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Output-oriented regulation – an overview

November 2020

This is the English translation of the original version in German, titled: "Output-orientierte Regulierung – ein Überblick" (BEWP 35; Jacobs University Bremen).

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Output-oriented regulation - an overview

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1 Introduction

The regulation of electricity networks is currently facing a potentially far-reaching adjustment in the direction of output-oriented regulation (OOR). This development can be observed in various forms in many countries. The aim of this report is to provide an overview of output-oriented regulation and its objectives. To this end, the development of OOR is categorised in the theoretical context of network regulation and, in a second step, relevant areas of application for OOR are discussed. Although the approach itself could be applied to various regulated network sectors, this report is restricted to electricity networks.

In many countries, price-based regulation (in the form of a price or revenue cap) is now the predominant regulatory model; in Germany, this approach is implemented in the form of incentive regulation. The core of price-based incentive regulation is the strong focus on cost efficiency. Particularly at the beginning of the liberalisation of the electricity markets, the aim was to reduce the inefficiencies that existed prior to liberalisation. This is precisely the strength of incentive regulation. In the meantime, however, the framework conditions have changed considerably:

- After several years of incentive regulation, the potential for further cost reductions in the existing electricity networks appears to be moderate.
- The energy transition and digitalisation also bring upheavals for the electricity networks, initially increasing costs; productivity increases in the form of cost reductions can only be expected later, if at all.
- The energy transition is leading to new tasks for network operators, most of which are defined as mandatory tasks in regulations and ordinances. However, there is often a lack of explicit incentives to ensure that the tasks are also performed in an economically efficient manner.
- Network operators are increasingly facing new business areas that promise added value outside the core area of networks: *value creation*. These may, for example, involve commercial activities relating to the processing, distribution and utilisation of data (*data facilitation*). However, regulation often does not provide for such business areas and there are no adequate regulatory incentives to actively participate in the development of new business areas.
- The fragmentation of the individual sectors due to unbundling and sector coupling require a whole system approach; this requires regulatory incentives that reflect the effects of network-related measures on other areas and sectors. These external effects should be internalised as far as possible.

Output-oriented regulation (OOR) addresses precisely these issues. It supplements the existing incentive regulation with revenue elements that are linked to the achievement of specific performance targets (outputs) and are intended to appropriately reflect the social benefits of the outputs. The idea here is therefore not to replace the existing regulation with a new approach. Instead, OOR selectively expands the base model (in Germany, the revenue cap determined as part of incentive regulation) to include individual OOR elements. *Figure 1* below summarises the idea:

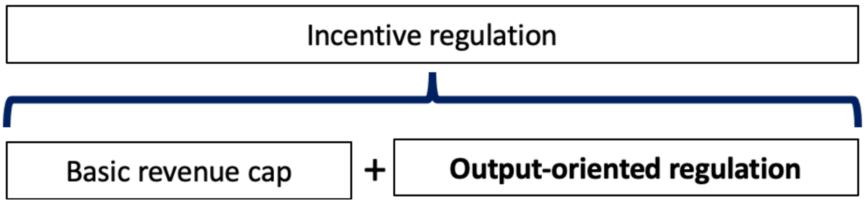

Figure 1: Classification of the terms
Source: own figure.

We distinguish between the following output categories, which are broken down into specific areas of application below (see *Table 1*).

Table 1: Description of the output categories

Output category	Description
Networks	Measures to optimise and accelerate the expansion and operation of the networks, in particular the timely commissioning of network-services and -connections.
Supply quality	Measures to increase the quality of supply, in particular network reliability and resilience of the energy system.
Market facilitation	Measures to strengthen competition and market efficiency and promote the development of new markets.
Digitilisation	Market-related services in the context of digitalisation, in particular the preparation and provision of data ("data facilitation") and data protection measures.
Whole System Approach	Measures to optimise the overall system beyond the boundaries of the electricity network.
Sustainability	Measures that contribute to environmentally friendly network operation and the achievement of national climate protection targets and promote sustainable behaviour on the part of network users.
Social affairs	Measures that affect the social aspects of network users, employees or society in general.

Source: own table.

This report intends to provide inputs for discussion on the development of output-oriented regulation in the electricity sector. The aim is to discuss possible areas of application for output-oriented regulation without claiming to be exhaustive. This report does neither provide a conclusive regulatory assessment, nor specific design of incentive mechanisms; these require further research and discussion, to which the comments in this report are merely intended to contribute.

The structure of the report is as follows: Section 2 places the concept of OOR within the theoretical framework of monopoly regulation. It discusses three justifications that can justify the application of OOR. Section 3 is the core of the report and identifies, describes and analyses specific areas of application. The main reason for selecting these areas was that they are directly related to the network sector and are not explicitly covered by the existing incentive regulation in Germany (ARegV). Section 4 concludes.

2 Theory: why output-oriented regulation?

Until the early 1980s, regulation in the monopoly electricity supply sector was predominantly cost-based; the predominant model was (and in some cases still is) rate-of-return regulation (cf. Joskow, 1974 and 1989). Regulation allows an appropriate rate of return on capital employed to finance capital expenditure (CAPEX). Operating expenditures (OPEX) are generally recognised on a cost basis (without interest). The core problem with cost-based approaches is that they provide little incentive for efficiency: High costs are simply passed on to consumers, and reverse, cost reductions must also be passed on directly to consumers. Efficiency efforts are therefore hardly rewarded, so that the regulated company has no effective incentives to improve its efficiency.

In the course of the liberalisation of telecommunications in the United Kingdom, prof. Littlechild was commissioned in 1983 to examine possible regulatory models for the remaining monopoly areas in the liberalised telecommunications sector (cf. Beesley & Littlechild, 1989). Littlechild criticised the cost-based approaches precisely on the grounds of low efficiency incentives and proposed a price-based approach instead (coined RPI-X), which was then also used for the electricity networks from 1990. Price-based approaches are now used in many countries, in different sectors and in different variations. In Europe and the UK, they are primarily known as price or revenue caps and incentive regulation, while in the USA they are often referred to as performance-based regulation. The central idea is the same and is illustrated in *Figure 2*.

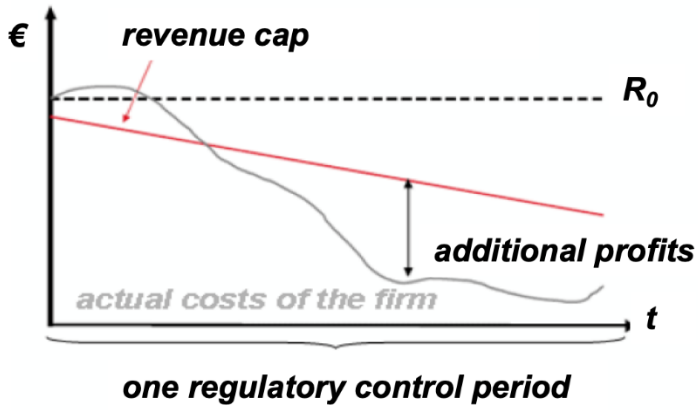

Figure 2: The effect of incentive regulation
Source: own figure.

For a predetermined regulatory period (usually 4 or 5 years), the development of the maximum revenue or price level is determined using a formula that is based on the macroeconomic price development (usually the retail price index (RPI)) and a predetermined efficiency target (X-factor). The development of the price or revenue level determined in this way is decoupled from the actual costs during the regulatory period, which only play a role in determining the initial revenue level. It is precisely this decoupling that creates the efficiency incentives: if the company reduces costs more than specified by the revenue path, it can realise additional profits. Conversely, it must bear the losses from cost increases itself.

Incentive regulation is considered to be very effective in terms of incentivising efficiency (cf. e.g. Sappington & Weismann, 2010). Nevertheless, questions arise whether incentives are effective if efficiency is not the only objective or if firms pursue tasks that are associated with increasing costs. The energy transition in particular entails additional tasks for network operators, which are insufficiently incentivised: This is precisely where OOR comes in.

2.1 Reasons for output-oriented regulation

Output-oriented regulation (OOR) sets explicit incentives to promote predefined output targets. But what distortions occur in incentive regulation that justify such additional support? We see the following three justifications: 1. *value creation*, 2. *whole system approach*, 3. cost-side distortion and risk.

Rationale 1: *Value creation*

The core problem lies in the mode of operation of incentive regulation (price caps or revenue caps). The key point with price-based approaches is to explicitly separate regulated revenues from the underlying costs. A problem arises when it is not the costs that change, but the demand. At a theoretical level, the issue was addressed (*avant la lettre)* by Spence (1975, p. 420, fn. 5) in the context of quality regulation: "*Of somewhat less interest is the case where price is fixed or taken as given. In that case, the firm always sets quality too low.*" The difference between a shift in the cost curve and the demand curve is crucial here. The following *Figure 3* illustrates this distinction.

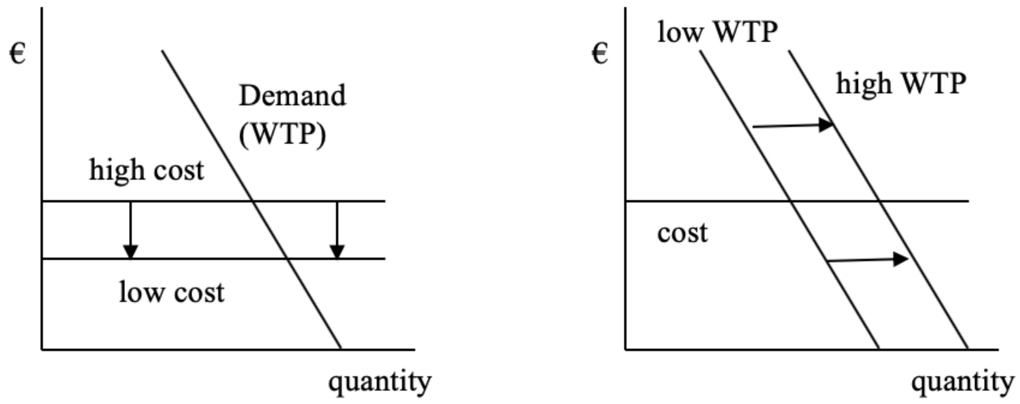

Figure 3: Shift in the cost curve versus shift in the demand curve
Source: Own figure.

When efficiency improves, the cost curve shifts downwards, while the demand curve remains constant. This is the aim of price-based approaches. The situation changes when the demand curve shifts: an innovation improves the product so that the consumer's willingness to pay (WTP) increases. As argued by Spence, price-based models, where the price is fixed, cannot handle this situation very well. When the demand curve is shifted, an additional surplus (the additional area under the demand curve) is created: *value creation*. Since regulation sets the prices, the company cannot skim off enough of the additional surplus and will therefore underinvest inefficiently in product improvements. This applies regardless of whether costs rise or not, but the problem worsens when costs increase. [2]

This is precisely where output-oriented regulation comes in: It attempts to define and quantify the product improvement (the shift in the demand curve) using a specific indicator and to link the additional consumer surplus with the additional profit for the company, thereby strengthening the incentives for additional value creation. The basic idea can be illustrated using an existing example from German incentive regulation. The ARegV contains the so-called quality element to promote network quality. The background to this instrument is that although a pure focus on efficiency leads to cost reductions, there is no guarantee that these

[2] Spence did the analysis at the time for a system with a price cap. In practice, we often have a system with a revenue cap. The details are different, but the core argument remains the same.

cost savings will not also lead to a loss of quality. The quality element was therefore already included in the revenue cap when incentive regulation was introduced, as the legislator recognised the conflict of objectives between efficiency and quality incentives at an early stage. With the quality element, "surcharges or discounts can be applied to the revenue caps if network operators deviate from key performance indicators with regard to network reliability or network performance" (Section 19 (1) ARegV). Specifically, monetary indices for the duration of supply interruptions (ASIDI/SAIDI[3]) are applied. This revenue adjustment represents an output-based incentive element in the ARegV, which serves precisely the purpose of internalising the social value of network quality in the sense of Spence (1975). The quality element has so far only been implemented for network reliability (see BNetzA, 2010), while a quality element for network performance is still in preparation (see BNetzA, 2020; BDEW & VKU, 2020).

Rationale 2: *Whole System Approach*

A variation of *value creation can* also be found in the *Whole System Approach* (WSA) (cf. CEER, 2018, 2020). Above, the activity of the network operator is expressed in a shift in its own demand curve; however, the activities of the network operator can also have an impact on other areas or stakeholders, without affecting the demand curve and thus the willingness to pay of its own network customers. In this case, we speak of external effects. In this context, external means that the effect is not recognised in a price and is therefore not taken into account in the profit analysis. The Whole System Approach aims to explicitly consider the external effects on other parties. OOR uses selected incentive elements that incorporate such external effects into the network operator's profit analysis.

The idea of aligning business incentives with economic benefits was analysed in the so-called McNulty report, which examined the inefficiency of the British rail system (McNulty, 2011). The McNulty report emphasises the distorted incentives between different players, which are caused in particular by the highly fragmented system. To a certain extent, this also applies to the electricity sector (see Brunekreeft, 2015). CEER (2018, 2020) has recently taken up this topic. CEER (2020) distinguishes between three levels of the Whole System Approach (WSA) and thus refers to the three central interfaces of the electricity networks where coordination problems can arise due to externalities: 1. between the electricity network levels (in particular TSO-TSO coordination), 2. between the network and the market and 3. with other sectors (sector coupling). Recently, this issue has become increasingly important in the question of coordination for the development of different infrastructures. This applies in particular to the

[3] ASIDI stands for "Average System Interruption Duration Index", SAIDI for "System Average Interruption Duration Index" (see BNetzA, 2010).

discussion about a new infrastructure for hydrogen. The WSA is discussed in section 3 (Area of application E).

