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Suggested Citation: Radecke, Julia; Hefele, Joseph; Hirth, Lion (2019) : Markets for Local Flexibility in Distribution Networks, ZBW – Leibniz Information Centre for Economics, Kiel, Hamburg

This Version is available at:
https://hdl.handle.net/10419/204559

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Markets for Local Flexibility in Distribution Networks

A Review of European Proposals for Market-based Congestion Management in Smart Grids

Version 2019-10-16

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Abstract – The three D's of the energy transformation – decarbonization, decentralization and digitalization – provide both challenges and opportunities for distribution grids. Small-scale generation, batteries, electric heating, and e-mobility may put grids under considerable strain. However, if operated smartly, they also represent a deep pool of flexibility that can help grid operators relieve congestion and defer investment. One way of incentivizing such resources is to implement local markets for flexibility. In Europe, at least two dozen research pilots, stakeholder initiatives, and business cases have proposed specific designs for such markets. This paper provides an overview and analysis of these proposals. With many proposals being poorly documented, we largely rely on interviews for details on market design. We find that only one third of proposals allow free price formation, hence, despite their names, most are not what we consider a market. None of the proposals aims to replace existing congestion management mechanisms; rather they are meant as complementary tools. Usually markets employ dispatch payments; only few remunerate the reservation of flexibility availability. Though most proposals acknowledge market power and strategic interaction with other electricity markets ("inc-dec gaming"), few have developed concrete measures to address these problems. As they are in an early stage of development, market designs may still evolve.

We thank Oliver Ruhnau, Anselm Eicke, Ingmar Schlecht, Andrea Dertinger, and all project and scoping interview partners for stimulating discussions and helpful comments. In particular, we would like to thank Eva Schmid for crucial inspiration and guidance throughout the process.

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1. Introduction

Energy transformation. Electricity systems are undergoing a historic transformation. On the production side, with two thirds of newly added capacity based on renewables (REN21, 2019), wind and solar energy are rapidly becoming a cornerstone of electricity generation. On the consumption side, electrification is starting to pick up pace: electric mobility and electric heating will significantly increase residential power consumption and change its pattern over time. Behind-the-meter batteries and smart appliances will deliver new flexibility for electricity consumption. On the one hand, these digital decentralized energy resources will pose significant challenges to distribution grids. Today, grid congestion in the European transmission and distribution grids is already much more common than it used to be (Hirth & Glismann, 2018), and decentralized resources will likely aggravate this trend and require large-scale grid investments (Agora Energiewende, 2019; Cambini, Meletiou, Bompard, & Masera, 2016; Oliver Wyman, 2018). On the other hand, decentralized resources are also an opportunity as they imply a large potential source of flexibility: batteries can be charged and discharged to reduce stress on grids, electric heating can be turned into flexible consumption if heat storage is added, and smart appliances can shift consumption. Hence, if dispatched accordingly, decentralized resources can be used to relieve grid congestion and defer the need for grid enforcement (Ecofys & Fraunhofer IWES, 2017; Kellermann & Priebe, 2019; IEA, 2019). This – the efficient coordination of decentralized flexibility to support grid operation – forms a crucial part of the vision of the smart grid.

Incentives. Much literature exists on smart grid technology (Good, Ellis, & Mancarella, 2017; Kittner, Lill, & Kammen, 2017; Tuballa & Abundo, 2016) as well as on the response of electricity consumers to price signals (Jia & Tong, 2016; Morstyn, Farrell, Darby, & McCulloch, 2018; Parag & Sovacool, 2016). What has attracted much less attention is the question of incentives and coordination in the context of grid operation: how can flexibility resources be incentivized to relieve, rather than stress, the grid? How could price signals be determined and what form would they take? In other words, what might "smart markets" underpinning the smart grid look like?

