Future ICT-Infrastructure for Smart Grids

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Potentials and Hurdles for a Co-operation between the Energy and Telecommunication Sector

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Abstract. For the deployment of future ICT-infrastructure within smart grids, a huge synergy potential between the telecommunication and the energy sector is expected. However, our analysis shows that there are substantial strategic hurdles to overcome in order to foster co-operation between communications providers and Distribution System Operators (DSOs) as there are various asymmetries among them. The main reason for co-operation among the energy and communications sector consists in assumed advantages, e.g. faster implementation of smart grid services and solutions. The regulatory framework, which is perceived to be in need of further clarification, has been identified as the main hurdle for co-operation, while technical issues are not as important. DSOs and communications providers showed substantially different opinions when it comes to their particular assessment of the co-operation potential between the two sectors. Additionally, this assessment also depends highly on the smart grid use case in question.

Keywords: ICT, Infrastructure, Smart Grid, Infrastructure Deployment, Co-operation

1 Introduction

In a decentralized world of energy generation and consumption, not only the data volume but also the number of data exchanging parties and devices will increase significantly. New business models and technical solutions will alter the interaction of all energy system participants on every level and scale [1]. Therefore the ICT-infrastructure has to evolve as well and provide the necessary communication solutions to allow for this evolution in the energy sector [2]. Within this context, one major task of significant complexity is the coordination between the energy and telecommunication sector. So far they have remained mostly separated and developed their respective positions and strategies on smart grids and deployment of e.g. metering infrastructures in parallel. However, there is a huge potential for synergies and cost savings in joint and co-operative approaches [3] [4].

adfa, p. 1, 2011.

To address these challenges and shed light upon the potentials of a possible co-operation between the energy and telecommunication sector, the European Commission Directorate General for Communications Networks, Content & Technology (DG CONNECT) launched the project ENERGISE[1] at the beginning of 2015. Until the end of March 2017, an extensive analysis of the European ICT-infrastructure deployment regarding smart grids will be carried out. The ultimate goal of the project is the development of a decision-making toolkit that will help all stakeholders to decide by objective parameters which deployment solutions are optimal under a given individual situation.

In literature, smart grids are widely discusses in various disciplines but hurdles in joint infrastructure deployment are not yet analyzed in detail. Zio and Aven (2011) identified "technological, environmental, financial, social and political" aspects to be the challenges for future smart grid implementation [5, pp. 6318]. Although they consider other than just the technological challenges, they are not focusing on strategic cooperation. The Smart Grid Task Force established by the European commission published their first results of investigation in the year 2009. Starting with the investigation on smart meters, they focused on e-mobility and finally on the concept of smart grids. Splitting the work into five expert groups allowed for a more detailed look on specific topics. A recent report by the Joint Research Centre evaluated certain smart grids projects across Europe [6]. Tahon et. al. (2013) analyzed the topic from the telecommunication perspective. They suggest enforcing cooperation between the energy and the telecommunication sector but do not focus mainly on the deployment of smart grids. In a current study, Aiello and Pagani (2016) drive the focus more on the ICT-infrastructure on smart grids but do not highlight the hurdles in cooperation between the respective sectors [7]. As Gungor et. al. (2013) already claimed, the ICT-Infrastructure is crucial for the deployment of smart grids [8]. In sum, there are various streams of literature on smart grids, but they are based on either the telecommunication or the energy view. Hence, a more interdisciplinary approach is favorable in theory as well as in practice. [9] In addition, no significant structural analysis about cross sectoral cooperation within those sectors is available so far.

The main topic of this paper evolves around the possible potentials and hurdles regarding approaches towards co-operation for joint infrastructure usage and deployment between the energy and telecommunication sector.

2 Survey concept

This paper focuses on the findings of a comprehensive online survey conducted in November and December 2015 among the project's target groups of communications providers (communications infrastructure /services), Distribution System Operators (DSOs), Transmission System Operators (TSOs), energy utilities (energy generation/trading/resale/solutions), manufacturers, research organisations and other compa-

[1] http://project-energise.eu/

nies involved in the energy and telecommunication business. Hereby the DSOs and communications providers are the most important subgroups and are therefore defined as main target groups in the following.