Rationale 3: Cost-side distortions and risk

As competitive markets basically always remunerate the outputs themselves, the types of costs associated with the provision of the outputs play a subordinate role. In contrast, in regulation, the price-based approaches also have a concrete cost reference, so that the details of cost acknowledgement have a significant influence on revenues and thus the incentive effects. This means that cost-side distortions can occur in basic incentive regulation, which can justify a further area of application for OOR.

The cause of possible distortions lies in the different regulatory treatment of various types of costs. In particular, the following types of costs must be distinguished:

- In the current ARegV, *capital expenditure (CAPEX)* is compensated annually through the capital cost adjustment (distribution networks) or possibly investment measures (transmission networks), so that the time delay in adjusting revenues to changing costs is short.[4]
- *Operating costs (OPEX)* generally fall under the time lag of incentive regulation as controllable costs (CC). Insofar as the expenses increase or are not incurred in a base year, they reduce profits for the network operators.
- *Permanently uncontrollable costs* are kept outside of incentive regulation and are passed through in full as revenue without any incentive effect (as a cost pass-through). Such costs are therefore neutral in terms of earnings, but on the other hand do not incentivise efficient spending.

The current ARegV provides relatively strong incentives for CAPEX-intensive investments, while OPEX-intensive measures are not explicitly incentivised. In many cases, however, innovative and economically sensible measures are accompanied by an increase in OPEX. Without accompanying incentive instruments, the network operator will tend to invest too little in OPEX-based activities. Risk plays a central role here.

As Poudineh et al. (2020) argue, innovative (digital) measures in the network, which have recently gained in importance, are associated with higher risks than conventional network activities. For risk-averse companies, the higher risk profile requires a move away from types of regulation that assign a large proportion of the risk to the company. However, efficiency-oriented incentive regulation leads to a high risk of volatile and/or rising costs, particularly for OPEX, due to the linking of revenues to the costs of the base year. In contrast, CAPEX is directly

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[4] As of 2020; at the time of writing, the draft report states that the principle of annual capital cost adjustment will also be implemented for TSOs and the concept of investment measures will no longer apply.

translated into revenues. Output-oriented regulation can equalise the risks between purely cost-based and price-based approaches. Poudineh et al. (2020) look specifically at risky innovation activities and argue that innovation activities should be explicitly subsidised where appropriate. Poudineh et al. (2020) are primarily thinking of a sliding scale mechanism that balances the incentive effect and risk. Another current application from the electricity network sector is congestion management; this primarily concerns costs for redispatch and curtailment (see also Meyer, 2020). Under the current status of the ARegV, expenses for congestion management are treated as permanently non-controllable costs; the congestion management expenses are simply passed on and - in contrast to controllable costs - remain outside the incentive effect. The risk issue is also reflected here: permanently non-controllable costs are risk-free but have no incentive effect, whereas the opposite is true for controllable costs. *Figure 4* below illustrates this trade-off.

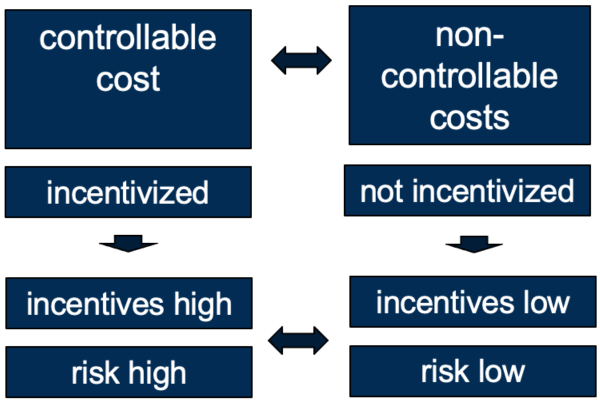

Figure 4: Trade-off between incentives and risk with controllable and non-controllable costs. Source: own figure.

A sliding scale mechanism can be designed as a supplementary incentive instrument in line with OOR: Proportional cost allocation can be used to achieve risk-adjusted cost-recovery on the one hand and counteract a possible incentive bias in favour of conventional network expansion on the other hand (Meyer, 2020). Brunekreeft and Rammerstorfer (2020) provide a theoretical base for such an incentive bias and show that incomplete consideration of the OPEX-risk can lead to a CAPEX-bias.

2.2 Classification of the term OOR

Output-oriented regulation (OOR) is a recent development in regulatory theory and practice. Accordingly, there are many, sometimes very different forms, while a standardised definition and name do not yet exist. In German-speaking countries, *output-based* or *performance-based is* also used alongside *output-oriented.* In the USA, *performance-based regulation* (PBR) and *targeted performance-incentive mechanisms* (PIMs) are also used. In this report, we use the terms as shown in *Figure 5*.

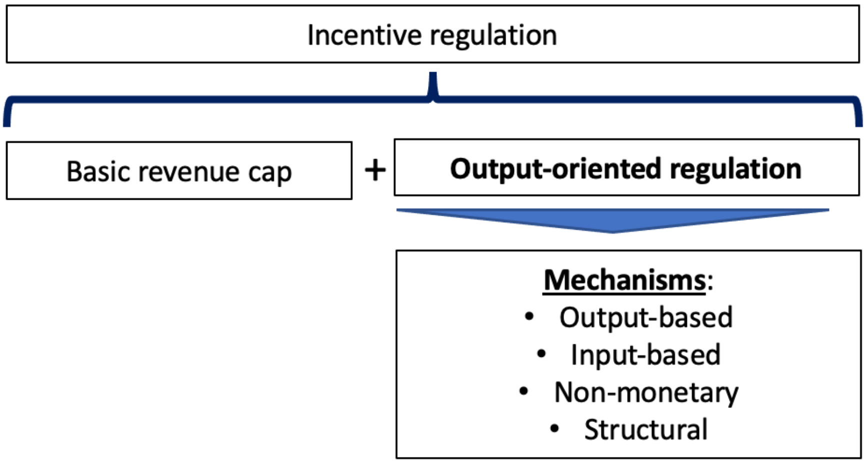

Figure 5: Classification of the terms
Source: own presentation.

We define the *entire* regulatory approach as incentive regulation. This contains two parts: On the one hand, there is a revenue or price cap for the network operator's core business (base incentive regulation). In addition, however, individual output-oriented regulatory components are used to promote selective areas. In this sense, a distinction is made, at least conceptually, between incentives for core tasks and those for extended tasks of the network operator. EDSO (2017) illustrates this well and distinguishes between (1) a base remuneration, (2) output-oriented incentives and (3) an explicit innovation support mechanism. Concerning the reform programme "Reforming the Energy Vision" in the US state of New York (NY REV), Bade (2016) mentions a comparable classification: the energy industry had proposed a two-tier system here, which provides for a "*broad-based earning impact mechanism*" as a source of income for the core business and "*more targeted programmatic incentives*" as income and incentives for certain tasks.

In the USA, incentive regulation is often referred to as *performance-based regulation* (PBR)[5] , meaning "*a regulatory framework to connect goals, targets, and measures to utility performance, executive compensation, and investor returns*" (NREL, 2017, p. ix). Some authors equate incentive regulation and PBR (Whited et al., 2015; Sappington & Weisman, 2016), while other authors take a somewhat broader view (e.g. NREL, 2017): Basic incentive regulation (e.g., RPI-X) is a form of PBR in which the primary performance objective is efficiency; however, PBR could have many other performance objectives. To summarise, however, it would not be wrong to say that basic PBR and basic incentive regulation are largely congruent.

[5] cf. e.g. NREL, 2017, Whited et al, 2015; Pfeifenberger, 2010; Sappington & Weisman, 2016.

In addition to base incentive regulation or PBR, it can be beneficial to strengthen the incentives for predetermined targets through output-oriented components. In the USA, these targeted performance incentive mechanisms are referred to as *targeted performance incentive mechanisms* (PIMs). NREL (2017, p. x) defines PIMs as:

> "PIMs are a component of a PBR that adopts specific performance metrics, targets, or incentives to affect desired utility performance that represents the priorities of the jurisdiction. PIMs can be specific performance metrics, targets, or incentives that lead to an increment or decrement of revenues or earnings around an authorised rate of return to strengthen performance in target areas that represent the priorities of the jurisdiction."

There are a large number of output-oriented regulatory components (see section 3). However, it should be noted that, particularly in the USA, many of these components relate to non-network activities of vertically integrated utilities. In the USA, utilities are largely vertically integrated, particularly at distribution network level, and retail is often not open to competition. Regulation then often affects the entire value chain. Output-oriented incentive elements can then also relate to commercial activities. In Europe, on the other hand, retail markets are largely open and unregulated; in addition, they are often administratively or legally unbundled from the network: Regulation and thus the output-oriented components in Europe are therefore necessarily limited to the regulated network.

2.3 Incentive categories for output-oriented regulation

A first question is which output targets should be incentivised. A second question then concerns the form of incentivisation: the incentive instruments. As with the terminology for OOR, as yet, there is no recognisable uniform pattern for the instruments to be used. However, one thing is clear: there is no one-size-fits-all solution that is suitable in every case. The appropriate incentive instrument depends on the target and the indicator. Above all, however, it is important that the specific instrument fits into the overall regulatory system. As the overall regulation systems differ greatly between individual countries, the choice of a suitable instrument for the respective system will also vary.

In our opinion, the most common incentive mechanisms can be divided into the following four categories:

- **Input-based**. Essentially, "input-based" incentive mechanisms consist of a mark-up on the use of inputs or on costs.
- **Output-based**. The "output-based" category defines an indicator for the output targets and links additional revenue or bonuses to the achievement of these output indicators.

- **Non-monetary**. Incentive elements are often thought of in terms of additional monetary gains and losses. But this is not necessarily the case. Non-monetary incentives or targets are perfectly conceivable and are used as such.
- **Structural**. In addition to monetary or non-monetary incentive instruments, structural measures that lead to a change in incentives by adjusting the framework conditions or the sector structure are also conceivable.

The distinction between input-based and output-based mechanisms is based on Bauknecht (2011) and Holt (2005), who use this categorisation in the context of promoting innovation activities. The example of innovation illustrates the categorisation of the terms from *Figure 5* well. Innovation is the output objective. The promotion of innovation is therefore output-oriented regulation. In this context, an innovation budget would be an example of an input-based incentive mechanism, as it is based on the inputs (costs). An example of an output-based incentive mechanism would be a bonus for achieving a certain number of patents.

An overview of the mechanisms of output-oriented regulation, categorised in the above four categories, can be found in *Table 2*. The mechanisms are not the main focus of this report, so we will not go into detail. It should also be emphasised that all of these mechanisms have advantages and disadvantages; a specific application requires a precise context-dependent analysis of the respective mechanisms.

Table 2: Overview of possible mechanisms of output-oriented regulation

Mechanisms for output-oriented regulation			
Input-based	**Output-based**	**Non-monetary**	**Structural**
• Cost mark-ups • Rate-of-return adders / mark-ups • Capital cost trackers • OPEX mark-up • TOTEX regulation (FOCS) • Budgets (e.g. for innovations)	• Benefit sharing • Targeted bonuses • Management bonuses • Bonus-malus system (caps & collars)	• Monitoring • Rankings • Publication obligations • Standards • Command & Control • Best Practice	• Unregulated commercial areas • Joint ventures • Vertical integration • Shortening the regulation period • Cost / revenue sharing

Note: The table does not claim to be exhaustive.
Source: own presentation, compiled from various sources.

Although we will not go into the multitude of possible incentive instruments in detail here, we will nevertheless selectively address individual mechanisms. Regarding external effects, such as *value creation* and overall system optimisation, the benefit-sharing mechanism would primarily be considered. The basic idea is that the network operator creates external benefits for others, which are therefore not included in its profit calculation. This is exactly where a benefit-sharing mechanism would come in: Part of the external benefit becomes a profit for the network operator. As an idea, this is immediately obvious. However, it is difficult to implement in practice for two reasons. Firstly, a sharing factor must be determined that defines the exact distribution of the external benefits. Secondly, the external benefits must be determined. Both aspects are problematic in practice.

One distortion that is repeatedly discussed in practice concerns the CAPEX-OPEX trade-off: CAPEX-bias. Details in the regulatory system can incentivise regulated companies to prioritise CAPEX activities at the expense of OPEX activities. This inhibits the efficient development of smart networks, which tend to be OPEX-heavy. The table above lists two mechanisms for eliminating such a CAPEX distortion: 1) an *OPEX mark-up*, i.e. OPEX would be remunerated with a regulated surcharge while at the same time correcting the return on capital. This works, but it is a crude instrument that may itself create a new distortion. 2) The fixed-OPEX-CAPEX-share (FOCS) (see Oxera, 2019; Meyer, 2020). The idea is elegant and simple. A predefined fixed part of OPEX is capitalised and treated like CAPEX: "fixed-OPEX-CAPEX-share (FOCS)". Under FOCS, all expenses, whether capital expenditure (CAPEX) or operating expenditure (OPEX), are treated as TOTEX. A fixed portion of this TOTEX is then "capitalised" (quasi-CAPEX) and the remaining portion is directly cost effective as quasi-OPEX ("pay-as-you-go"). The capitalisation rate is specified by the regulator: fixed-OPEX-CAPEX-share. In regulation, the resulting quasi-CAPEX and quasi-OPEX are treated in the same way as CAPEX and OPEX in the normal system. Quasi-CAPEX is included in the regulatory capital base and generates depreciation and interest. Quasi-OPEX are acknowledged within the financial year. As a result, the company is c.p. indifferent between CAPEX and OPEX and the CAPEX-biases are thus cancelled out.