Congestion management in Europe. In some countries, such as Germany and Switzerland, congestion relief is administrative and cost-based: generators are legally obliged to comply with grid operators' congestion management instructions and are subsequently compensated for costs incurred and profits forgone. This requires grid operators to estimate costs and profits with reasonable accuracy. This is much more difficult for load than for generation. One would essentially need to estimate consumers' willingness to pay for electricity, which may be highly case-specific. Thus, cost-based congestion management is not seen as a viable option to make load and behind-the-meter storage accessible for congestion relief (Hirth, Schlecht, Maurer, & Tersteegen, 2019). Other countries, including the Netherlands and the UK, employ market-based congestion management. This approach allows market participants to sell flexibility to grid operators at prices they chose. While current schemes primarily address the transmission grid and often only allow

large industrial loads to participate, it is hoped that enhanced market-based approaches will facilitate the participation of decentralized resources. The European Union has declared market-based congestion management as the default choice for both transmission and distribution grid operators.[1] Article 32 of the 2019 Electricity Market Directive emphasizes that regulatory frameworks need to incentivize distribution grid operators to procure services from decentralized energy resources and employ market-based procedures.

Flexibility markets. Across Europe, "markets for local flexibility" are being developed to create new, market-based tools for congestion management in the distribution grid. In the context of this study, we define a flexibility market as a mechanism that i) aims to relieve congestion in the distribution grid, ii) works through impacting the dispatch of generation, load and/or storage assets, with iii) voluntary participation, and iv) remuneration that is determined based on participants' bids. Although these markets are much discussed, an overview and analysis of existing proposals is lacking. This is the gap we intend to fill.

Scope and methods. This paper provides a comprehensive overview of current flexibility market proposals in Europe. We do not include local peer-to-peer trading platforms that trade local flexibility for purposes beyond congestion management. Given the lack of comparative literature and limited public documentation of most projects, we complemented a document analysis with interviews. Our goal is *not* to assess or evaluate proposals, or to propose a new flexibility market design. Rather, we want to provide an overview and a systematic comparison of existing proposals. This, we hope, might serve as a basis for future assessments and evaluations and ultimately inform the debate on the market design for smart grids.

Findings. Our main deliverable is a large Excel spreadsheet collecting key features of all proposals under analysis (available as supplementary material). In addition, we find seven observations worth noting. First, most proposals aim to develop holistic solutions to make local flexibility available for congestion management. Therefore, they do not only develop incentive mechanisms but also propose additional technical and operational changes to congestion management. Second, none of the projects explicitly aims to replace existing congestion management mechanisms. Instead, they aim to broaden the scope of available resources and complement existing systems. Third, most markets compensate flexibility providers for each deviation from their assets' original dispatch, rather than for the reservation of flexibility availability. Fourth, not everything called a flexibility market passes our definition of a market. Only four projects use price formation based on free bids of market participants. Most employ different variants of regulated prices. Fifth, almost all proposals focus on delivery periods of 15 or 60 minutes, similar to European spot markets. Sixth, while most markets can be described as a reverse auction, the details of matching and clearing differ. Finally, we find that many proposals acknowledge strategic behavior and market power to be relevant issues, yet few provide concrete suggestions to address them.

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[1] For the Regulation on the internal market in electricity, refer to https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0861R%2801%29. For the Directive, refer to https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0864R%2801%29. Accessed 25.09.2019

2. Flexibility Market Proposals

Overview and selection. We reviewed twenty-two European flexibility market proposals. Broadly speaking, they follow two overarching objectives. On the one hand, they aim to provide *technological and operational solutions* to enhance the flexibility of decentralized energy resources, make them accessible for grid management, and improve communication between flexibility demand and supply. On the other, they propose *market mechanisms* to incentivize resources to participate in congestion management and adapt their generation or consumption behavior to benefit the grid. As we are interested in the latter, we excluded ten of the initial twenty-two proposals (see Methods).

Data collection and analysis. For the remaining twelve proposals, we conducted a comparative analysis to identify key similarities and differences regarding market design and incentive structures. Given the lack of publicly available project documentation, we carried out at least one semi-structured expert interview per proposal to collect information. Interview partners were parties directly involved with the respective proposal, such as staff from research institutions, grid operators, or power exchanges. To facilitate the collection of information and subsequent analysis and comparison, we set up an analysis framework that covered the technical, economic, and political dimensions of the proposals (see Methods).