2.1 Methodology and structure

Prior to the main survey, a short online survey among TSOs, DSOs and communications providers as was conducted. In addition, expert interviews with regulatory authorities and industrial stakeholders from the energy and communications sectors reviewed the structure of the survey and partly (re)phrased the individual questions and items. For final modifications and practical testing, two DSOs (from the main target group) were asked to pre-test the survey before it was published.
The structure of the survey was designed to analyze responses of the main target groups as well as of specific subgroups separately. In order to reach a large variety of respondents from the energy and communications sector, relevant contact persons in enterprises, institutions and associations were identified via desk research. Individual invitations were sent by e-mail to the contact persons in the addressed enterprises and organizations. Additionally, the survey's domain was published on the ENERGISE website as well as in the ENERGISE LinkedIn group, and within the ENERGISE newsletter. This way, organizations outside of the main target groups could participate in the survey and thus add valid aspects to the picture across the European smart grid ecosystem.

The total number of responses (N=294) and an exhaustive geographical coverage of the European Union show, that the results of this survey mark an important statement in the discussion of infrastructure development for smart grids. Nevertheless the amount of responses cannot claim to statistically represent all European DSOs and communications providers. This non-representative character arises also from the fact that the European energy market structures still remain widely separated, fragmented and highly heterogeneous [10]; thus any statistically accurate depiction of the European smart grid ecosystem is barely feasible.[2]

2.2 Sample characteristics

The survey provides a comprehensive characterization of the European organisations involved in smart grid activities. 26 European member states are covered by at least one DSO and one communications provider (only in Estonia and Slovenia no DSO answered), while most of the European member states are covered by a substantial number of the main target groups. Figure 1 offers a graphical illustration of the survey's participants by country.

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[2] The number of TSOs, DSOs and communications provider differs significantly from member state to member state. Since the National Regulation Authorities are mostly independent, regulatory schemes differ highly between countries. Thus, comparisons in terms of proportions can hardly be made because of the lacking of a joint point of reference. Additionally, the response rates are relatively high compared other relevant studies [cf. 10, p. 50].

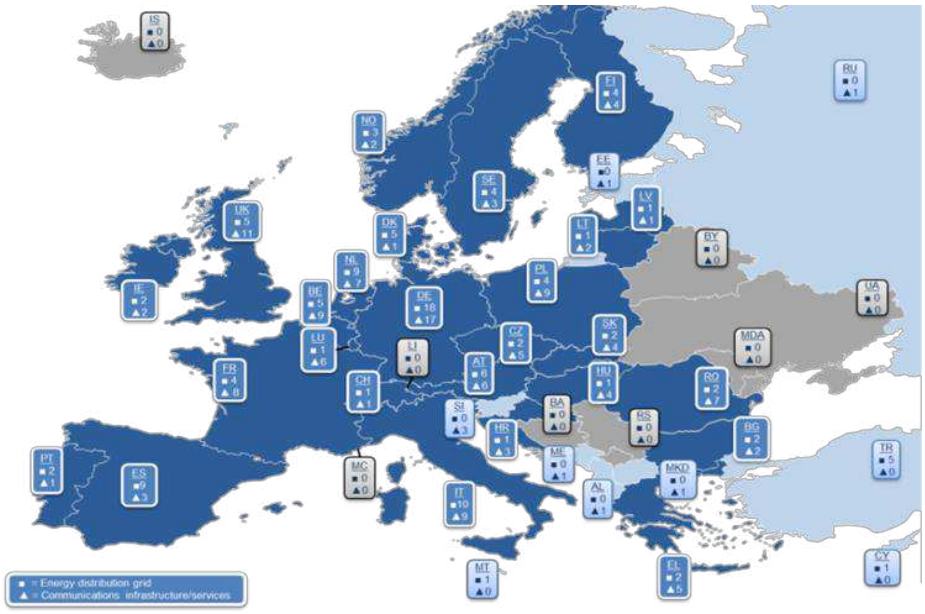

Fig. 1. European distribution of the respondents from the main target groups

In order to specify the sectoral structure of the respondents within the overall sample, respondents were given the possibility to describe the organisation they represent, based on the organisation's primary field of activity. The deduced sample characteristics by the type of company splits the division into subgroups as defined in section 1 above. Figure 2 shows the detailed sample and the representation of the different subgroups. With regard to the companies located in the energy sector, a separation between DSOs, TSOs and the subgroups which compete in a liberalized market environment such as energy generation, trading, resale, solutions was made. Communications providers were not split into subgroups. [12][13]. This approach facilitates a tangible comparison of the two main groups of interest for the project: DSOs and communications providers.

