playing field for all actors is of great importance. The results of this research are expected to enable and drive the development of new business models and services around the aggregator

concept, especially in the Netherlands which was the focus of this study. The results are primarily meant to be used by the Dutch TSO to systematically structure its approach to progress the market integration of demand-side resources for flexibility services through aggregators, and by the Dutch regulator to enable the necessary regulations and policy adaptations that will allow aggregators to compete in a level playing field with incumbent utilities and market parties, and make the provision of flexibility services possible at different levels, from regional to international level. The analysis revealed a strong relevance to AS markets for the provision of operating reserves, and especially for products related to frequency restoration reserves.

For the TSO there are some crucial issues in further unlocking flexibility and integrating the aggregator concept in the Dutch market, namely making available the necessary data, based on which market parties can complete commercial deals with each other, ensuring that energy positions can be established beyond doubt and imbalance volumes can be attributed to the correct market parties. The TSO, as a market facilitator, is working in close cooperation with market participants in order to tackle these issues and ensure the proper integration of the aggregator concept and a level playing field for all actors in the market. This will require policy adaptation for the provision of operating reserves, i.e. adjustments in the model agreement for mFRRda, and the rules for the provision of FRR. Other important issues are related to the access of data, since some processes have to be adjusted and/or expanded and the smart meter data must be easily accessible to support new business models around the aggregator concept.

The Dutch regulator can play a key role in advancing the development of DR programmes for retail customers in the Netherlands. That would require the revision of the ‘Vangnet’ regulation which is meant as a guarantee scheme for ensuring reasonable applied retail tariffs for the supply of electricity. Specifically, the regulator could promote the development of DR by publicly disclosing the calculation method which is used for regulating the supply tariffs. Furthermore, the regulator should investigate any incidents that might distort the competition and establish a level playing field with incumbent utilities by taking appropriate measures, e.g. the creation of a niche environment for new market entrants. The Dutch regulator, as the main responsible authority for deciding on network connection tariffs, can support the deployment of flexibility mechanisms at the customers’ side by promoting and approving the implementation of differentiated tariffs for grid connections by the DSOs. This would provide a price incentive for customers’ responsiveness and enhance the aggregator concept.

Some of the identified items and recommended actions point out to follow-up research activities. Research and knowledge institutions can contribute to investigating and assessing the potential of new business models and the suitability of potential solutions. Supporting the development of appropriate policies and novel organisational and cooperative structures for the energy management of demand-side resources will enable new products and services for both wholesale electricity trade functions and the provision of AS to the power system such as fast operating reserves, and local network support. New aggregator business models and opportunities support the transitioning to a sustainable energy system, through the effective integration of the demand-side in electricity markets. DR mechanisms can support the integration of sustainable energy in the market, and replace fossil-fuelled power generation units for the provision of operating reserves.

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Appendix A. Main actors, roles and tasks in the Dutch power system

See Appendix [Table A.1](#).