2.1 Overview

Geographic scope and state of implementation. Table 1 provides an overview with each proposal's name, region, current state of implementation, and key goals as stated by the interviewees. A majority of proposals are German, reflecting the considerable academic, political, and industry interest in market-based congestion management during recent years. Furthermore, we identified one proposal in the UK, one in the Netherlands, and one multinational proposal. Most projects are in the process of piloting and have already facilitated first transactions between grid operators and flexibility providers. The two projects categorized as business cases are being implemented by private companies and have partially started commercial operation. Nevertheless, no large-scale flexibility market exists at this stage.

Key objectives. All proposals seek to develop platform-based solutions to tap local flexibility to alleviate congestion and broaden the scope of congestion management tools for distribution grid operators. By setting up a market platform, they intend to create a mechanism that i) makes flexibility demand and supply visible to each other, ii) coordinates both sides, considering the increasing number of supply side participants, and thereby iii) creates incentives for previously unused resources to participate in congestion relief. Only few proposals additionally aim to incentivize large-scale investments into new flexible assets or at deferring grid reinforcement. Finally, none explicitly seeks to replace existing congestion management mechanisms. Instead, flexibility markets are considered complementary tools. In the case of Germany, this would mean a hybrid system of regulatory and market-based congestion management.

Table 1 List of Proposals

Proposal	Region	State of Imp.	Key Objectives
Bne Flexmarkt	DE	Proposal	Reform German grid fee regulation to tap existing and incentivize new resources for congestion management in the distribution grid and reduce concurrence
SINTEG C/sells: Altdorfer Flexmarkt (ALF)*	DE	Pilot	Develop a platform to solve congestion management issues in the distribution grid using decentralized assets (focus on small-scale assets)
SINTEG C/sells: ReFLEX Dillenburg*	DE	Pilot	Develop a market platform to tap flexible assets in the distribution grid to improve system operation and reduce renewable energy curtailment (focus on load potential)
SINTEG C/sells: Comax*	DE	Pilot	Develop a coordination platform to promote congestion management with small-scale flexibility on lower voltage levels and improve grid operator coordination
SINTEG WindNode: Flexibilitätsplattform	DE	Pilot	Expand congestion management options by tapping additional flexibility sources connected to the distribution grid
SNTEG Enera: Flexmarkt	DE	Pilot	Develop a platform to coordinate flexibility demand and supply, improve congestion management options for grid operators, and reduce renewable energy curtailment
SINTEG New 4.0: ENKO	DE	Pilot	Develop a coordination mechanism for grid operators to showcase the potential of local loads as an alternative to redispatch, and renewable energy curtailment
DA/RE	DE	Pilot	Develop IT platform to tap flexibility potential located on the distribution grid for congestion management and improve coordination between grid operators
Nodes Market	Europe	Business case	Create a marketplace to improve grid operation, tap additional flexibility potential and enhance congestion management options for grid operators
Grid Integration	DE	Proposal	Develop a flexibility market platform with largely automated processes to improve congestion management in the distribution grid
GOPACS/ IDCONS	NL	Pilot	Develop a mechanism to increase available flexibility volume, reduce costs, and standardize and harmonize grid operator products and processes to address congestion on lower voltage levels

Piclo Flexibility Marketplace	UK	Business case	Develop a marketplace to standardize and facilitate DNO flexibility procurement, make more efficient use of the existing grid, and reduce the need for grid reinforcement

* *SINTEG C/sells* set up three research pilots, i.e. *ALF*, *ReFLEX*, and *Comax*, to explore flexibility markets in different contexts, including different voltage levels, grid topologies, and available resources. Insights generated from all three pilots will be used to propose one joint *SINTEG C/sells* flexibility market blueprint.