Non-monetary incentive instruments are used surprisingly frequently. Monitoring, comparative rankings and disclosure requirements basically address the problem of asymmetric information. Even if companies are committed to external goals (e.g. environmental protection, employee protection or social goals), the public may not be sufficiently informed about them. This makes it difficult for companies to build up a corresponding reputation. Non-monetary mechanisms endorsed by the regulator can help here. Obviously, non-monetary mechanisms are particularly helpful where monetary quantification of the benefits is especially problematic.

The last point to mention is the structural measures. The energy sectors are highly fragmented as a result of liberalisation, competition, unbundling and the energy transition. Although the new market dynamics have had many positive effects, this is at the expense of overall system optimisation. In addition to explicit monetary incentives in incentive regulation, another, more direct approach is to promote cooperation between different parties, e.g. joint ventures and cost-revenue sharing models. This sounds simple at first glance, but is associated with the difficulty of implementation that the sectors in question do not operate in a completely free market: it must also be ensured that the measures are compliant with regulation and unbundling.

3 Tasks of network operators which might qualify for OOR

In section 2, output-oriented regulation was presented and embedded in a theoretical framework. However, the question now arises what this means for network operators in practice. Section 3 looks in more detail at the areas and tasks of network operators in which OOR could be applied. The presentation generally applies internationally, but for the purpose of this report, particular attention is paid to the regulatory framework in Germany.

Table 3 shows seven major output categories. *Table 4* specifies concrete areas of application for these categories, which are described in more detail later in this section.

Table 3: Description of the output categories

Output category	Description
Networks	Measures to optimise and accelerate the expansion and operation of the networks, in particular the timely commissioning of network services and network connections.
Supply quality	Measures to increase the quality of supply, in particular network reliability and resilience of the energy system.
Market facilitation	Measures to strengthen competition and market efficiency and promote the development of new markets.
Digitilisation	Market-related services in the context of digitalisation, in particular processing and provision of data ("data facilitation") and data protection measures.
Whole System Approach	Measures to optimise the overall system beyond the boundaries of the electricity network.
Sustainability	Measures that contribute to environmentally friendly network operation and the achievement of national climate protection targets and promote sustainable behaviour on the part of network users.
Social affairs	Measures that affect the social aspects of network users, employees or society in general.

Source: own table.

The areas of application were selected on the basis of the following criteria:

- Firstly, the areas of application discussed are related to the networks; other examples of OOR, particularly from the USA, often also relate to market areas of utilities (e.g. retail), which are mostly unregulated in Europe and therefore cannot be covered by output-oriented regulation.
- Secondly, international experience is generally available for the selected areas of application, which emphasises the relevance of the areas.
- Thirdly, with a few exceptions, the areas of application mentioned are not yet covered by the German ARegV or other regulations.
- Fourthly, a plausible economic justification for OOR can be found for the areas of application mentioned: In general, there is a distortion in the system, the elimination of which justifies the application of an OOR element.

Table 4: Specification of the areas of application.

Output category	**Areas of application**
A. Networks	1. Timely network expansion 2. Timely network connections 3. Utilisation of cross-border interconnectors 4. Development of smart grids
B. Quality of supply	1. Resilience 2. Service quality
C. Market facilitation	1. Promotion of existing markets 2. Promotion of new markets 3. Market monitoring
D. Digitilisation	1. Data facilitation 2. Smart meter rollout 3. Data protection & cyber security
E. Whole System Approach	1. TSO-DSO coordination 2. Coordination between network and market 3. Sector coupling (polygrid)
F. Sustainability	1. Reduction of GHG emissions in network operation 2. Network integration of renewable energies
G. Social affairs	1. Social equality among network users 2. Occupational health and safety 3. Society in general: smart cities

Source: own table.

It should be noted that the list does not claim to be exhaustive and may change over time. In addition, the distinction between individual areas of application and therefore the allocation to the output categories is not always clear. The primary aim of this report is to provide an overview of the possible areas of application; it is not intended to propose a self-contained, coherent extension of the ARegV.

The remaining part of this section describes the individual areas of application in detail.

A Networks

The expansion and operation of the network infrastructure is the core area of the network operator. It is therefore also at the centre of regulatory incentives and thus does not need to be additionally incentivised. Nevertheless, targeted incentives for specific network expansion targets can be useful. In the following, four central aspects of network development are considered for which output-oriented incentives can be applied:

A.1 Timely network expansion

A.2 Timely network connections

A.3 Utilisation of cross-border interconnectors

A.4 Development of smart grids

A.1 Timely network expansion

In the current regulatory framework, incentives for network expansion are provided in particular by the approved investment measures (for TSOs) and the CAPEX-true-up (for DSOs). Although these ensure prompt reimbursement of costs for network expansions, they do not provide any specific incentives to complete the network expansion within a specified period of time. In practice, network expansion is often delayed, particularly due to lengthy approval procedures and a lack of public acceptance (ACER, 2015; Brunekreeft & Meyer, 2019; Roland Berger, 2011a). In the case of cross-border network expansion, Roland Berger (2011b) therefore sees a considerable need for adjustment in the broader regulatory framework, and the most recent amendment to the Network Expansion Acceleration Act (NABEG, 2019) also aims to simplify and accelerate approval procedures.

Delays in network development have a significant impact on the electricity market and cause network congestion, which are associated with high costs for redispatch measures (Ritter et al., 2019). Although the causes of this do not lie with the network operators, they still have the possibility to influence the speed of network expansion themselves. They can take various measures to speed up approval processes and increase public acceptance, for example in the form of

- Planning and coordination of the application process
- Participation of citizens and interest groups

- Compensation payments

However, these measures incur costs and require corresponding regulatory incentives. Output-oriented revenue components could be used to directly incentivise the goal of rapid network expansion, for example by linking bonus (or malus) payments to specific targets for when the network expansion should be realised. One practical example is the NorNed interconnector between Norway and the Netherlands, which was commissioned in 2008. Here, the then Dutch regulatory authority DTe (now ACM) specified a bonus-malus system that included surcharges (discounts) for commissioning before (after) 1 January 2008 (DTe, 2004).

A.2 Timely network connections

In addition to network expansion, timely network connection is also of great social interest. This applies both from a perspective of climate policy (connection of decentralised renewables) and economic policy (connection of flexible resources to avoid expensive redispatch measures). Although network operators are legally obliged to prioritise network connections for renewable energies, particularly in accordance with section 8 of the German Renewable Energy Sources Act (EEG), targeted economic incentives can create added value for society overall. A practical example is provided by regulation in the United Kingdom, where the regulator Ofgem has implemented specific incentives for distribution network operators to connect decentralised generation plants in the current regulatory period (RIIO-ED1) (Ofgem, 2013). The reduces uncertainty for network operators due to the often "speculative" connection requests for projects that are ultimately not realised, but nevertheless cause planning costs for the network operator in advance. If the market-side realisation of a generation unit to be connected is still at an early stage and therefore uncertain, an incentive problem arises. The network operator may have to fear that costs for planning and authorisation procedures will not be reimbursed. It will therefore have little incentive to initiate the corresponding measures at an early stage. As a result, the network connection may be delayed. Ofgem has addressed this problem of uncertainty by means of so-called *assessment and design (A&D) fees*, according to which decentralised producers requesting a network connection have to pay a fee in advance to the network operator to cover the latter's planning costs for the network connection. An output-oriented component would also be possible here, which explicitly remunerates the speed of the network connection and thus compensates for the economic risk.

Regulatory incentives for the connection of decentralised generation plants are being considered as part of New York REV. In addition to the connection speed as a benchmark for revenue components, a reference to the customer satisfaction of connection recipients is also being considered (cf. Littel & Shipley, 2017).

A.3 Utilisation of interconnectors

For the further development of the European internal electricity market, not only the rapid expansion of cross-border interconnectors is important, but also the optimal utilisation of existing lines. Paragraph 27 of the Regulation on the internal electricity market[6] states: "Uncoordinated restrictions on interconnection capacity are increasingly limiting electricity trade between Member States and have become a major obstacle to the development of a functioning internal electricity market. The maximum capacity of interconnectors and critical network elements should be made available in compliance with the safety standards for secure network operation, including compliance with the safety standard for outage variants (N-1)." However, it is up to the national regulatory regimes to create the incentives for the responsible transmission system operators to take all economically reasonable measures to make the maximum possible capacity of the interconnectors available.

An output-oriented approach can achieve this by linking revenue elements to the availability of capacity. Such an incentive mechanism was established in the form of a bonus-malus system in the case of NorNed. The Dutch regulator DTe has provided for increases and reductions of €400,000 per percentage point for deviations in the average annual availability of the interconnector from the specified target value (95.62%). The amount of the revenue adjustment is based on the expected trading revenue per percentage point of available interconnector capacity (see DTe, 2004).

A.4 Development of smart grids

The development of smart grids continues to be a major topic. There is no strict definition of what exactly smart grids are, nor are there any standardised objectives. However, there seems to be a consensus that the development of smart grids is worthy of funding. Combined incentive components can be used for the development of smart grids. For example, the performance of network operators can be evaluated based on benchmarks of development strategies, practices and investments in the area of network modernisation. In the USA, the GridWise Alliance of network operators, market operators and technology providers operates and publishes a Grid Modernisation Index[7] to assess and rank the status of network modernisation efforts in all 50 US states. Another example is the Smart Grid Index (SGI)[8],

[6] REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the internal market in electricity, European Commission, Brussels.

[7] https://gridwise.org/grid-modernization-index/

[8] https://www.spgroup.com.sg/what-we-do/smart-grid-index

which was developed by the SP Group from Singapore. SGI measures the expansion of smart grids and value creation for network customers in seven dimensions:

1) Monitoring and control,
2) Analysing data,
3) Reliability of supply,
4) DER integration,
5) Renewable energies,
6) Security,
7) Customer satisfaction.

The benchmarking results also identify best practices for the further development of smart grids (T&D Europe, 2020, p. 25-28).

B Quality of supply

As the electricity networks represent a critical infrastructure in the network-based electricity supply, ensuring a high quality of supply is a central task of the network operators. According to the Energy Industry Act, the operators of energy supply networks are therefore obliged to "operate, maintain and optimise, strengthen and expand a secure, reliable and efficient energy supply network in a non-discriminatory manner in line with demand" (Section 11 EnWG; translation by authors). It is primarily the responsibility of the regulator to specify this requirement for network expansion and operation more precisely and to create the economic incentives for this. We distinguish between two areas of quality of supply that can qualify for OOR:[9]

B.1 Resilience

B.2 Service quality

B.1 Resilience

The concept of resilience goes beyond security of supply, which is already covered by the quality element in the ARegV, and has recently become increasingly important. Although there is no standardised definition and clear demarcation, resilience aims at the robustness and adaptability of the electricity system in relation to risks of *large-scale* and *long-lasting* power interruptions (see acatech et al., 2020). Generally speaking, a system is said to be resilient if it "maintains its functionality even under high stress or recovers quickly after failure and learns from such events" (acatech et al., 2017, p. 6). Resilience therefore differs from the

[9] We note that the quality element is a very good example of OOR, but is already taken into account in Section 19 (1) ARegV and is not discussed here for precisely this reason.

requirements for short-term security of supply and is therefore not covered by the quality element. The ARegV currently lacks targeted incentives to improve resilience.

The decentralisation and digitalisation of the electricity system is a key driver of the discussion on resilience. The increasing number of decentralised, interconnected players is leading to greater complexity and therefore greater susceptibility of the overall system to system failures. On the one hand, there are more simultaneities and self-reinforcing effects in the network, which may have a destabilising effect on the system (see BMWi, 2019). On the other hand, there are more potential targets for cyberattacks (BSI, 2018). Resilience must be distinguished from traditional supply quality primarily in that it is aimed at widespread power outages and addresses potential dangers that cannot be estimated in terms of their nature or probability of occurrence.[10] The question of how a resilient electricity system should be designed and what economic incentives should be used to achieve this is correspondingly difficult. The two overarching aspects of resilience are, on the one hand, robustness against external stressors, so that supply failures are possibly avoided, and, on the other hand, adaptability, to enable a rapid return to stable system operation after a failure. In the more general literature, numerous resilience-improving measures can be found at the lower levels, some (but not all) of which are applicable to the energy supply. Three frequently mentioned criteria are, for example (see acatech et al., 2017)

- Diversification: The risks of system failures can be spread by varying the components and balancing them.
- Redundancies: By installing surplus capacity, failures of individual components can be compensated for.
- Buffers, storage and reserves can compensate for short-term outages and discontinuities and thus increase system stability.