Table A.1

Main actors, roles and tasks in the Dutch electrical power system.^a

| Actors and/or roles | Description and tasks |
|-------------------------------------|---|
| Balance Responsible Party (BRP) | A BRP carries the role of energy nomination at the wholesale level (ENTSO-E, 2015b), and is responsible for balancing supply and demand for its portfolio. Equivalently to the BRP term, the programme responsible party (PRP) term is used in the Netherlands. The Dutch TSO, TenneT, is responsible for acknowledging and supervising PRPs. Each PRP is obliged under a programme of responsibility to draw up programmes for all associated connecting points to the electricity network relating to the expected electricity supply and/or expected consumption (TenneT TSO B.V., 2014). These energy programmes have to be supplied to TenneT on a daily basis, and are settled based on the differences between the scheduled volume (a priori) and the actual measured volume (TenneT TSO B.V., 2010). |
| Balancing Service Provider (BSP) | The BSP term is used for the market participant that provides balancing services to its connecting TSO or in case of the TSO-BSP model (where a BSP has a contractual relationship with another TSO than its connecting TSO) to its Contracting TSO (ENTSO-E, 2016). The BSP term is not attributed to a standardised role at European level, as there are several variations at national level, and is defined in an ad-hoc manner in relation to the provision of a specific service. |
| Distribution System Operator (DSO) | A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution network in a given area and, where applicable, its interconnections with other networks and for ensuring the long-term ability of the network to meet reasonable demands for the distribution of electricity (ENTSO-E, 2016). In the Netherlands, there are nine designated independent regional distribution network operators for electricity. In relation to network operators, the Electricity Act contains four key prohibitions which can be summarised as follows: it is prohibited for network operators (national or regional) to undertake any energy supply activities; network operators are not allowed to undertake any activities that may be in conflict with the interests of the network management and/or operation; network operator may only do those things as prescribed by the law against regulated tariffs; and the privatisation prohibition, which imposes that the shares in any network operator are always, directly or indirectly, owned by the state. The actual third-party access to the networks is regulated within the Electricity Act, while the conditions for access as well as the tariffs are regulated by the Dutch regulator, ACM (Bouchez and Bos, 2014). |
| National Regulatory Authority (NRA) | The ACM is the NRA for energy in the Netherlands. One of the core tasks of ACM is enforcement, with the objective to prevent and resolve market and consumer problems. The supervision of compliance with the contents of the Electricity Act lies in general with the ACM, with the exception of the areas regarding security of supply, network access conditions and tariff structures for which the Minister of Economic Affairs is responsible and accountable to the parliament. The ACM also supervises the exercise of dominance in the electricity sector, including regulation of third-party access and tariffs related to the Dutch electricity networks (Bouchez and Bos, 2014). |
| Supplier | The role of the supplier is to source, supply, and invoice energy to its customers. The supplier and its customers agree on commercial terms for the supply and procurement of energy (Universal Smart Energy Framework (USEF) Foundation, 2015). The supplier must be assigned the metering points of the customer it supplies (ENTSO-E, 2016). For electricity supply to small-scale or residential consumers a specific licence is needed pursuant to the Electricity Act, which is granted by the ACM (through delegation by the Minister of Economic Affairs). The general terms and conditions used by the suppliers of energy to consumers have been standardised in collaboration with the ACM and the Dutch Consumer Union ^b (Bouchez and Bos, 2014). |
| System user | System users are the natural or legal persons that supply, or are being supplied by, a transmission or distribution system (ENTSO-E, 2015b). The system users are all the producers and consumers of electricity that own and operate within their premises any generation unit, load and/or storage device. |
| (Transmission) System Operator | A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area (ENTSO-E, 2015b). TenneT, the Dutch TSO is responsible for operating the High Voltage (HV) Network (intended for the transport of electricity at 220 kV or higher), maintaining the cross-border interconnectors and balancing supply and demand in the whole network by operating a single-buyer imbalance market (Bouchez and Bos, 2014). The prohibitions contained within the Electricity Act in relation to network operators are also applicable to the TSO (see the above-mentioned description and tasks for DSOs). |

^a Terms and roles have been aligned with those used in [Universal Smart Energy Framework \(USEF\) Foundation \(2015\)](#), and by the [ENTSO-E \(2015b, 2016\)](#).

^b Consumentenbond in Dutch.

Appendix B. Overview of ancillary services in the Netherlands

See Appendix [Tables B.1 and B.2](#).

Table B.1 (continued)

| Network Code on Load Frequency Control & Reserves (NC LFCR) | Frequency Containment Reserves (FCR) | automatic Frequency Restoration Reserves (aFRR) ^a | manual Frequency Restoration Reserve (mFRR) |
|---|--|---|---|
| Activation minimum step | N/A | 1 MW | 4 MW |
| Activation duration | Continuous | ≥ 4 (s) | Mostly full contracts but it can also be less (partial activation with a min. of 20 MW and steps of 5 MW but in general the requirements are for a total of 200–300 MW) |
| Verification method | Ex-post check (Monitoring of plant performance carried out after the event) (ENTSO-E Ancillary Services Working Group, 2014) | Ex-post (ENTSO-E Ancillary Services Working Group, 2014), based on signal visual inspection (Lampropoulos et al., 2012), regularly every day/week (ENTSO-E, 2016) | Ex-post (ENTSO-E Ancillary Services Working Group, 2014), based on measurements and a reference value (TenneT TSO B.V., 2016a) |
| Settlement method for activated energy | N/A | Based on requested energy (according to the TSO's activation LFC signal) (TenneT TSO B.V., 2015; ENTSO-E Ancillary Services Working Group, 2014) | Based on 5 min periods, the metered value is deducted from the reference value (TenneT TSO B.V., 2016a) |
| Share (%) of aFRR in total activated FRR/RR energy ^m | N/A | > 80% | Imbalance settlement system (TenneT TSO B.V., 2015) |
| | | | N/A |