2.2 Country Context

Germany. A broad range of German stakeholders is currently investigating market-based approaches to congestion management. A prominent example is the large-scale government-funded research program "SINTEG," to which six of the nine German proposals belong. It supports research projects that explore innovative solutions for the future energy system, including the development of blueprints for local flexibility markets. These projects operate under a special regulatory ordinance with "experimental options" that exempts participants from certain regulation and reimburses them for potential economic disadvantages.[2]

The UK and the Netherlands. Incentivized by "total expenditure" regulation, distribution grid operators in the UK are increasingly employing alternatives to grid reinforcement, including flexible grid connection schemes and bilateral procurement contracts with flexibility providers. To facilitate transactions and coordinate procurement processes, grid operators together with the regulator are exploring flexibility markets, such as the *Piclo Flexibility Marketplace* (Ofgem, 2017, 2019). In the Netherlands, congestion management is also market-based, and market parties sell their flexibility to the transmission grid operator at self-determined prices. In 2017, the local flexibility market platform *GOPACS* was set up to broaden the scope of resources, explore innovative congestion management tools for distribution grid operators, and improve grid operator coordination (Hirth & Glismann, 2018).

2.3 Beyond Market Mechanisms

Operational and technical challenges. As most proposals seek to develop holistic flexibility market solutions, they do not only develop incentive mechanisms but also propose technical and operational changes to congestion management. Among others, they set up new coordination processes between grid operators to facilitate an integrated conduct of congestion management and avoid situations in which congestion alleviation in one part of the grid aggravates congestion in another. Additionally, many projects seek to improve grid operators' technical capabilities by implementing new grid forecasting tools and installing smart meters along with the necessary information and communication infrastructure.

[2] https://www.sinteg.de/fileadmin/media/Publikationen/SINTEG-Broschuere_2018.pdf

3. Market Design

In this section, we discuss the key properties and characteristics of the proposed flexibility markets. Given that most proposals are in the piloting stage, changes to the market design will likely materialize as they further develop. Detailed tabular information for each proposal can be found in the supplementary material.

3.1 Market Participants

Demand and supply. All markets under analysis are meant to make flexibility in the distribution grid accessible for congestion management. They are single-buyer markets where grid operators purchase flexibility, i.e. the right to alter the dispatch of production, consumption or storage assets. While the focus lies in providing additional tools for distribution grid operators, most proposals also integrate transmission grid operators to facilitate their access to distribution grid-connected resources. Regarding supply side access requirements, all proposals follow a technology-neutral approach, participation is voluntary,[3] and no minimum asset size is required. This is intended to ensure broad participation and non-discriminatory access. Only the *Piclo Marketplace* requires flexibility providers to be registered companies. It also allows flexibility providers to sell the flexibility of assets that are not yet in operation. For the purpose of piloting, several proposals focus on specific asset types or voltage levels. For instance, *SINTEG C/sells: ALF* focuses on small-scale assets, such as heat pumps or PV home storage systems. *SINTEG NEW 4.0: ENKO* and *SINTEG C/sells: ReFLEX* seek to demonstrate the potential of load facilities, ranging from electric vehicles and commercial load to cogeneration and power-to-heat plants. *SINTEG Enera* and *Grid Integration* focus on the medium-voltage level for their initial stages of piloting. Besides tapping distribution grid assets, *SINTEG Enera, Nodes Market,* and *SINTEG WindNODE* have developed platform concepts that could also incorporate transmission grid resources.

Aggregators. For small assets, transaction costs can be prohibitively high. Hence, many proposals rely on aggregators and similar actors to pool these resources and sell their aggregate flexibility. Only *SINTEG C/sells: ALF* explicitly encourages small-scale assets, such as residential heat pumps and electric vehicles, to participate individually in its platform. The platform itself aggregates their flexibility and assigns them to congestion management purposes.

[3] If assets are included in administrative, cost-based congestion management and covered by flexibility markets, their participation is mandatory.