The three resilience-improving measures mentioned above illustrate the economic incentive problem: A competitive market would not remunerate these aspects of resilience efficiently. This is particularly obvious in the case of redundancy, which may appear inefficient according to market-based criteria. But what if the costs of a possible outage would affect many consumers, but the willingness to pay would not materialise in the free market due to positive externalities? In addition, not all resilience-promoting measures are within the remit of the network operator. Some tasks can or may only be undertaken by market players (e.g. due to unbundling regulations). While, for example, the N-1 criterion for electricity networks addresses the investment activities of the network operator, comparable redundancy requirements for generation plants and storage facilities operating on the market must be

[10] In this context, the term "black swans" is often used to describe a large number of potential risks, each of which has a low probability of occurrence but would have a major impact in terms of social costs if they were to materialise.

established in the market design and/or regulatory framework. Specific examples are the balancing energy market and the network and capacity reserve in the German regulatory framework, which must be made available by the network operator when required and contribute to system stabilisation.

The network operator can also assume a central role between the regulated network area and the electricity market to ensure resilience. In contrast to the classic tasks relating to system responsibility, however, roles and responsibilities are still largely open. Output-oriented incentive components could be based on measurable resilience indices and be included in the regulatory formula similar to the quality element. Initial regulatory approaches exist in New York, for example, where a *diversity index* for decentralised generation plants is used to promote the connection of many small plants (compared to a few larger plants) (Brown et al., 2018). In the United Kingdom's RIIO 2 approach, the regulator Ofgem intends to incentivise the resilience of electricity network systems based on a "Network Asset Risk Metric (NARM)" for the upcoming regulatory period for transmission networks, which is intended to measure the susceptibility of the electricity network to supply failures (Ofgem, 2019a). In general, a systematic and coherent incentivisation of resilience requires the clarification of a number of open questions, the two most important of which are well formulated by Schwartz (2019, p. 1):

- "What level and scope of resilience do we need and how much are we willing to pay?
- Who's responsible for resilience, and how should other entities coordinate with utilities when there are mutual benefits?"

B.2 Service quality

The tasks of the network operator are not limited to the secure and uninterrupted transport of electricity, but also include a variety of other services for network customers. Accordingly, the German Federal Network Agency (BNetzA) also considers service quality to be a pillar of supply quality, with specific examples being adherence to deadlines and the quality of billing.[11] However, there is no specific incentivisation of service quality in the ARegV. In a comparatively static and centralised energy system, as was the case a few years ago before the start of the energy transition, service quality is also likely to have played a rather subordinate role and appeared to be adequately covered by the legal and regulatory requirements. With decentralisation and digitalisation, however, the dynamics of the energy sector have increased considerably. With the development of prosumers, flexible feed-in and consumers,

[11]https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Netzentgelte/Strom/Qualitaetselement/qualitaetselement-node.html.

the heterogeneity of network customers and thus the specific requirements for service quality have increased.

In the UK, service quality is an output category in its own right. The British regulator Ofgem has introduced a comprehensive tool for measuring and incentivising customer satisfaction ("Broad Measure of Customer Satisfaction"). Incentives take the form of a bonus-malus system for three areas: (1) customer satisfaction based on a customer survey, (2) the number of customer complaints and (3) the extent of stakeholder engagement. Each of the three areas is incentivised separately (see Whited et al., 2015, p. 74).

C Market facilitation

With the liberalisation of the energy sector, various markets have emerged around the electricity networks, which directly (electricity markets) or indirectly (e.g. balancing energy markets and capacity markets) serve to provide customers with a reliable and affordable supply of electricity, but are increasingly creating added value for society as platforms for energy services in a broader sense. A key driver of the development of new services and market platforms is increasing digitalisation and decentralisation (see section **Fehler! Verweisquelle konnte nicht gefunden werden.**). The emergence and functioning of new digital and/or decentralised markets is significantly influenced by the network operator, whose actions can facilitate trade, promote competition and economic efficiency and create or help shape new markets. In the context of market facilitation, we distinguish three possible areas in which network operators can take on important tasks for which output-oriented incentives can be considered:

C.1 Promoting the functionality and competition of existing markets

C.2 Promoting the development of new markets

C.3 Market monitoring

C.1 Promoting the functionality and competition of existing markets

Network operators have a significant influence on the functioning of the electricity markets as part of their core task of expanding and operating the networks in line with demand. On the one hand, they are responsible for reducing by expanding the network, so that restrictions on trade and competition as a result of market segmentation are limited to an efficient level. On the other hand, they have the task of efficiently managing any network bottlenecks that occur in network operation in order to minimise distortion of the price signals on the electricity markets.

The influence of the network operator on the electricity market is most evident with cross-border interconnectors, the expansion of which the EU Commission considers important for the single European internal electricity market (see EU, 2019). In order to ensure the highest possible level of cross-border electricity exchange, the current EU regulation stipulates, for example, that transmission system operators may not restrict interconnection capacities to eliminate bottlenecks in their own bidding zones and must ensure a net transmission capacity of 70 % of the transmission capacity.[12] Setting such a fixed target value may be an effective measure to promote EU-wide competition on the electricity markets, but it does not generally lead to a welfare optimum as it does not explicitly take into account the marginal social costs and marginal benefits of providing capacity. However, efficient economic incentives should capture precisely this trade-off between costs and benefits and integrate it into the network operators' optimisation. Output-oriented incentives can contribute to the internalisation of social benefits and thus achieve a more efficient incentivisation of tasks in the area of market facilitation (cf. Oxera, 2019).

Market facilitation (in cross-border trading) creates welfare (*value creation*) through the merit-order effect, as less expensive generators in one market replace more expensive generators in another market. This welfare effect can be calculated directly using the bid curves created by the electricity exchanges. Oxera (2019) developed an incentive system for this purpose; this sets the financial incentive for a network operator to provide capacity for cross-border trading in relation to the welfare effects that arise from trading. In each hour, network operators could then internalise the trade-off between the costs associated with providing more capacity and the welfare generated by additional trade. A closer look reveals four critical design aspects in this approach: the quantification of welfare effects, the isolation of welfare effects that are due to more efficient network operation (rather than exogenous factors such as weather), the determination of the incentive parameter and the allocation of welfare effects between individual network operators. Nevertheless, an initial review of the design of such a mechanism suggests that the methodological problems can be overcome (Oxera, 2019, Part 2).

C.2 Promoting the development of new markets

Network operators can themselves contribute to the development of new markets and, if necessary, take on central functions within these markets. One current example is flexibility markets, in which consumers and flexible resources can offer flexibility, which the network operator can use to efficiently manage network congestion. As consumers, network operators play a central role in these markets and can make an important contribution to the

[12] See REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the internal market in electricity, European Commission, Brussels.

development of the markets due to their importance and expertise. Flexibility markets also create added value beyond the network-serving benefits of flexibility markets, as they can enable suppliers to optimise their balancing group and market-based business models that go beyond the functions of traditional electricity markets.

For example, flexible large-scale consumers such as cold stores, which usually have no ambition to be active on the electricity market, can act as suppliers on a local flexibility market whose rules are better geared to the specific requirements of suppliers than centralised electricity markets.

Network operators can be involved in the design of market rules due to their close proximity to potential suppliers. An example comes from the Netherlands with USEF (Universal Smart Energy Framework), which was founded in 2014 as a cooperation between various market players, network operators and IT companies. As a neutral organisation, USEF pursues the goal of developing a common flexibility market to promote the integration of the electricity market with the help of ICT-based approaches. As illustrated in Figure 6 below, flexibility is seen as a connecting element between the market players in the value chain. The USEF example shows that network operators can also take on a market-promoting function beyond pure network management. This can also go as far as network operators becoming active as operators of market platforms.[13] This is already the case for TSOs in the balancing energy markets, as they are jointly responsible for the transparent and non-discriminatory tendering of balancing energy requirements. The same applies to the capacity and network reserve, where reserve capacities to be maintained are put out to tender by the TSOs. In the case of DSOs, a development towards "Distributed System Platform (DSP) Providers" can be observed.

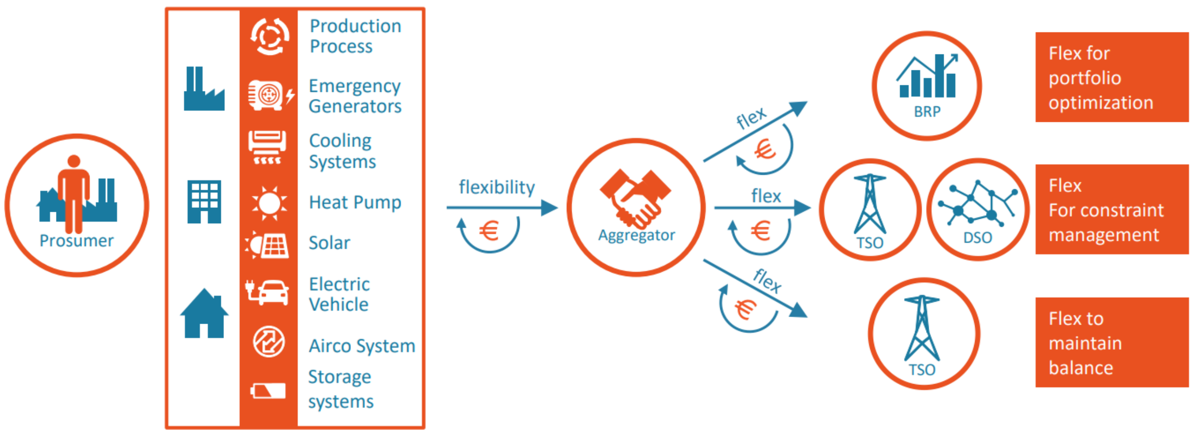

Figure 6: Flexibility as a connecting element of the value chain
Source: USEF (2018), p. 7.

[13] The prerequisite for this is, of course, that unbundling conformity and thus freedom from discrimination can be guaranteed (see Buchmann, 2020).

Under basic incentive regulation, however, network operators will typically only have network efficiency in mind, while "external" welfare effects in terms of market efficiency are not part of the optimisation calculation. In the current regulatory framework, tasks beyond the core area are treated at best in the form of "permanently non-controllable costs" (dnbK) and are excluded from the efficiency incentives as annual cost pass-through. However, digitalisation and decentralisation are increasingly giving rise to new and more complex areas of responsibility that make explicit incentivisation sensible. If the network operator should actively contribute to the promotion of markets, output-oriented revenue elements linked to the active utilisation of such markets (trading volumes or comparable indices) would be conceivable. This would incentivise network operators to efficiently balance the costs and benefits of promoting a market. Some tasks at the interface between the network and the market can be performed by both a market player and the network operator. This raises the question of whether regulatory incentivisation is appropriate at all, or whether competition would suffice to efficiently incentivise the network operator to take on new tasks. In other words: Can market-based incentives *outside of* the regulatory framework be considered that allow the network operator additional business models in addition to the regulated revenues?

As part of the New York REV regulatory approach, "Platform Service Revenues (PSR)" are being discussed in New York, which are intended to remunerate distribution system operators for their role as Distributed System Platforms (DSP) (see Brown et al., 2018). The background is the decreasing importance of traditional network revenues in a system with a stronger focus on energy efficiency and thus decreasing demand. In effect, PSRs are fees that local utilities can charge for new products and services that are offered via their own platforms (DSP). Such services could be, for example, the provision of dispatch and balancing services on the network or the switching of customers and provision of data to service providers. The pricing and revenue sharing of these fees will have to be approved by the regulatory authorities. The model is currently being trialled in a number of REV demonstration projects (NY PSC, 2016).

C.3 Market monitoring

Network operators can also play an important role in market monitoring, which ultimately contributes to the improved functioning of the markets. One example currently being discussed concerns the potential for gaming on flexibility markets. The term "inc-dec gaming" refers to perverse incentives for market participants by underbidding strategically on the day-ahead electricity market to realise excessive profits with redispatch on the flexibility market (see Hirth & Schlecht, 2019). Network operators have the necessary data on the capacities and load flows in their network and therefore seem well suited to act as a strategic counterpart and take on market monitoring tasks in the area of flexibility markets and, if necessary, implement sanctioning measures (cf. Brunekreeft et al., 2020).

D Digitilisation

Digital technologies (smart metering systems, new applications such as big data analytics, blockchain and cloud computing) are leading to a far-reaching transformation of the energy industry and have enormous potential to contribute to value-added growth in the network sector. They make it possible to extend the life cycle of the infrastructure, optimise electricity flows and network losses and thus increase the efficiency of network operation. By using new technologies, decentralised renewable energy systems, storage and consumption can be better coordinated. Intelligent networks (smart networks) are becoming an important prerequisite for a successful transition to a GHG-free energy supply.

Furthermore, digital technologies also create the opportunity for network operators to drive innovation in customer service and in product and service development. In the coming years, digitalisation processes can not only simplify the increasing complexity of network operators' tasks, but also create additional customer benefits. Network operators can offer more personalised solutions and combine their products and services with those from other sectors, such as telecommunications (BDEW, 2016). CEER identifies potential for new products and services in areas such as smart houses, smart buildings (with regard to electricity, heating and cooling), mobility as a service and in new, more flexible contract and procurement models for energy (CEER, 2019). It is also assumed that customer demand will increase for product packages that can offer additional services alongside network-related solutions (*Figure 7*).