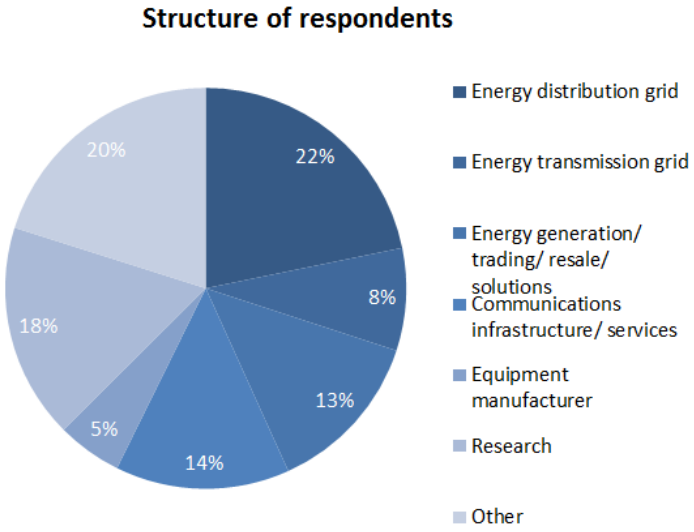

Fig. 2. Structure of respondents (n=294)

3 Rationale of the analysis

According to the literature review (see 1. Introduction), various expert interviews and on-site visits during the first project year, the authors deduced a two-dimensional rationale for the analysis: The first aspect covers the issues of co-operation between companies and sectors for developing and implementing new solutions and infrastructures. The second aspect deals with the question whether the respective communication infrastructure for smart grid applications should be dedicated to a single purpose (and separated from other purposes) or shared among different use cases and players.

A graphical representation of these two dimensions is depicted in figure 3 below. Hereby the vertical axis indicates the degree of co-operation varying from non-co-operative, purely competitive market environment to highly co-operative constructs like joint ventures. In between, all kind of co-operation levels can be thought of (e.g. sales partnerships or joint product developments) [14].

The horizontal axis indicates the mode of usage of the communication infrastructure. It covers the use of dedicated and shared infrastructure and reaches from communication solutions restricted to one use case operated by one company (e.g. DSOs' network monitoring infrastructure) up to using a shared medium, (e.g. as it is the case in mobile communications usage for smart meter readout). [3]

[3] Because of the targeted low threshold in terms of generating a high return and easy access of the survey, detailed definitions for the terms "co-operative", "non-co-operative", "shared" and "dedicated" were not provided within the questionnaire of the survey.

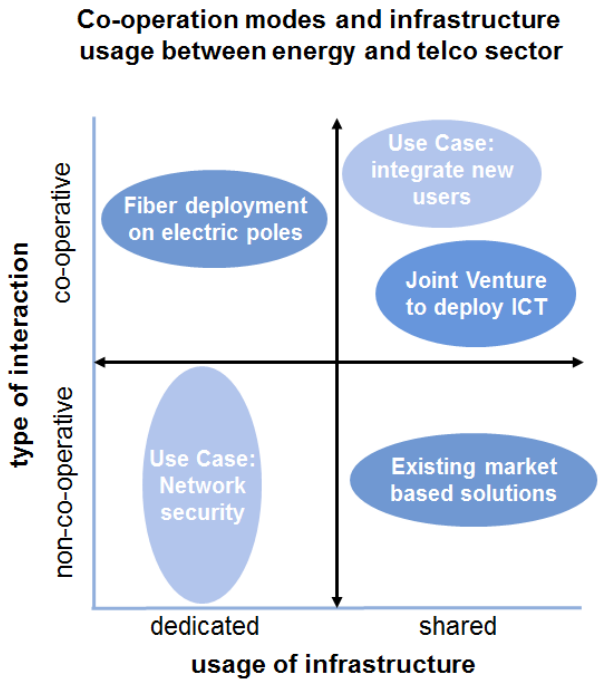

Fig. 3. Co-operation modes and infrastructure usage between energy and telco sector