3.2 Product and Remuneration

Product and remuneration. In all markets, flexibility providers sell the deviation from their assets' baseline, i.e. they sell the service to generate or consume more or less electricity than originally planned or scheduled. Typically, they do so for 15-minute or 60-minute intervals. In return, they either receive dispatch payments (€/kWh), i.e. flexibility providers are paid for each effected deviation from their assets' original dispatch, or availability payments (€/kW), i.e. flexibility providers are paid for reserving flexibility availability, or a combination of both (see Table 2). In all cases, flexibility providers are responsible for balancing their schedules, e.g. through trade on the zonal market. Most proposals employ dispatch payments. Five employ availability payments or a combination of the two.

Product differentiation. Half of the proposals offer more than one type of flexibility product. For instance, *Nodes Market* offers a spot market product as well as a so-called "availability contract." For the former, flexibility providers receive dispatch payments. The latter allows them to commit a certain flexibility profile over a longer time horizon for which they receive an availability payment. In addition, most proposals offer largely standardized product specifications, such as interval length and remuneration schemes. *Nodes Market* and the *Piclo Marketplace* allow for a greater scope of individualizing product features. For instance, in flexibility procurement contracts that are auctioned off through the *Piclo Marketplace*, grid operators individually determine procurement periods that currently range from one season to several years, offer different combinations of dispatch and availability payments, and select different weekdays, hours of the day, and interval lengths for which they require flexibility.

Table 2 Remuneration, Pricing Rule, and Price Formation

Proposal	Remuneration	Pricing Rule	Price Formation
Bne Flexmarkt	Dispatch payment	N/a	Regulated
SINTEG C/sells: Altdorfer Flexmarkt	Availability payment	Pay-as-bid	Free with regulated elements
SINTEG C/sells: ReFLEX Dillenburg	Availability payment	Pay-as-bid	Free with regulated elements
SINTEG C/sells: Comax	Dispatch payment	Pay-as-bid	Regulated
SINTEG WindNode: Flexibilitätsplattform	Dispatch payment	Pay-as-bid	Regulated
SNTEG Enera: Flexmarkt	Dispatch payment	Pay-as-bid	Free with regulated elements
SINTEG New 4.0: ENKO	Dispatch payment	Pay-as-bid	Regulated

DA/RE	Dispatch payment	Pay-as-bid	Regulated Free*
Nodes Market	Dispatch payment Availability payment	Pay-as-bid	Free
Grid Integration	Dispatch payment Dispatch and availability payment	Pay-as-bid	Free
GOPACS/ IDCONS	Dispatch payment	Pay-as-bid	Free
Piclo Flexibility Marketplace	Dispatch payment Availability payment Dispatch and availability payment	Pay-as-bid	Free

* *DA/RE* focuses on the coordination of resources that are included in administrative, cost-based congestion management. They are compensated accordingly. Still, *DA/RE* also includes other resources and allows free price formation for them.

3.3 Pricing

Pricing rule and price formation. All proposals except the *bne Flexmarkt* implement pay-as-bid pricing. Regarding price formation, four follow a bid-based pricing approach in which flexibility providers can freely set their prices: *Nodes Market*, *Grid Integration*, *GOPACS*, and the *Piclo Marketplace*. All others employ different variants of regulated prices or regulatory elements. The *bne Flexmarkt* proposes fixed bonus payments or grid fee reductions in return for entering into mid- to long-term flexibility contracts with the grid operator. Payments would be determined by grid operators together with the regulator and would be the same for the entire German bidding zone. Proposals, such as *SINTEG WindNODE* and *SINTEG NEW 4.0: ENKO,* determine prices by applying procedures similar to administrative congestion management regimes. Prices are negotiated between grid operator and flexibility providers for different asset groups before bidding and trading take place. They are based on the assets' cost estimates plus a mark-up. *SINTEG Enera* allows free bidding but applies a price cap for non-renewable energy assets. *SINTEG C/sells: ALF* allows free price bids for assets selling their flexibility under a "schedule product" but pays regulated yearly premiums under the "long-term contract." The premiums are based on the assets' respective opportunity costs.

Administrative congestion management. The German proposals *DA/RE* and *SINTEG C/sells: Comax* have developed platform concepts that focus on the coordination of resources that are legally mandated to participate in congestion management. Hence, they also employ regulated prices as they compensate resources according to existing regulatory procedures.