^a There are two types of aFRR, one contracted and one non-contracted but the merit order lists are merged.

^b Mandatory for units > 60 MW in accordance with the Network Code.

^c Tenders are published on the website of TenneT (<http://www.tennet.eu>) and TenderNed (www.tenderned.nl).

^d Tender for regulating power (2016): 50% annual contracts, and 50% quarterly contracts. Contracts for units > 60 MW in accordance with the Network Code.

^e Call for emergency power (mFRRda) is announced by TenneT.

^f The total volume is determined on a yearly basis by ENTSO-E regional group Continental Europe (CE). At least 30% must be delivered within the Netherlands whereas the remaining capacity can be delivered through a common auction: <https://www.regelleistung.net>.

^g In accordance with ENTSO-E directive: 340 MW for the year 2016.

^h Largest possible incident minus already existing reserves (2016): 700 MW (upward regulation), whereas 350 MW are available through TSO – TSO cooperation (DE & BE). Contract for 97% minimum availability per year or quarter. Tender for downward regulation capacity (200 MW) has been announced but not yet released. Emission standards for combustion plants result into less availability for directly activated mFRR.

ⁱ Purchase through weekly auctions on: <https://www.regelleistung.net>. Contracts for 100% availability.

^j ENTSO-E transparency platform: <https://transparency.entsoe.eu/>.

^k The prices that are paid to the balancing service providers do not influence the marginal price of TenneT's normal internal operations.

^l Manual deployment 24/7 by telephone call.

^m Based on data for February and June 2015 from the ENTSO-E Transparency platform and information provided directly by TSOs (ENTSO-E, 2016).

Table B.2

Main characteristics of other ancillary services (black start and transmission services) that are currently traded in the Netherlands (Ophuis, 2015).

| Name (Name in Dutch) | Black start capability ^a (Herstel-voorziening) | Reactive power (Blindvermogen) | Network losses (Netverliezen) ^b |
|----------------------------------|--|--|---|
| Type (Contracted/Non-contracted) | Contracted | Contracted, the TSO may (partially) own and operate reactive power compensation systems (ENTSO-E Ancillary Services Working Group, 2014) | Contracted |
| Contracted capacity (MW) | > 1200 MW ^c | Need to be estimated ^d | Need to be estimated ^e |
| Procurement | – | Annual Tender/Request for quotation (RFQ) ^f | Periodic tender (current agreement from 2014 to 2016) |
| Activation method/Requirements | – | Manual ^g , the optimal use is determined based on the TSO's experience (ENTSO-E Ancillary Services Working Group, 2014) | Supply and acquisition of programme responsibility |

^a ENTSO-E Common Glossary: Black start capability is the recovery of a Power Generating Module from a total shutdown through a dedicated auxiliary power source without any Electrical Energy Supply external to the Power Generating Facility.

^b Electricity supply service for the compensation of grid losses, estimated at 1198 GWh for the year 2017 (TenneT TSO B.V., 2017e).

^c Three recovery facilities in the Netherlands (North, Central & South) and 2 units per facility of at least 200 MW.

^d Deployment on the basis of effort in the previous period and network developments.

^e Estimation based on history by taking into account recent and planned developments. There are many dependencies which have a consequence on predictability and the variance is large, e.g. 823.4 GWh (2012), 831.1 GWh (2013), 947.1 GWh (2014). 1198 GWh (2017).

^f Invite suppliers (units connected to the HV (110/150 kV) or Extra HV (220/380 kV) level) into a bidding process to address local problems with local solutions.

^g Reactive power deployment by phone.