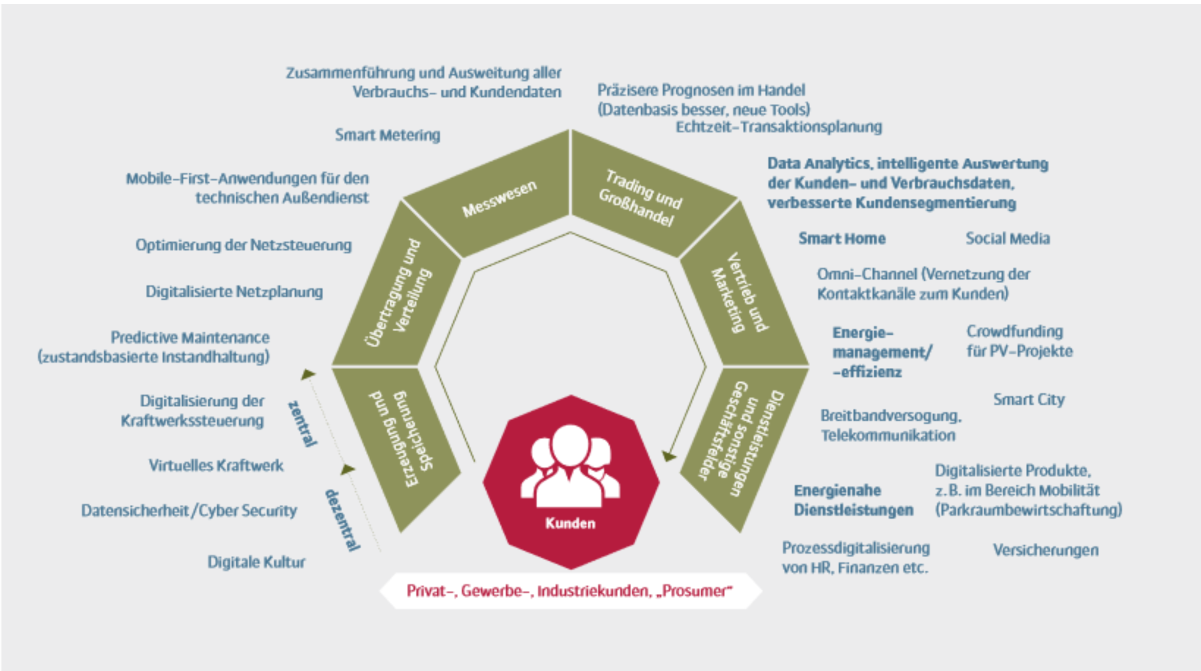

Figure 7: Digitalisation along the energy/value-added stages

Source: BDEW, 2016, p. 19 (German original).

The network operator can take on different roles: 1) as an infrastructure operator ("infrastructure as a service"), 2) as a platform operator ("business as a service"), and/or 3) as a marketer of products and services for customers (BDEW, 2016, p. 35; cf. *Figure 8*).

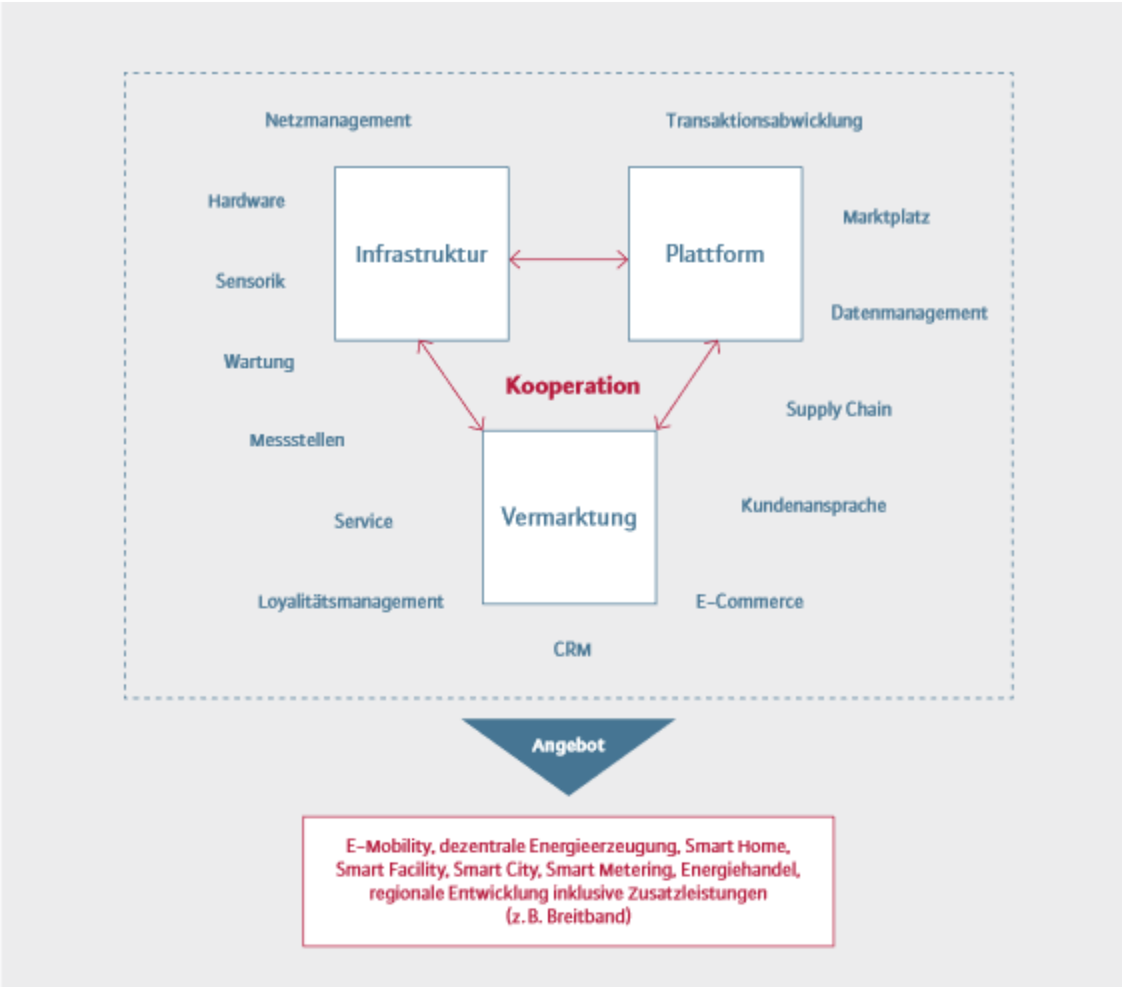

Figure 8: Schematic representation of a value creation network in the energy sector
Source: BDEW, 2016, p. 35 (German original).

Digitalisation in the network sector is being driven in particular by regulatory requirements to create more flexible networks. Both nationally and internationally, the legal basis for the digitalisation of network operation is increasingly being created. Network operators are obliged to implement new national and European requirements, such as the Act on the Digitilisation of the Energy Transition and the EU Regulation on the Internal Electricity Market.

Three areas of application for OOR in the field of digitalisation are presented below:

D.1 Processing and provision of data (data facilitation)

D.2 Smart meter rollout

D.3 Data protection and cyber security

D.1 Processing and provision of data (data facilitation)

An intelligent energy and information system provides large amounts of data on electricity transmission, distribution and utilisation, which are of economic interest to many market players. This data includes, in particular, electrical information from electricity meters and distribution stations, but also non-electrical information such as meteorological data and regional economic data. In addition, there is data from business and management processes, in short, network data from the actual monopoly area. This data can be divided into (at least) three groups:

1) Data from and for network operation as the core business of the network operator,
2) Network data that is used externally or made available to third parties, and
3) More general data beyond network operation as an independent business segment.

In these three business areas, the network operators are directly at the source of the relevant data, the analysis of which enables a high economic benefit.

The question is what role network operators can play in data provision and under what regulatory conditions? Assuming that regulation allows active participation in a competitive data business and that this remains part of regulation, the challenge is to set the right incentives for the network operator to take on this task (Buchmann, 2017). Currently, network operators can use data to improve the efficiency of the network, but other forms of data processing are not incentivised by regulation. Therefore, it is possible that network operators will not collect, process and provide data in an efficient, effective and market-oriented manner.

Network operators could for instance be incentivised by means of an output-oriented element to provide data on a self-developed data platform for other data users or market players. However, this raises questions about the limits of unbundling, the structure of the payment and the way in which the additional costs and revenues are included in the regulation (Brandstätt et al., 2016). In the following, the three business fields mentioned above are discussed in more detail and examples of output-oriented incentives are outlined.

1) Data from and for network operation as the network operator's core business

Network operators use data from their core business to improve the efficiency of network operation. The expenses for the provision, management and operation of the IT systems required for this are remunerated accordingly via the incentive regulation. However, analysing network-related data in real time is becoming a technically demanding task because it requires sophisticated data management, state-of-the-art analysis techniques and IT specialists. Compared to traditional network operation, these activities are associated with higher and possibly uncertain OPEX and represent a financial risk for network operators that is not adequately compensated by the traditional regulatory revenues under the current ARegV. Network operators may thus hesitate to make large-scale operational expenditures for the development and provision of service-based IT solutions in the case of uncertain innovations within the framework of normal incentive regulation (cf. Poudineh, et al., 2020).

A further incentive problem is that network operators face the decision of which IT tasks they want to take on themselves and which can be outsourced to third-party providers more cost-effectively. In the latter case, they would resort to cloud computing as an alternative to developing their own IT infrastructure for data processing by using networked services, servers, databases, storage, software and analyses developed and operated by third-party providers (such as Amazon Web Services, Google or Dropbox). The contractual usage fees (subscription fees) would then be included in full as OPEX in the regulation and worsen the incentive problem. The result would be an OPEX-CAPEX-bias, which would prevent a technology-neutral decision by network operators due to flawed incentives.

To promote technology-neutral digitalisation, network operators should be encouraged to make efficient decisions on OPEX-heavy IT solutions. As described above, one option would be to capitalise the total expenditure - regardless of whether it is CAPEX or OPEX - to a fixed proportion as assets, i.e. to capitalise it as capital expenditure, pay interest on it and depreciate it over a fixed useful life. This form of TOTEX regulation, which can also be referred to as a "fixed-OPEX-CAPEX share" (FOCS), cancels out the regulatory differences from the different types of costs and can therefore improve technology neutrality and better account for risks in the regulated revenues (see Oxera, 2019; Meyer, 2020).

A good practical example of incentivising OPEX-heavy activities is provided by the New York REV. In May 2016, the NY PSC issued a "Reforming the Energy Vision (REV) Track 2" order allowing network operators to capitalise a range of REV-related operating expenses, including prepaid "Software-as-a-Service" (SaaS) contracts with third-party providers; i.e. the total cost of the service contract is treated as a regulatory asset. This should put IT services on an equal footing with other digital solutions and allow network operators to choose an IT solution that provides the greatest benefit to network operations and customers (NY PSC, 2016, pp. 104-107; AEEI, 2018a).

2) Network data that is used externally or made available to third parties.

Point 1 above concerns "internal" data that is required and used for network operation itself. In addition, this (or extended) data from the monopolistic network can also be made available to third parties or used for purposes outside the network area: This makes the data "external". A regulatory distinction must be made here.

On the one hand, processed network data (from the monopolistic business) can be sold to third parties. The network operator itself does not use the data, but only sells it. Questions that arise are:

- How is the data remunerated?
- What does the data platform look like and is the network operator allowed to operate it itself?
- What incentive mechanism is used to incentivise network operators to provide good quality data in an effective and efficient way?

On the other hand, network operators could utilise any data themselves for a further business model. This raises the following regulatory questions:

- How are the revenues from this additional business treated from a regulatory perspective and what would a suitable incentive mechanism look like?
- As the network data originates from the monopoly network, unbundling issues arise:
    - Is the additional business for the network operator permitted under the unbundling rules?
    - Does the network operator have to make this data from the monopoly business available to eligible third parties (third-party access)?

To ensure that network operators are more responsive to customers and their wishes in the area of data management, network operator activities in this area can be acknowledged as an output in regulation and thus remunerated. For example, network operators can be financially rewarded according to their commitment and the results of their cooperation with customers. In the UK, a "stakeholder engagement" incentive instrument was introduced as part of RIIO. The incentives under this tool aim to encourage network operators to proactively engage with electricity consumers to provide consumer-centred services. Network operators receive a financial reward for these activities (Ofgem, 2018). In the case of data facilitation, it could be assumed that customers are best placed to judge the practical applicability of their data. To find this out, the network operators conduct customer surveys on the use of the data. The financial reward would depend on the result of this survey (Oxera, 2019, p.12-13).

3) More general data beyond network data as an independent business area

Points 1 and 2 above relate to network data from the actual monopoly business. Pure network data can be expanded with additional data to add value. However, this additional data does not originate from the actual monopoly business, but from the market. In addition to the network operator, other parties on the market can also collect and provide this data. Here, the network operator leaves the business field of the actual monopoly area and operates in the market.

The regulatory questions that arise here:

- Should the network operator's revenue from the provision of freely available data be regulated or unregulated?
- How can such an interface between the regulated and unregulated areas be defined?
- Unbundling is also important here:
    - Can there be cross-subsidisation between the regulated and unregulated sectors?
    - Can the network operator be active in the unregulated area under the prevailing unbundling rules?