3.4 Matching and Clearing

Matching process. Every proposal suggests a unique matching and clearing process. Nevertheless, some similarities and differences can be identified. Most proposals develop matching processes that resemble the logic of a closed auction: bids are collected up to a certain point in time when supply and demand are matched according to a sensitivity-adjusted merit order.[4] Only *SINTEG Enera*, *Nodes Market*, and *GOPACS* follow a process in which supply and demand are continuously matched, similar to the trading procedures in many European intraday markets. In the case of *SINTEG Enera*, grid operators determine market areas in which flexible resources are assigned the same sensitivity factor, i.e. they are assumed to be equally effective in relieving congestion. Each market area corresponds to a local order book on the platform. On a continuous basis, flexibility providers can bid sell offers into their respective order book, and grid operators bid buy offers into the order book that corresponds to the market area from which they need flexibility. If there are sell and buy offers in the same order book, they are automatically matched by the platform. Similar to *SINTEG Enera*, *GOPACS*, *Grid Integration*, and *SINTEG C/sells: ALF* have developed concepts in which the platform matches demand and supply. All others propose processes in which the platform receives bids, reports them to the grid operators, and the grid operators carry out their respective optimization processes and choose the flexibility they need. They report the results back to the platform, which then informs flexibility providers of their new schedules.

Market clearing. Proposals differ both in the timing and frequency of market clearing. Regarding timing, proposals range from day-ahead to intraday market clearing. Only the *Piclo Marketplace* clears demand and supply long before the day-ahead process, reflecting flexibility procurement procedures in the UK. Regarding frequency, some proposals offer market clearing at several points in time from day-ahead to intraday, while others offer only one day-ahead market clearing.

3.5 Strategic Behavior and Market Power

Gaming and market power abuse. Previous studies have argued that the coexistence of zonal and local electricity markets incentivizes strategic behavior, aggravating congestion, causing windfall profits, and distorting investment signals (Hirth & Schlecht, 2019; Holmberg & Lazarczyk, 2015; Wolak, 2011). Strategic behavior is incentivized as prices in both markets differ systematically such that market actors exploit the resulting arbitrage opportunities. This behavior is referred to as "increase-decrease" (*"inc-dec"*) gaming (Alaywan, Wu, & Papalexopoulos, 2004; Hogan, 1999). In addition, given the local nature of flexibility markets and their focus on lower voltage levels, market power abuse is also considered a potential risk (Hirth et al., 2019). While market power is not required for strategic bidding, it can amplify strategic bidding and its consequences.

[4] An asset's load flow sensitivity describes its effectiveness to relieve congestion in a specific part of the grid. To select the most effective assets, grid operators apply sensitivity factors to the original merit order to account for assets' marginal costs and their congestion relief effectiveness (Frontier Economics, 2017).

Countermeasures. All interviewees acknowledged these issues as potential risks for flexibility markets. However, *SINTEG Enera* is currently the only proposal that employs a concrete mechanism to identify market power abuse and strategic behavior, the so-called "verification platform." Some interviewees referred to self-regulating measures by market participants and the possibility for regulatory sanctions to prosecute market power abuse. It was also argued that flexibility markets should first be piloted on a limited scale to determine whether and to what extent strategic behavior takes place. Regulatory or platform-specific mitigation mechanisms could be developed in a subsequent step. Furthermore, a partial solution for countries like Germany is seen in the coexistence with administrative congestion management. This would provide an implicit price ceiling and could thereby limit strategic behavior and market power abuse. Hirth et al. (2019) provide a skeptical review of these suggestions.

4. Concluding Remarks

Findings. After reviewing twenty-two European proposals for local flexibility markets, we find that not everything called flexibility market passes our definition of a market. Only a minority of projects employ prices based on free bids of market participants. While regulated prices might, for instance, limit the scope of strategic bidding, the question arises as to whether they can provide adequate incentives for local flexibility to participate in congestion relief. Also, none of the projects explicitly aims to replace existing (often regulatory) congestion management mechanisms. Product definitions, contract length, and market clearing and matching procedures vary greatly. Most markets employ dispatch payments (€/kWh), rather than availability payments (€/kW), which potentially gives rise to inc-dec gaming. This issue is broadly acknowledged but not addressed.