Considering both dimensions, there are four possible types of combinations that can be classified in quadrants:

1. Co-operative / Shared
2. Co-operative / Dedicated
3. Non-co-operative / Shared
4. Non-co-operative / Dedicated

The depicted boxes in the matrix indicate potential scenarios on different levels. First of all, general joint deployment scenarios (with no necessary direct applicability for smart grids) are shown as examples in the upper left ("fiber deployment on electric poles") and on the upper right ("joint venture to deploy ICT"). Likewise, specific use-cases in a smart grid environment can be located on the matrix as shown in the lower left (Use Case: Network security) and the upper right (Use Case: integrate new users) [15]. Lastly, the box in the lower right indicates the position of an "existing market based solution" for smart grid (e.g. smart meter read out) purposes that is already offered today by communications providers.

In practice, localization within the matrix can only act as an indicator and is therefore depicted by an area rather than by an absolute coordinate. For example, it must be taken into account that an approach for a solution might be considered differently on the scale of co-operation, depending on which of the involved parties is asked.

For the purpose of a detailed examination, the further analysis within this paper focuses on a detailed investigation on the type of interaction axis, though there is a logical link between the two aspects “usage of infrastructure” and “type of operation”.

Deduction of Hypotheses:

According to the prior rationale, several hypotheses for further analysis were deduced. The most important are to be investigated in greater detail in the following section:

- H1: The costs for deploying ICT infrastructure depend to large degree on digging costs (55 up to 80%). [4][16][17]Hence a huge saving potential can be realized in joint infrastructure deployment. Therefore “cost saving” will be the most important reason for co-operation for all main target groups.
- H2: Technological issues are the main hurdles for co-operation
- H3: The issue of “Strategic strengthening of the market position” will be especially important for the communications providers because they want to participate in the “digitalization of the energy sector” which is currently widely discussed [18][19]
- H4: “Political demand for co-operation” is perceived as an important reason by all stakeholders since the cost saving directive [20] that is aiming at joint infrastructure usage and deployment must be implemented by all member states in 2016.
- H5: Significant differences in the assessed likeliness of co-operation are expected since the strategic goals are different for both sectors and communication services are valued asymmetrically. DSOs represent one customer out of many for communications providers; in contrast for DSOs, communications providers are a crucial partner for ICT-infrastructure. This asymmetry creates a complex framework for standardized commercial solutions and the use of existing infrastructures.
- H6: DSOs need financial security for the risk of default of communication services provided by telecoms, which poses a significant hurdle for co-operation

4 Results

This section shows the survey results for all respondents and the two main subgroups (DSOs and communications provider) in particular.

4.1 Reasons and hurdles for co-operation

The strategic assessment of co-operation among the energy and communications sectors was analyzed by asking for significant reasons and hurdles for co-operation. The results below focus on the findings for the DSOs and communications provider subgroups. Additionally, the results for the overall outcome are serving as an indicator of deviation. The results of the comparison between the DSOs and the telecommunications providers are shown in figure 4 below.