In some countries, regulatory incentives are already being designed and implemented in pilot projects. A good example is a regulatory solution that was developed as part of the "Reforming the Energy Vision (REV) Track 2" strategy. For example, the NY PSC distinguishes between three types of regulatory treatment for the provision of data analyses: 1) Network operators must make certain data (basic data) available to customers and third parties free of charge; 2) If customers request detailed information ("beyond basic customer data"), network operators can make this data available for a fee; 3) Network operators can analyse customer-specific data and make recommendations based on this analysis or, with the customer's consent, make these analyses and recommendations available to third-party providers for a fee. The revenues for this would fall into the category "Platform Service Revenues" (PSRs) (see also subsection C.2 on PSRs). It is important to emphasise here that this third type of service would be competitive, with a distinction being made between monopoly services and services that can be provided by third parties (NY PSC, 2016, pp. 138-144; AEEI, 2018a, p.2).

D.2 Smart meter rollout

Intelligent metering systems (iMSys) are key for an infrastructure fit for the energy transition, making the planning and operation of the network more effective and efficient. It represents a platform in buildings that makes the various applications in the areas of smart network, smart home/building and smart mobility possible and opens up many new market-related business areas for network operators. iMSys is a combination of a digital electricity meter and a communication module, the smart meter gateway, which makes it possible to measure electricity consumption and generation at the level of individual systems accurately. The "Act on the Digitilisation of the Energy Transition" (GDEW) of 2 September 2016 and the "Act on Metering Point Operation and Data Communication in Smart Energy Networks" (MsbG) of 29

August 2016 created the legal basis for the deployment of iMSys[14] . Among other things, the regulations established a schedule for the mandatory installation and technical specifications for iMSys. The mandatory installation of smart metering systems was to begin as early as 2017. However, the nationwide installation of iMSys could not begin until the technical specifications were defined by the Federal Office for Information Security (BSI) in February 2020. Even now, at the moment of writing, the implementation of the GDEW is slow.

The implementation of GDEW and MsbG also represents a challenge for network operators from a microeconomic perspective. A wide range of cost variables for the rollout of iMSys, price increases for smart meter rollouts in recent years and a number of services, such as metering services, are not sufficiently taken into account in the price cap (POG) (Ernst & Young, 2018). In addition, the framework conditions for the accompanying investments in the market area are lacking (Ernst & Young, 2018). The cap on revenue from the smart meter rollout due to the price cap means that network operators will only be able to generate a positive return after years. As a result, network operators are focussing on other areas and alternative technologies to smart meter gateways (SMGW). There are doubts as to whether the GDEW can be implemented as planned. Ernst & Young (2020) recommend creating further incentives for the expansion of iMSys to accelerate the smart meter rollout. Among other things, they suggest reviewing the current price cap for metering fees and linking incentives to rollout progress (achievement of certain rollout quotas as output) (Ernst & Young, 2020, p. 45).

In France, the regulatory authority has introduced an instrument of bonus-malus payments for network operators based on the following three criteria:

1) Investment costs; obligation to make investments at the lowest cost,
2) Timely deployment; the indicator is linked to the number of smart meters installed and capable of communication compared to the planned number, and
3) Service performance; this is measured by successful or failed meter readings, efficient online services and the response time for remote service requests.

If the network operators do not comply with the predefined output, they must expect malus payments (French Energy Regulatory Commission, 2014).

The smart meter rollout could also be accelerated through less capital-intensive financing models. One example of this would be outsourcing the physical and operational aspects of a smart metering system to third parties. Here, the network operator can hand over operational responsibility for smart metering to a third-party provider - a so-called "Smart Metering as a Service" (SMaaS) model. Network operators can also use an "Infrastructure-as-a-Service"

[14] German households with an annual consumption of significantly less than 6,000 kWh are not affected by the statutory installation obligation. By law, only a modern measuring device - i.e. a simple digital electricity meter without a gateway - must be installed in these households by 2032.

(IaaS) model, whereby they have the option of renting or leasing the metering technology in return for a usage-based fee. A financing partner provides the metering technology. The costs for installing the meters, the hardware and software and maintenance are included in the network operator's operating costs. One option to improve incentives for this model would be to treat the cost of such services as a capital cost using the FOCS approach mentioned above. Government agencies in California, New York and Illinois are exploring these new financial incentive mechanisms to increase the uptake of such services by network operators (AEEI, 2018b).

D3. Data protection and cyber security

Digitalisation processes entail high risks in terms of data protection and cyber security. Network operators assume responsibility for the non-discriminatory and secure handling of the customer data entrusted to them and are legally obliged to ensure IT security (functional security, availability) and data security (protection against falsification, deletion and unauthorised disclosure). For example, CEER recommends that the national energy regulatory authorities create the necessary regulatory mechanisms, provide practical guidelines and monitor expenditure in the areas of data protection and cyber security (CEER, 2018).

In July 2016, the European Commission adopted the first EU-wide directive on network and information security (NIS Directive) with the aim of increasing the general level of cyber security in Europe. The EU NIS Directive was transposed into German law in June 2017. In addition, a standardised legal framework for cooperation between the state and companies for greater cyber security in critical infrastructures (KRITIS) was established in Germany when the IT Security Act came into force in July 2015. Regulations for providers of digital services have also been implemented.

Since the General Data Protection Regulation (GDPR) came into force in May 2018, data storage has been subject to particularly strict regulations. In this regard, the regulatory authorities must work closely with the authorities responsible for data protection and IT security and ensure that the energy companies implement the corresponding security measures. The data protection measures should not only take network-related aspects into account, but also various benefit aspects for customers, such as increased security of personal data, efficiency offers and cost savings and measures to increase transparency and trust in the handling of personal data and the acceptance of new, digital business models. Network operators are therefore faced with the important task of transferring their innovative activities and the associated reputation to data management (data collection, storage and processing) and the associated customer benefits.

Output-oriented incentives can encourage network operators to be proactive in this area. The regulatory authority can, for example, draw up "data best practice" guidelines for cyber security and data protection and financially reward or penalise network operators for their implementation. In addition, a separate regulatory approach could be developed for IT costs within the framework of the ARegV.

A prominent example of the regulatory treatment of IT costs in relation to cyber security is the British regulatory model RIIO. Under this model, network operators can take cybersecurity costs into account as part of an uncertainty mechanism created for cost categories that are difficult to predict in the RIIO regulatory model. In the second regulatory period (RIIO-2), which begins in 2023, a separate regulatory mechanism will be introduced for these costs. Based on a new regulation, network operators will be able to include cyber cost allowances directly in their business plans, which will then be reviewed and approved by the regulator Ofgem (Ofgem, 2019b; CEPA, 2018).

E Whole System Approach

In many parts of the world, eg. in Europe, the network operator is legally and organisationally largely unbundled from the overall system. This applies both to the other stages of the electricity supply value chain and to other related sectors (eg. gas, heat, telecommunications).

However, the actions of one network operator have a direct impact on other players in the overall system and vice versa. The individual optimisation of the network operators' individual actions can therefore lead to conflicts that run counter to the economic goal of optimising the system as a whole. CEER (2018, p. 29) addresses this issue under the term Whole System Approach (WSA): "The WSA requires the DSO to look at net benefits on a wider basis than their own network." The British energy regulator Ofgem is also increasingly working in this direction as part of RIIO-2. The McNulty report from 2011 is likely to have been a background to this. The so-called McNulty report (2011) for the British government examines the efficiency of the British railway system with two main conclusions: 1) the British railway system was (as of 2011) significantly less efficient than comparable railway systems, 2) the main cause of this inefficiency is a far-reaching fragmentation of the system, which leads to misaligned incentives. The report makes many recommendations for action, above all, however, the focus is on improved overall system optimisation. The regulatory challenge here is, as CEER (2018, p. 29) notes: "in some situations, externalities not fully priced in must be considered by regulators." This gets right to the heart of the matter: output-oriented regulation provides selective incentives to take such externalities into account in individually optimised decisions. The WSA is relatively new and many questions, particularly in terms of implementation, are open and certainly complex.

The WSA also highlights the limits of unbundling: Unbundling of network areas promotes competition among network users, which is undoubtedly beneficial to society, but the extensive fragmentation of the sector leads to a loss of coordination (cf. Brunekreeft, 2015).

These two effects must be balanced. However, this realisation does not lead to a reversal of the unbundling measures, but to a further development of incentive regulation: output-oriented regulation should take better account of cross-network effects.

CEER (2020) distinguishes between three levels of the WSA, each of which corresponds to the interfaces at which coordination problems can occur: 1) Whole-network approach, 2) Whole-chain approach, and 3) Cross-systems approach (cf. *Figure 9*).

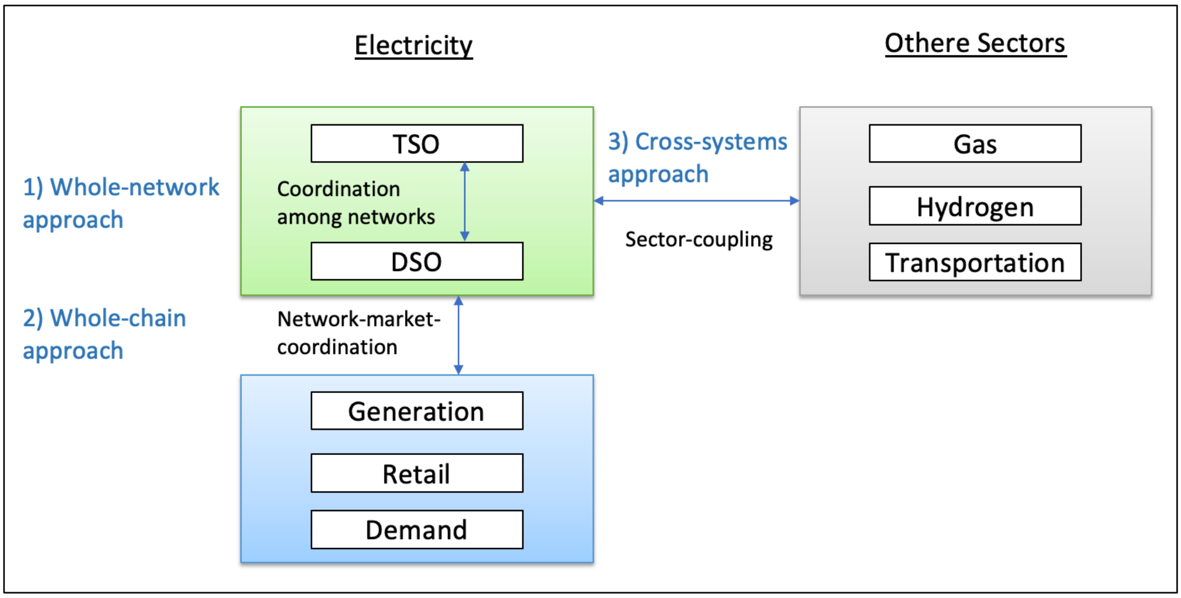

Figure 9: Three levels of the Whole System Approach
Source: own presentation according to categorisation by CEER (2020).

The whole-network approach concerns the coordination between the networks in the electricity sector, and in particular the TSO-DSO coordination. The whole-chain approach is aimed at coordination between the regulated networks and electricity markets (network-market coordination). The cross-systems approach is concerned with coordination between different sectors (sector coupling). These three levels of the WSA are analysed in more detail in the following subsections:

E.1 TSO-DSO coordination

E.2 Coordination between the network and the market

E.3 Sector coupling (polygrid)

E.1 TSO-DSO coordination

The rapid increase in decentralised generation, mostly with renewable energies, is causing an increase in network congestion at medium and higher voltage levels. At the same time, access to decentralised generation and load can also make it possible to eliminate congestion by using them specifically as flexibility. There is currently a debate about how the available flexibility can be utilised and, above all, by whom. This can lead to (negative and positive) external effects: The use of flexibility to eliminate a bottleneck in one network can increase or reduce the bottleneck in another network.

The design of the rules for flexibility procurement is currently in process and is characterised by the question of optimal coordination between vertically-related network operators: TSO-DSO coordination. Two aspects need to be considered here.

Firstly, the exchange of information. The flexibility platforms are designed in such a way that every network operator has cross-network information. In principle, the approach comprises three components: 1) the distribution of roles between the TSO and DSO in the use of flexibility is clearly defined, 2) network operation and planning are transparent, and 3) the exchange of information on cross-system effects of the network operator's actions is guaranteed. The exchange of information is necessary for coordination, but is not sufficient.

Secondly, the incentive structure of the network operators. Even if every network operator has all the information on the effects of their own flexibility procurement, it is quite possible that the individual network operator will not choose the optimal solution for the system as a whole, but rather the individually "optimal" solution for their own network due to regulation. This is where the WSA comes into play: the incentives for individual network operators must be designed in such a way that they simultaneously use the optimal solution for the system as a whole when optimising individually; i.e. the effects of flexibility procurement to eliminate network congestion on other networks should also be taken into account.

Various incentive mechanisms are conceivable here, but these cannot be discussed in any further detail at this point:

- Adaptation of regulatory systems (eg. sliding scales)
- Cost and benefit sharing models (eg. cap and trade)
- Adaptation of market design (eg. innovative pricing mechanisms)
- Innovative governance structures (eg. common goals, alliances, joint ventures)

E.2 Coordination between network and market

With the increasing need for network-serving flexibility, which is to be provided primarily by market players, coordination between the regulated network and the market is also becoming more important. The unbundling rules pose a central challenge in this respect: The fragmentation of the value chain leads to a "blind spot" in regulatory terms, as costs and benefits that are incurred outside one's own network are no longer explicitly part of the network operator's optimisation calculation. The legal and regulatory requirements also frequently restrict the opportunities for cooperation between the network and the market.