Appendix C. Supplement to priorities for overcoming identified barriers

See Appendix Table C.1.

Table C1

Secondary priorities for overcoming identified barriers to support the development of flexibility services and the market integration of aggregators in the Netherlands, supplement to Table 3.

Source: Own elaboration.

| Rank | Barrier element | Identifier | Priority level |
|------|--|------------|----------------|
| 16 | Market – Design: Gate Closure Time | 1.1.2 | Nice to have |
| 17 | Market – Design: Rules for passive contribution | 1.1.4 | Nice to have |
| 18 | Market – Entry thresholds: Market participation fees | 1.2.1 | Nice to have |
| 19 | Market – Entry thresholds: Min. bid size for aFRR and mFRR | 1.2.2 | Nice to have |
| 20 | Market – Lack of transparency: Non-disclosure of the collateral calculation formula | 1.3.1 | Nice to have |
| 21 | Market – Lack of transparency: Non-disclosure of the criteria for bypassing mFRR schedule activated (mFRRsa) bids | 1.3.3 | Nice to have |
| 22 | Market – Process: Administration of contracts | 1.4.1 | Nice to have |
| 23 | Market – Process: Limited options in distribution tariffs | 1.4.5 | Nice to have |
| 24 | Regulatory – Lack of standards: Verification of aFRR | 2.1.3 | Nice to have |
| 25 | Regulatory – Lack of standards: Non-harmonisation of markets | 2.1.4 | Nice to have |
| 26 | Regulatory – Lack of standards: Verification and settlement of DR | 2.1.7 | Nice to have |
| 27 | Regulatory – Market imperfections and distortions: Safety net regulation | 2.2.2 | Nice to have |
| 28 | Regulatory – Market imperfections and distortions: Level playing distortion between incumbents and new market entrants | 2.2.3 | Nice to have |
| 29 | Technical – Metering and data exchange barriers: Measurement resolution of smart meter data | 3.1.3 | Nice to have |
| 30 | Technical – Delay in smart meter data accessibility: Data access barriers | 3.2.1 | Nice to have |
| 31 | Social – Lack of consumer acceptance: Low acceptance of smart meters systems | 4.1.1 | Nice to have |

Appendix D. Acronym list

See Appendix Table D.1.

Table D.1
Acronym list.

| | |
|------|--|
| ACM | Autoriteit Consument & Markt (i.e. The Dutch NRA) |
| AS | Ancillary Services |
| aFRR | automatic Frequency Restoration Reserves |
| APX | Amsterdam Power eXchange |
| BRP | Balance Responsible Party |
| BSP | Balancing Service Provider |
| C-AR | Central register system ('Centraal Aansluitregister' in Dutch) |
| CWE | Central Western European |
| DAM | Day-Ahead Market |
| DR | Demand Response |
| DSO | Distribution System Operator |

(continued on next page)

Table D.1 (continued)

| | |
|---------|---|
| EAN | European Article Number |
| EBGL | Electricity Balancing Guideline |
| EDSN | Energie Data Services Nederland (in Dutch) |
| ENTSO-E | European Network of Transmission System Operators for Electricity |
| EPEX | European Power Exchange |
| ETPA | Energy Trading Platform Amsterdam |
| FCR | Frequency Containment Reserves |
| FRR | Frequency Restoration Reserves |
| GCT | Gate Closure Time |
| HV | High Voltage |
| IGCC | International Grid Control Cooperation |
| ISP | Imbalance Settlement Period |
| LFC | Load Frequency Control |
| mFRR | manual Frequency Restoration Reserves |
| mFRRda | manual Frequency Restoration Reserves directly activated |
| mFRRsa | manual Frequency Restoration Reserves schedule activated |
| NEDU | Nederlandse EnergieData Uitwisseling (Dutch Energy Data Exchange) |
| NRA | National Regulatory Authority |
| ODA | Onafhankelijke Diensten Aanbieder (in Dutch) |
| PIR | Production Installation Registry |
| PRP | Programme Responsible Party |
| R&D | Research & Development |
| RES | Renewable Energy Sources |
| RR | Replacement Reserves |
| TSO | Transmission System Operator |
| USEF | Universal Smart Energy Framework |

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