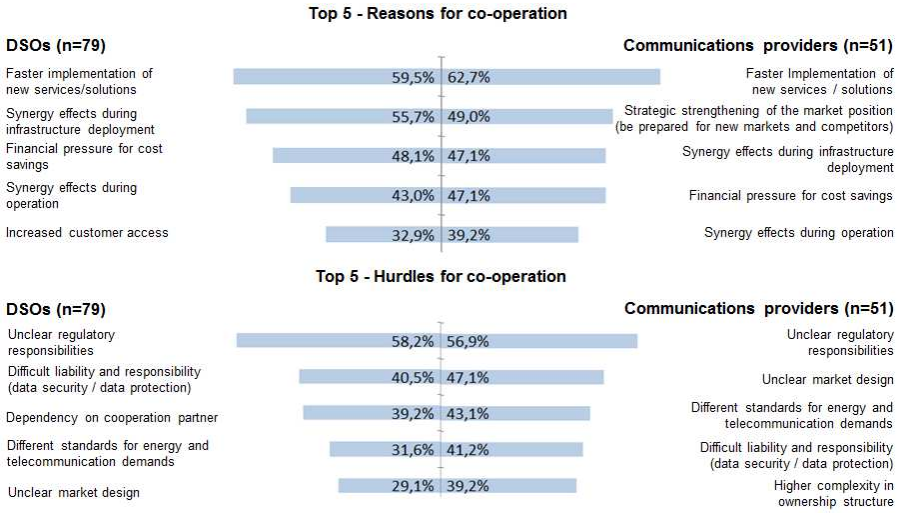

Fig. 4. Top 5 reasons and hurdles for co-operation for DSOs and communications providers

4.2 Reasons for co-operation

Focusing on the top five selected options the evaluation of the overall response shows that 60.2% of the respondents selected "faster implementation" as the most important reason of co-operation, followed by the possibility to use "synergy effects during the infrastructure deployment" (46.3%). The option "financial pressure for cost savings" scored third with 44.9%. The importance of "synergy effects during operation" (40.5%) and "market positioning and strategic strengthening" (37.8%) were regarded as the fourth and fifth most important reasons.

The DSOs' evaluation of the main reasons has the same order as the overall results, expect for the fifth most important position: For DSOs, "increased customer access" plays a more important role than "market positioning and strategic strengthening".

From the communications perspective, 62.7% of the respondents selected "faster implementation of new services/solutions" as the most important reason for co-operation between the different fields, followed by "strategic strengthening of the market position" (49.0%). In contrast to the DSOs, it becomes evident that "strategic strengthening of the market position" represents a much more relevant reason for co-operation. The notion of the strategic purpose is emphasized by the vast amount of communications providers that are planning smart grid activities within the next two years (82% of all communications providers).

4.3 Hurdles for co-operation

The second set of questions on the strategic assessment of co-operation dealt with the identification of the most relevant hurdles for co-operation. Focusing on the top five selected options, the evaluation of the overall response showed that 57.8% se-

lected “unclear regulatory responsibilities” as the biggest hurdle, followed by an “unclear market design” and “different standards for energy and telecommunication demands” with 42.2% each. The option “difficult liability and responsibility in data security and data protection” scored fourth (40.5%), whereas “dependency on co-operation partners” was selected by 32.0% of the respondents.

The apparent focus of DSOs on “unclear regulatory responsibilities” is by far the biggest hurdle (58.2%). The next important hurdles are “difficult liability and responsibility in data security and data protection” (40.5%) and “dependency on co-operation partners“(39.2%). The items “different standards for energy and telecommunication demands” (31.6%) and the “unclear market design” (29.1%) are also considered as relevant hurdles and score fourth and fifth.

The responding communications providers also regard “unclear regulatory responsibilities” as the biggest hurdle, selected by 56.9% of the respondents. “Unclear market design” scores second (47.1%), although the distance between first and second choice is notably smaller in comparison to the DSOs. The options “different standards for energy and telecommunication” and “difficult liability and responsibility in data security and data protection” are also considered as relevant barriers by 43.1% and 41.2% respectively. The next important hurdle is the item “higher complexity in ownership of the infrastructure” (39.2%).

4.4 Assessment of co-operation per use case

To be able to assess the level of co-operation among the subgroups for specific smart grid applications, six different use cases were provided in the questionnaire to allow for a more detailed investigation[21][22]. The use cases are consistent with the work of the European Commission’s Smart Grid Task Force [1] and defined as follows:

1. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
2. Improving market functioning and customer service
3. Enabling better planning of future network investment
4. Ensuring network security, system control and quality of supply
5. Enhancing efficiency in day-to-day grid operation
6. Enabling the network to integrate users with new requirements

When considering the assessments whether specific use cases are likely to be implemented co-operatively or non-co-operatively, the great majority of respondents assumed co-operation between the energy and communications sector for each of the use cases (cf. figure 5).