The problem is well illustrated by the example of so-called multi-use storage systems (see Meyer et al., 2017). Electricity storage systems, e.g. in the form of batteries, can be used both for market purposes (to realise arbitrage profits) and for network purposes (as flexibility). As a rule, however, they are only profitable if they can be used flexibly for both purposes. This requires co-operation in which deployment times, costs and revenues are shared between the regulated network and the market. However, according to Article 54 (1) of the EU Directive,[15] at least transmission system operators are explicitly "not allowed to own, construct, manage or operate energy storage facilities". The unbundling provisions only allow for an exception if no market investor can be found following an open, transparent and non-discriminatory tendering procedure. Even in this case, however, the legal and regulatory framework does not permit multiple utilisation, as the transmission system operator may only use the storage facility on the network side.

However, a storage tender could also be organised in such a way that the storage facility can be co-financed from market revenues and regulated revenues. The competitive tender bids represent the market investors' willingness to pay and thus correspond to the expected market value of the storage facility. The network-side value of the storage facility must therefore at least correspond to the remaining costs, and only these costs would be remunerated by the regulator. This means that the network operator could also bid for the construction of the storage facility and would not have the option of cross-subsidisation if the bid is successful. On the contrary, this would incentivise the network operator to deploy the storage facility efficiently where it would achieve the greatest benefit, as its revenues would be determined precisely according to the market revenue that can be achieved with the storage facility in terms of output-oriented incentives (Meyer et al., 2017).

E.3 Sector coupling (polygrid)

The energy transition is a challenge for society as a whole, which affects not only the electricity sector but also other sectors such as gas, mobility and telecommunications. The primary goal of sector coupling is to utilise potential synergy effects at the interfaces between these sectors. From the perspective of network regulation, this means giving the network operator the opportunity and the economic incentives to support cross-sector cooperation through network measures.

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[15] DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 concerning common rules for the internal market in electricity and amending Directive 2012/27/EU, European Commission, Brussels.

In the decarbonisation of transportation and industrial sectors, for example, the use of green electricity is in direct competition with green hydrogen. Hydrogen can then generally be transported to its destination via four different infrastructures:

a) through a dedicated hydrogen network,

b) through a converted gas network,

c) through the electricity network for on-site hydrogen conversion, and

d) as a liquid through the transportation network.

The infrastructures operating as monopolies in the respective sectors are therefore competing with each other in the decarbonisation of transport and industry. Currently, decisions on the further development of these infrastructures are made under different sector-specific framework conditions that are only harmonised to a limited extent. This distorts the efficient development of the infrastructure and thus causes additional economic costs.

The whole system approach can be used to link the electricity, hydrogen, gas and transport networks and promote the efficient decarbonisation of the transport and industrial sectors. The resulting "polygrid" is optimised from a system perspective by coordinating the operators of the affected infrastructures with each other. Similar to the coordination of electricity network operators, which we have already discussed above, various implementation approaches are also conceivable in this context:

- Harmonisation of the sector-specific framework conditions
- Cost- and benefit-sharing models
- Direct infrastructure competition
- Innovative governance structures

One question that arises here is the extent to which differentiated network pricing in the electricity network provides the right incentives for the use and development of other networks. This applies in particular to the hydrogen infrastructure.

F Sustainability

The electricity networks also play an important role in realising the European and national targets for reducing GHG emissions. In the period from 2000 to 2018, the installed capacity of renewable energy connected to the electricity network in Germany increased almost tenfold, from 12 GW to 118 GW. The distribution networks play an important role in this: 90 % of renewable energy is fed into these networks (E-Bridge, IAEW & Offis, 2014). According to the latest draft of the 2030 network development plan, the installed renewable generation capacity will increase to up to 200 GW by 2030 (Federal Government, 2020, p.33). The demand for supra-regional electricity transport from many new renewable energy plants is increasing rapidly, and the technological demands on the electricity network are also growing as a result (Buchmann et al., 2019).

The binding CO2 reduction targets were included for the first time in all three scenarios of the 2019-2030 network development plan; the maximum target for CO2 emissions in 2030 was set at 184 million tonnes, and the maximum target for 2035 is 127 million tonnes (BNetzA, 2018, p.5). In an accompanying strategic environmental assessment, the BNetzA examines the measures in the network development plan for their likely environmental impact. During the assessment process, it consults with authorities, experts and the public (BNetzA, 2019). [16]

In addition to sustainability efforts through the further integration of renewable energies, the electricity networks and their operation can also make a significant contribution to sustainability. *Figure 10* provides an overview.

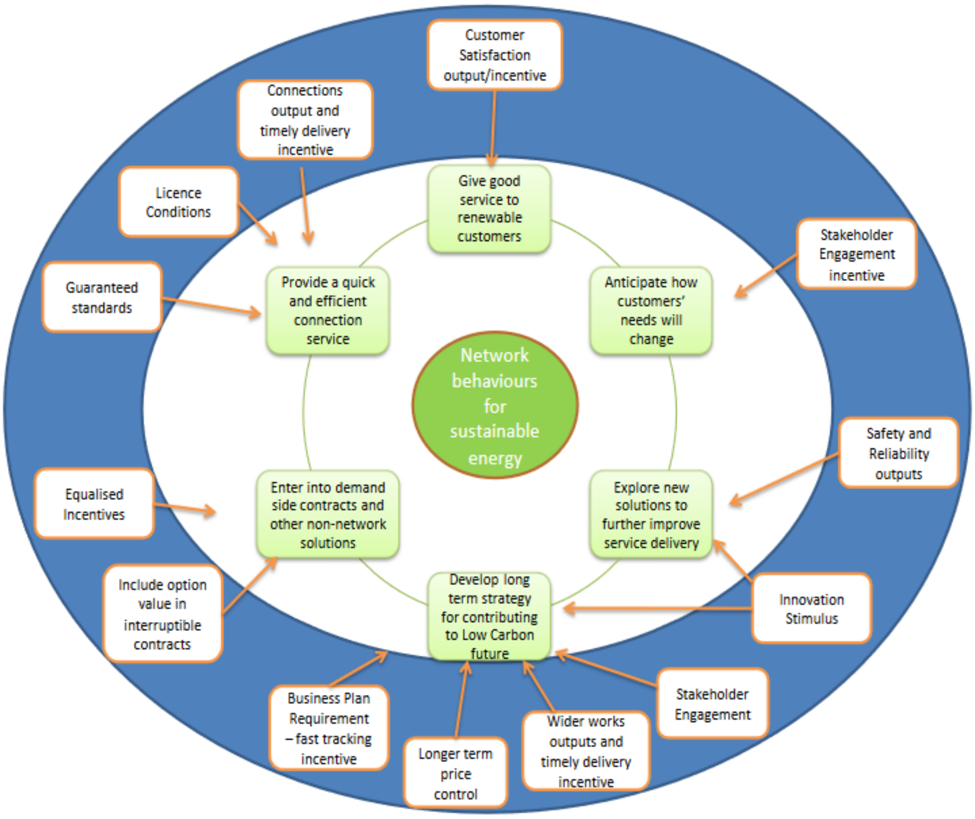

Figure 10: Incentive components under RIIO to achieve the environmental targets. Source: Ofgem, 2012, p. 13.

In connection with the reduction of GHG emissions, two fields of action are of particular importance for network operators, which are described in more detail below:

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[16] https://www.netzausbau.de/bedarfsermittlung/2030_2019/nep-ub/de.html

F.1 Reduction of GHG emissions in network operation

F.2 Network integration of renewable energies

F.1 Reduction of GHG emissions in network operation

For sustainability, network operators have the task of organising operations with a minimum of negative environmental impact. The carbon footprint is an important tool for assessing the climate impact of their operational activities. Network operators that are committed to sustainability balance and report their carbon footprint in accordance with the guidelines of the Greenhouse Gas Protocol[17], which includes Scope 1, Scope 2 and Scope 3 emissions:

- The Scope 1 emissions directly controlled by the company are made up of CO2 emissions from operations, such as SF6-THG[18] and CO2 emissions from fossil-fuelled building heating and the use of the company's own vehicle fleet.
- Scope 2 emissions include indirect CO2 emissions from procured electricity, district heating and cooling consumed within the company. This includes electricity consumption in power network facilities and electricity losses in the network lines, which occur primarily during the transmission of renewable electricity because it often has to be transported over long distances and renewable electricity losses are currently difficult to avoid.
- Scope 3 emissions include other indirect emissions such as CO2 emissions from business travel, CO2 emissions caused by the consumption of procured electricity by customers and other procured services and products. The carbon footprint also includes the CO2 emissions avoided through the expansion of renewable energy generation and energy efficiency projects and the expansion of renewable energy at customers.

However, the associated environmental protection expenses (investments in environmental protection and ongoing applications in environmental protection) are not explicitly incentivised. The costs of procuring energy losses (energy to compensate for physically induced network losses) can be taken into account as volatile cost components in accordance with Section 4 (3) sentence 1 no. 3 of the ARegV. However, this rule does not apply to electricity losses or the CO2 emissions caused by electricity losses (Ecofys, 2013). There are no financial incentives to compensate network operators for limiting the use of SF6 in operation,

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[17] For more information see https://ghgprotocol.org/.

[18] Sulphur hexafluoride (SF6) is a greenhouse gas used in substations. It is also a greenhouse gas with a radiative forcing 23,900 times higher than that of carbon dioxide (CO2). At the same time, it is an extremely effective electrical insulating material for which there is as yet no adequate alternative (Ofgem; https://www.ofgem.gov.uk/data-portal/sulphur-hexafluoride-sf6-emissions-electricity-transmission-riio-t1).

for example. Output-oriented incentives could enable network operators to choose the cost-effective means of achieving GHG reduction and receive financial or non-monetary rewards for doing so.

A good example of this is the output-oriented incentives introduced in the UK as part of RIIO to reduce CO2 emissions and eliminate environmental problems in network operation. They include the following incentive mechanisms:

1) *Business carbon footprint*; a non-monetary incentive mechanism that promotes the fulfilment of environmental tasks and the reduction of climate emissions in the three scopes of the carbon footprint. The achievement of targets by the network operator is assessed, but there is no financial reward for this (Ofgem, 2017a).
2) *Incentive mechanism to reduce SF6 emissions*, whereby the TSOs are subject to a financial incentive (bonus-malus system) to limit their gas emissions. Ofgem sets the target values for SF6 emissions that the network operators are expected to achieve or even exceed (Ofgem, 2017a).
3) *Losses Discretionary Reward*; a financial incentive mechanism that promotes measures to minimise network losses that go beyond the loss reduction measures set out in the business plans. The performance of network operators is assessed by Ofgem and financially rewarded accordingly (Ofgem, 2017a).
4) *Environmental Discretionary Reward*; this scheme promotes good environmental performance by the network operator with financial and non-monetary incentives. The network operator's performance is assessed by a committee of stakeholders. In the assessment, points are awarded for high standards in environmental management and GHG reduction, among other things (Ofgem, 2014).

F.2 Network integration of renewable energies

Network operators act in a technology-neutral manner provided that regulation is symmetrical. From a climate protection perspective, however, it would be justifiable to further promote the integration of renewable energies and to start with the network operators and to lift technology neutrality for this purpose.

Although the EEG in particular dictates priority for renewable energies, this does not mean that the network operators have adequate incentives to implement this efficiently or even go beyond this. On the contrary, it is easy to imagine that there are distorted incentives against increased integration of renewable energies.

To promote the network integration of renewable electricity effectively, further measures could be taken, for example

- Accelerate network expansion (see section A.1)

- Improve network connection for renewable energies (see section A.2)
- Promote digital solutions and storage for optimising and increasing network capacity
- Prioritise renewable energies in the procurement of ancillary services (control and reserve energy), if possible.

These measures often result in additional expenditure and require corresponding regulatory incentives, such as in the case of digital solutions that enable an increase in network capacity for better integration of renewable energies. The measures include the use of energy storage systems and investments in smart technologies. For example, network operators can utilise DERMS (distributed energy resources management system) together with modern communication sensors, data platforms and artificial intelligence. In accordance with Section 23 ARegV, costs for such measures are recognised as expansion and restructuring investments. However, this regulation only applies to network investments that are part of the network development plan. New technological solutions that go beyond the measures already anchored in the network development plan are often associated with a high OPEX-share of the total costs, which are only incentivised to a limited extent in the ARegV.

The measures for network integration of renewable energies could be incentivised directly by means of targeted output-oriented revenue components. In New York, for example, the performance of network operators regarding network integration of renewable energies is assessed on the basis of a survey of providers of renewable energies and incentivised through an earning adjustment mechanism (a bonus-malus scheme) (Littell & Shipley, 2017, pp. 17-18). In addition, network operators could receive a fixed financial reward for achieving the renewable energies feed-in quota into the network (Gold et al., 2020).

G Social affairs

Recently, management consultants developed the concept of "true value" or "total value" (see True Price et al., 2014). The economic, social and legal environment in which companies operate is changing. Performance targets that go beyond pure financial indicators are becoming increasingly important. In other words, the "true value" of a company is not limited to "internal" financial indicators, but also includes other "external" dimensions. These also include a social dimension (see True Price et al. 2014, p. 23).