Early stage of flexibility market design. It becomes clear that there is no definite market design yet for a "smart market." Most proposals are in the early stages of piloting and are still exploring a broad range of market design options. Hence, at this point, few proposals provide clear findings and recommendations for regulators and policy makers.

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Methods

Scope. The scope of the analysis is set to Europe. While the study covers a broad range of different proposals, projects, and stakeholder initiatives for local flexibility markets in the context of zonal power markets, it is not meant to provide an exhaustive overview. Rather, it aims at showcasing the most prominent and advanced examples, analyzing their economic workings and incentive structures, and identifying key similarities and differences between them.

Proposal selection. Based on desk research and snowball sampling, twenty-two projects were initially selected, and potential interview partners contacted to request interviews. This included all proposals listed in Table 1 as well as *SINTEG New 4.0: Energieplattform*, *VDE Regioflex*, *Bdew Flexrouter*, *HeatFlex*, *Horizon2020*: *Interflex*, *Horizon 2020: Interrface*, *TenneT Blockchain-Pilot*, *SINTEG New 4.0: Designnetz - System Cockpit*, *Dingle Project*, and *USEF*. Based on the insights provided by the interviewees and project documentation, it became clear that these projects, while initially deemed relevant, did not qualify for the subsequent analysis. They were excluded according to the following four criteria: First, projects that did not develop market mechanisms

and incentive schemes were excluded. Instead of analyzing how new and existing resources can be made available for congestion management more broadly, this paper focuses on the coordination and incentive mechanisms required to achieve this. As a result, proposals were dismissed that, for instance, exclusively focused on technical and technological aspects of tapping flexibility. Similarly, proposals were excluded if they did not follow the explicit objective of facilitating congestion management but instead encouraged local energy trading for purposes beyond relieving network constraints. This led primarily to the exclusion of peer-to-peer trading platforms. Second, only proposals published or updated within the last four years were included. This was to account for recent regulatory and grid-related developments on the national as well as European level, such as the European Commission's Clean Energy Package. Third, the analysis did not include recent proposals that had not yet developed key market design features. Finally, proposals were dropped if detailed information could not be attained. After applying these criteria, twelve proposals remained for analysis.

Data collection. Accounting for the lack of publicly available information on concrete market design features of flexibility market proposals, this study mainly relied on insights provided by semi-structured expert interviews. At least one interview was conducted per proposal. Respondents were guaranteed confidentiality if desired and interviewed only after an initial email solicitation. Once they agreed to engage in the interview, they were provided with the standardized questionnaire in advance of the interview. Following the interview, the completed questionnaire and corresponding presentation in the master spreadsheet were shared with the respondents to make edits and correct factual errors if necessary. The interview duration was between 40 and 120 minutes. Interviews were conducted in person or via phone between March and September 2019.

Data analysis. To compare the proposals, an analysis framework covering technical, economic, and political dimensions was applied. This approach was based on recent studies that have conducted similar research regarding electricity market design options (Ecofys & Fraunhofer IWES, 2017; Hirth, Schlecht, Maurer, & Tersteegen, 2018; Maurer, Zimmer, & Hirth, 2018). For the analysis, key properties of proposals were considered and grouped into three large categories (see Figure 1): A) rationale and background, B) interaction with existing markets and the regulatory framework, and C) economic workings and incentive structures. For clarity, the last category is divided into two subcategories: C1) market participation and C2) product design, matching process, and price setting. Without a doubt, the respective grouping of properties is not unambiguous. Most of them cannot be strictly separated and interact with one another. Nevertheless, this framework was chosen as it provides an easy-to-follow structure for the collection of data and subsequent proposal analysis.

Figure 1 Analysis framework