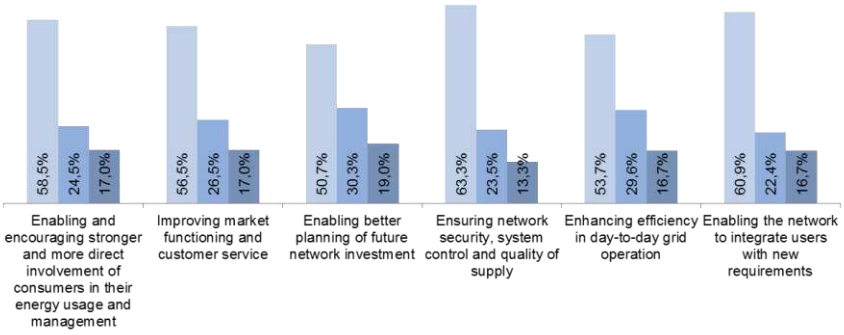

Fig. 5. Assumed co-operation for each use case over all respondents (n=294)

The percentage of all respondents assuming co-operation differs between 50.7% ("Network Planning") and 63.3% per use case ("Enabling network security"). The percentages of those who assume no co-operation differ between 22.4% and 30.3%. Less than 20% of the respondents did not know whether the two sectors would co-operate or not.

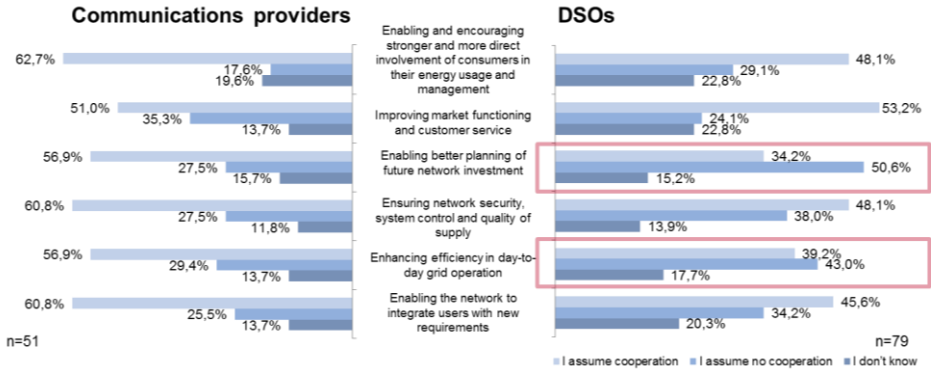

Fig. 6. Assumed co-operation for each use case separated by communications providers (n=51) and DSOs (n=79)

Regarding the different answers from the relevant subgroups, respondents from the communications providers group are more likely to assume that the use case will be implemented in co-operation: more than 51% of them assume co-operation for each use case. The picture changes when the DSOs are in focus. Especially considering the use cases "Enhancing efficiency in day-to-day grid operation" and "Enabling better planning of future network investment" the percentage of DSO respondents who assume that there will no co-operation between the two sectors is significantly higher than the percentage of those who assume co-operation (cf. figure 6).

5 Analysis of the results and conclusions

Assessment of reasons for co-operation:

The most important insight throughout all results and subgroups is that there is a significant overall consent on the need of cross-sectoral co-operation. When examining the results more closely, it becomes evident, that "speed of implementation" is the most important reason for co-operation. This leads to the conclusion that a pressure to act is widely perceived by the main target groups. In addition, "synergy effects during deployment" are generally more important than "synergy effects during operation". The assigned relevance of the aspects of "financial pressure", the possibility of "generating new revenues" as well as "strategic positioning" and "increased customer access" are the most volatile issues and vary among the subgroups.

The results illustrate that the respondents emphasized more concrete aspects with direct advantages (like the speed of implementation) in contrast to more abstract reasons such as "political demand". At least when considering that the directive to reduce the cost of deploying high-speed electronic communications networks [23] needs to be implemented by the EU member states until July 2016, the low ranking of the political aspects appears surprising[4]. With the same notion, it was not expected that financial pressure is outweighed for all subgroups by the speed of implementation as the most important reason for co-operation.