In the following, we take a closer look at three areas of application for incentivising social aspects:

G.1 Social equality for network users

G.2 Occupational health and safety

G.3 Society in general: Smart cities

G.1 Social equality for network users

Ideally, network operators should fulfil the network-related needs of network users in a fair and socially responsible manner. Key areas of action for social equality are, above all, the structure of network charges and the organisation of network-side procurement.

The initial focus is on the affordability of network usage for different user groups and the proportionality of the contributions that different groups make to network financing. In addition to the obvious concern of relieving the burden on small, low-income network users, there is currently a debate, for example, about 'de-solidarisation', i.e. a disproportionately low, possibly unsolidary, financing contribution from network users with their own generation. Assuming constant total costs, reduced contributions from self-generators directly mean higher network charges for the remaining network users. A similar dynamic results from discounts for large customers in international competition, which are financed by surcharges on the general network fees.

A similar problem, albeit slightly different, arises for local energy communities that exchange electricity via the public network, but only locally. According to the EU directives for renewable energies and the internal electricity market (EU 2019/2001 and EU 2019/944), such decentralised structures strengthen inclusion and local cohesion, among other things, but are currently subject to prohibitively high network charges as a contribution to financing the entire, rather than specifically local, infrastructure.

Other social aspects can arise from the earning potential of network operator procurement or the provision of suitable network services for different groups. Markets for network services and flexibility are often designed primarily for large network users due to transaction costs and prequalification; consequently, access for decentralised users can be difficult.

The criteria of fairness or social justice are naturally not very well defined. The corresponding perception is strongly culturally characterised and context-dependent (Neuteleers et al., 2017). Accordingly, the necessary acceptance, and thus also the fulfilment of objectives, can be achieved both through communication and through an objective improvement in the situation for disadvantaged groups. Deviations from the accepted, familiar status quo are often perceived as inadequate. In a rapidly changing energy system, incentives to equalise undesirable distribution effects are therefore even more necessary.

Social compensation is not currently the focus of network operators. Incentives sometimes exist in the form of non-monetary, structural mechanisms, such as municipal participation in distribution network operators below the deminimis threshold. The ordinances on network connection and network fees determine principles of proportionality and special circumstances, for example for household customers. However, especially against the backdrop of changing usage behaviour, they also include rules that potentially increase inequality.

It is quite conceivable that some social aspects can be incentivised as targeted outputs by the network operator, while other disadvantages within the network system should be accepted and compensated for by progressive elements in the overall system.

G.2 Occupational health and safety

Network operators must operate safe networks and guarantee occupational health and safety not only for their own employees, but also for the employees of contractors working on the network operator's construction sites. Ensuring occupational safety contributes (in)directly to maintaining the reliability of the electricity supply system and is therefore also of great importance for security of supply. Network operators are legally obliged to minimise health risks to workers from accidents in the company, on electrical installations and when working at height, as well as to prevent illnesses. In accordance with the Occupational Safety and Health Act and the ISO 45001 standard for the standardisation of occupational safety management systems, network operators must ensure that occupational safety and health protection are part of the company's objectives and are consistently implemented at all levels of the company. As employers, network operators are obliged to form an operational occupational health and safety organisation and to provide the necessary resources, to develop appropriate safety measures in the workplace and to guarantee the effective implementation of these measures at all levels of the company. These measures are implemented in various forms, including adapting personal protective equipment to legal requirements, conducting workshops and training courses for employees as part of vocational training, organising occupational safety competitions among employees, monitoring construction sites and implementing health promotion programmes, as well as recording workplace accidents statistically. Such activities are carried out on the basis of legal regulations and the social responsibility of network operators towards their employees.

Expenditure on these operational activities is generally in the company's own economic interest, as the implementation of occupational health and safety measures primarily increases productivity and the company's social reputation. However, corporate activities in the area of occupational health and safety are not explicitly incentivised by regulations. As compliance with safety requirements is enshrined in law and monitored by the health authorities, it is subject to other rules and regulations. However, individual costs are taken into account in the ARegV, e.g. the costs of vocational training in the company are treated as cost-pass-through in accordance with Section 11 (11) ARegV.

Output-oriented regulation with monetary or non-monetary incentives for achieving certain safety levels or activities in the area of occupational safety can provide regulatory support for network operators. The safety requirements can be combined with other requirements for the network operators. In the UK, network operators include the costs of safety obligations in their business plans and occupational safety is considered one of the important components when assessing the overall risk of the network (Ofgem, 2011, pp. 9-14; Ofgem, 2017b, p. 27).

G.3 Society in general: Smart cities

The term smart city encompasses a wide range of concepts for urban spaces that enable cities to be more energy-efficient and therefore more climate-friendly thanks to networked information and communication technologies (ITU, 2015). More than 150 cities worldwide have officially launched a smart city strategy (Roland Berger, 2019). In Germany, 50 cities have already adopted digital strategies. Six federal ministries are currently working on smart-city and smart-region funding programmes.

The focus of smart-city projects is on the digitalisation of critical infrastructures such as telecommunications, energy or public services, which should increase the efficiency, effectiveness and resilience of the overall system and promote CO2 neutrality (see Meier & Portmann, 2016; Vogel et al., 2018). With the help of sensors throughout the urban environment, for example, an Internet of Things is created that makes all the data collected available in a data cloud. The technology enables comprehensive interaction between city dwellers and surrounding technologies, e.g. in the transport sector (e-mobility) or building sector (smart home, smart building) (cf. Weber et al., 2015 Gstrein et al 2016). This also enables better solutions to be developed for reducing environmental pollution and energy consumption.

Developing smart and connected solutions for e-mobility and network-related services in smart cities not only requires network operators to work closely with various stakeholders, such as cities, municipalities, municipal utilities and start-up developers, but also to develop digital infrastructure (Götz, 2020).

With the inclusion of the transport sector (e-mobility) in smart-city projects, these projects are becoming increasingly important for network operators. They are particularly relevant for distribution network operators, as the charging stations for electromobility are primarily connected to the low and medium voltage level of the electricity distribution network. The task of distribution network operators is to guarantee that the charging infrastructure for electric mobility is connected to the network in line with demand, to manage network integration intelligently and to ensure a high-quality power supply for electric vehicles (BDEW, 2017). New business fields emerge for network operators that serve to fulfil the various mobility needs of customers and offer the opportunity for new sources of revenue for services such as the design of the connection of charging points and network integration of electric vehicles, energy storage and intelligent traffic light circuits

Output-oriented incentives could also be used for these activities. Network operators could receive a financial reward for quickly connecting charging points to the network. Switching off chargers to reduce power demand (in return for appropriate compensation) when high electricity demand occurs could also be financially rewarded. In California, for example, several demand-side management pilot projects are currently being carried out in which electric vehicles are used to shift or reduce load. These pilots include a regulatory incentive mechanism designed to facilitate demand-side management on a pilot basis and reduce or at least defer the need for capital expenditures on distribution infrastructure (CPUC, 2018).

Smart street lighting is set to play a major role in energy efficiency in the future. Light sensors will be used to control or automatically switch on the streetlights. Options are also being tested to use the streetlights as charging points for electric vehicles and for measuring noise, traffic flow, temperature and air pollution (Umweltdialog, 2018).

4 Discussion and conclusion

With *output-oriented regulation* (OOR) this report addresses a current development in regulatory practice that is becoming increasingly relevant, particularly driven by the energy transition. The aim of OOR are targeted incentives for predefined performance targets (outputs) that are not sufficiently within the framework of incentive regulation, which is usually predominantly geared towards cost efficiency. OOR does not replace the existing revenue cap of incentive regulation, but supplements it with revenue elements (such as bonus-malus payments) that are linked to the achievement of regulatory output targets. *Figure 11* illustrates how OOR fits into the incentive regulation system.

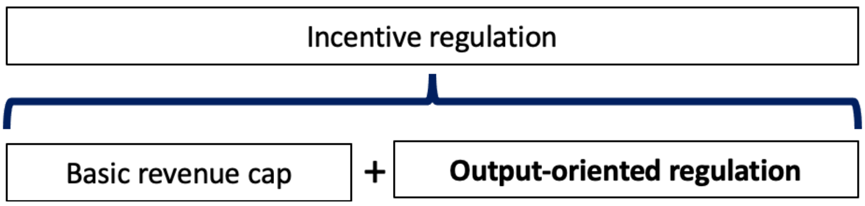

Figure 11: Classification of the terms
Source: own figure.

In this study, the primary economic rationale for the use of output-oriented regulatory instruments were discussed and specific areas of application for the regulation of electricity network operators were identified and discussed. In addition to the economic justification for OOR and the direct reference to electricity networks, two criteria in particular were decisive for the selection of the areas of application: Firstly, (international) experience should be available on the areas of application, and secondly, the study should primarily be limited to cases that have not yet been covered or only insufficiently covered by incentive regulation in Germany. The core of the study is the discussion of specific, practice-relevant areas of application in Section 3, which are summarised in Table 5 below.

Table 5: Specification of the areas of application

Output category	Areas of application
A. Networks	1. Timely network expansion 2. Timely network connections 3. Utilisation of cross-border interconnectors 4. Development of smart grids
B. Quality of supply	1. Resilience 2. Service quality
C. Market facilitation	1. Promotion of existing markets 2. Promotion of new markets 3. Market monitoring
D. Digitilisation	1. Data facilitation 2. Smart meter rollout 3. Data protection & cyber security
E. Whole System Approach	1. TSO-DSO coordination 2. Coordination between network and market 3. Sector coupling (polygrid)
F. Sustainability	1. Reduction of GHG emissions in network operation 2. Network integration of renewable energies
G. Social affairs	1. Social equality among network users 2. Occupational health and safety 3. Society in general: smart cities

Source: own table

For the energy transition, some of these areas of application appear particularly relevant and promising for implementation of output-oriented regulatory instruments.

- As part of the digitalisation of the electricity system, *data facilitation* is likely to become one of the key concepts when it comes to creating new energy supply services to actively involve small, decentralised players in the decarbonisation process. The availability of market-relevant data is fundamental here, and the network operator can play an important role. However, the (data protection-compliant) collection, processing and provision of the data increase costs, while the benefits are partially externalised via the markets. OOR instruments can improve the incentives of the network operator by transferring the social benefits of data facilitation into regulatory revenues. Ideally, this leads to an alignment between business and economic optimisation (incentive alignment).

- The concept of the Whole System Approach (WSA) includes three levels of overall system optimisation: from coordination between the electricity networks to coordination between the electricity network and the market to cross-sector coordination (sector coupling). The WSA aims to internalise external effects that arise from the interactions between the actors involved in the individual stages of the value chain and sectors. With the aim of cross-sectoral decarbonisation, the WSA focuses primarily on the development of new infrastructures. In addition to the development of charging infrastructure for e-mobility, the topic of a future hydrogen infrastructure has recently been discussed as a regulatory challenge. The creation of an economically optimised infrastructure for various energy sectors (in the sense of a "polygrid") requires regulatory incentives that go beyond isolated network optimisations of the individual networks and sectors and adequately internalise social welfare effects.

Whereas the theoretical foundation of OOR is clear, at least in the case of existing external effects, the implementation in practice will be a major challenge and will also differ fundamentally in detail between the fields of application. The difficulties of implementation can therefore only be hinted at here and essentially comprise the following areas:

- Economic justification: OOR is based on the idea that a distortion occurs in the base incentive regulation, as is the case with external effects, for example. However, convincing evidence of a distortion must first be provided in individual cases to justify the use of OOR.
- Determining the output targets: The first challenge is to define the desired output targets that are to be incentivised by means of OOR. It must be ensured that these are targets that can be reasonably achieved by the network operator and are not, for example, the responsibility of the market players.
- Selection of output indicators: Measurable indicators (*metrics*) that are suitable as a measure of target achievement must be found to match the defined output targets. A suitable indicator must be significantly under the control of the network operator and also have a high correlation to the selected output target.
- Design of the incentive instrument: a suitable incentive instrument must be selected and designed. The choice of incentive factor is likely to be particularly critical - how strongly should the revenues (e.g. bonuses or penalties) be linked to the output indicators? The ability of the network operator to influence the output indicator must be taken into account. In combination with the other regulatory incentives, overincentivising must be avoided. Undesirable distribution effects between network customers and network operators should be avoided.
- Complexity of the regulatory system: Overall, the central challenge of output-oriented regulation is that it leads to greater complexity of the regulatory system, which must be weighed against the advantages. The regulatory incentives ultimately result from a

combination of basic incentive regulation and (potentially numerous) extensions, so that complicated interactions in the incentives and in benchmarking may also occur. This increases the complexity for the regulator, whose task it will be to design the incentive instruments coherently to avoid perverse incentives. It also increases the complexity for the regulated network operators, who must align their strategic and operational measures with the regulatory requirements and therefore require transparency and long-term stability of the regulatory framework.

The primary aim of the report was to discuss the potential of output-oriented regulation as comprehensively as possible. The report identified potential application for many (existing and potentially new) roles and responsibilities of the network operator. Nevertheless, many questions regarding the specific design of the incentive instruments and the challenges of practical implementation could only be hinted at and not examined in depth. This requires further analysis and systematic evaluation of practical experience. Although the examples from (international) practice discussed in the report tend to indicate positive experiences with OOR, overall development is still in its infancy. A systematic analysis is therefore still pending, as is a concrete, practice-oriented elaboration of individual applications.

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