In the cross-sectoral analysis it was proven that communications providers are more likely to assume that smart grid use cases are realized in co-operation than the DSOs. This originates in the different strategic initial position: since communications providers wish to strengthen their market position, they strive to enter the energy sector by offering their core competencies not only in "classical" communications services, but also in future internet of things (IoT) applications and services that will supposedly alter the European energy system in the mid-term range. Accordingly they also emphasize the speed of implementation as a driver for co-operation.

Assessment of hurdles for co-operation:

When looking at the overall results, unclear regulatory responsibilities outweigh all other considered hurdles by far. This holds true for all subgroups. Besides the issue of different standards, all the other top-ranked main hurdles happen to originate in the legal realm.

There are some significant differences among the other potential barriers when comparing the main subgroups DSOs and communications providers. While DSOs perceive dependencies on co-operation partners as a hurdle, communications providers do not. Though DSOs are in favor of co-operation for four out of six use cases, they fear unfavorable short and long-term consequences. Especially the use cases "Enhancing efficiency in day-to-day grid operation" and "Enabling better planning of future network investment" are perceived to be realized non-co-operative since they

[4] The directive does not directly affect smart grid issues. However, it determines a wide array of politically induced co-operation among DSOs, utilities and communications providers that – at least in the mid-term run – also affect aspects of ICT-deployment for smart grids

belong to their core realm of operations. In standard economics, these issues are analyzed in game theory [24] or within the principal-agent framework [25]. Accordingly companies might be restrained of co-operation; due to asymmetric information, co-operation can lead to conflicts of interests, strategic losses and dependencies. Those differences and dependencies reveal considerable constraints for future cross-sectoral co-operation.

Generally the results support the asymmetric valuation of communications services, as the more co-operation-restrained DSOs prove. In addition, the variations between the responses by the different subgroups that were analyzed during this survey might also indicate a different interpretation of the terms provided. Different sectoral languages were observed during the survey and expert interviews that were gathered complementary. Furthermore the respective understanding of the other side´s business drivers and constraints can be a crucial hurdle.

Discussion of the hypotheses:

As elaborated above, the hypotheses can now be investigated and proven as follows:

H1	"Cost saving" will be the most important reason for co-operation for all main target groups.	Must be rejected
H2	Technological issues are the main hurdles for co-operation	Must be rejected
H3	"Political demand for co-operation" is perceived as a important reason by all stakeholders	Must be rejected
H4	Significant differences in the assessed likeliness of co-operation are expected since the strategic goals are different for both sectors and communication services are valued asymmetrically.	Supported by the tendency of the DSOs not to assume co-operation for their core-operations
H5	DSOs need financial security for the risk of default of communication services provided by telecoms, which poses a significant hurdle for co-operation	Supported by the tendency of the DSOs not to assume co-operation for their core-operations
H6	The issue of "Strategic strengthening of the market position" will be especially important for the communications providers	Confirmed

Table 1. Analysis of the hypotheses

6 Summary & Outlook

A general positive outlook on the potential of co-operation is strongly underlined by the data collected during the survey. The relative consistency in the respective perception of co-operation indicates that the appointed main reasons and hurdles that matter

to all stakeholders should be addressed with priority by political actors and private companies to foster co-operation. Coincidently, the differences between the reasons and hurdles among the subgroups point out the varying interests and points of origin for the involved industry sectors.

As long as financial pressure is not the main driver for co-operation, there must be financial latitude for most of the companies to develop non-co-operative infrastructure; likewise, the political demand for saving costs is not perceived by the respondents as penetrating as intended by legal authorities. Another important fact is that technological issues (such as lifecycles, are not the main hurdles for co-operation; instead the main hurdles happen to originate in the legal realm.

Overall, the analysis of the survey assumes that the energy market is about to change and speed up quite significantly. However, there are substantial strategic hurdles to overcome in order to enforce co-operation between communications providers and DSOs as there are various asymmetries among them. Nonetheless, the main reason for co-operation among the energy and communications sectors emerged to consist in assumed advantages as regards faster implementation of smart grids.

Especially the topics addressed in hypotheses H5 and H6 are of interest for future research. The investigation and better understanding of asymmetrical valuation communication services can help to overcome the perceived hurdles. Additionally the legal and regulatory realm must be investigated more closely with a special focus on the question how incentives for DSOs to co-operate can be induced more efficiently while maintaining the goals of security of supply.

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