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Working paper: Barriers towards Energy Cooperation

Envisioning and Testing New Models of Sustainable Energy Cooperation and Services in Industrial Parks

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Disclaimer

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Executive summary

This working paper intends to comprehensively identify, summarize and cluster the manifold barriers associated with various solutions of energy cooperation and mutualized energy services. It is assumed that barriers towards renewable energy and energy efficiency measures that are relevant to the single-company case are also relevant to energy cooperation between two or more companies. This study focuses on those barriers that are relevant to the collaboration of two or more companies. The listing includes technical as well as non-technical barriers.

The intention of this paper is not limited to the sole identification and description of barriers. Rather, it aims to provide a comprehensive list of barriers to help companies and park managers to actively avoid or avert them. Another intention is to identify opportunities for innovation, which are often directly derived from a detailed discussion of the barrier.

An extensive literature about barriers to energy efficiency measures in industry has been published since energy efficiency became important in the second half of the 20th century. Most literature deals with barriers to energy efficiency within a company, while this project deals with energy (efficiency) cooperation between two or more companies. This approach leads to the principle of Industrial Symbiosis and Eco-Industrial Parks. Past projects have also referred to Industrial Symbiosis and Eco-Industrial Parks, which are connected to energy efficiency cooperation. This working paper is based on pre-assessed barriers, and especially those barriers that have been pre-identified as relevant to cooperation solutions. Furthermore, barriers that have been identified through literature research and by conducting expert workshops are presented.

One purpose of this working paper is to cluster individual barriers and, by doing so, structure and understand them more clearly. Different approaches of categorization were elaborated, for example by type of origin, time of occurrence, research discipline or energy carrier. It was found that due to the barriers’ comprehensive and cross-thematic characteristics, there is no clear distinction, no matter which categorization is chosen. In this working paper, it was decided that the categorization in disciplines fits best as it is the most meaningful classification, i.e. barriers were categorized for economic, social/managerial, framework, technical/engineering and information provision barriers. These clusters encompass many barriers, which are described in detail in chapter 4 and its subsections.

In this working paper, a detailed analysis of barriers was conducted. Barriers were clustered to disciplines, steps of implementation (see Figure 1-1), and type of origin. Identified barriers were associated to their potential appearance during the implementation of energy cooperation solutions in parks, which were elaborated in other tasks of S-PARCS.
Stage 1: Status Quo

Stage 2: Will of investing and cooperation

Stage 3: Knowledge of inefficiencies and cooperation opportunities

Stage 4: Energy Efficiency Cooperation implemented

Action 1: Generation of interest

Action 2: Investigation/Data Acquisition on inefficiencies and partners

Action 3: Investment analysis and intervention implementation

Figure 1-1: This figure shows the scheme of a decision flow chart during the implementation of energy cooperation actions. In the appendix and the digital attachment of the working paper the flowchart can be found together with assigned barriers for the Actions 1-3. This flowchart is based on the decision-making process of Cagno et al. [1, p.302]

The working paper shows that the implementation of energy cooperation or mutualized energy services is a multi-stage process involving many disciplines. Therefore, barriers are allocated alongside these stages and are relevant to all academic disciplines, as opposed to being linked to a dominant discipline, for example the technical one. Although social and informational barriers also occur inside single companies, they play a more crucial role for energy cooperation and mutualized energy services. As compared to internal measures, which converge at a central decision-making point (e.g. board), cooperation implies additional efforts to exchange information, advance in negotiations and set up bilateral contractual agreements.
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List of Abbreviations
EDP.................................................................................................................. Electronic Data Processing
EIP................................................................................................................... Eco-Industrial Park
EMS .............................................................................................................. Energy Management System
IEC .............................................................................................................. International Electrotechnical Commission
IS................................................................................................................... Industrial Symbiosis
ISO............................................................................................................ International Organisation for Standardisation
IT .................................................................................................................. Information Technology
MS............................................................................................................. Member States
NSIP............................................................................................................ National Industrial Symbiosis Programme
ROI............................................................................................................. Return of Investment
TRL........................................................................................................... Technology Readiness Level
1 Introduction

In this working paper technical as well as non-technical barriers of manifold solutions for energy cooperation within the S-PARCS Lighthouse parks are identified in relation to Task 1.1 and Task 1.2 of the S-PARCS project. The barriers are clustered according to five topics, which are Economic, Social/Managerial, Framework (legal), Technical/Engineering and Information Provision Barriers. The working paper is based on the pre-assessed barriers from the original project proposal and barriers, which have been allocated to also pre-assessed cooperation solutions. Furthermore, barriers, which have been identified by literature research and own considerations will be presented.

An extensive amount of literature has been published about Barriers to Energy Efficiency Measures in Industry since energy efficiency became an important policy aim in itself in the second half of the 20th century. Most literature deals with barriers to energy efficiency within a company, while this project deals with energy (efficiency) cooperation between two or more companies. This approach leads to the principle of Industrial Symbiosis and Eco-Industrial Parks.

There is a significant amount of literature and a considerable number of projects referring to Industrial Symbiosis and Eco-Industrial Parks, which are connected to energy efficiency cooperation, e.g. from Chertow [2], Gibbs [3], Ehrenfeld and Gertler [4] and Mirata [5]. Comprehensive practical experience is presented by the Eco-Innovera study [6].

The authors of this working paper assume that barriers towards energy efficiency measures within one company also apply to energy efficiency cooperation of two or more companies. However, the scope is expanded to include and focus on those barriers that are created by the collaboration of two or more companies.

Due to the manifold literature and reviews on intra-industrial energy efficiency barriers, a summarising overview is provided and reference is made to relevant literature. This working paper aims at identifying and revealing barriers, which occur when more than one company is involved.

At first, the working paper will give a short overview of Industrial Symbiosis and Eco-Industrial parks in Chapter 2. Furthermore, a short literature review of the experiences with barriers and success factors of Eco-Industrial Parks is presented.

In Chapter 3 the barriers, which have been identified in the S-PARCS project, is presented to give a comprehensive overview.

Chapter 4 deals with the analysis of the identified barriers, which are sorted by different fields of research.

The chapter is followed by a short section on opportunities and success factors, which oppose the identified barriers. This section is kept short because it will be discussed in detail in a separate task of S-PARCS.

The last Chapter 6 offers a range of cooperation solutions, which were partly pre-assessed in the original project proposal and identified by Task 1.1. For each of these solutions important barriers will be summarized.
Lastly, a summary and conclusion complete off this working paper.

The results presented in this working paper shall support identifying and designing energy cooperation solutions, which can be implemented in the S-PARCS Lighthouse parks, build the foundation for recommendations for changes or amendments of regional, national or EU wide regulations and identify the scope of innovations, which can help to overcome the detected barriers. Furthermore identified energy cooperation solutions from Task 1.1 will be evaluated with a view to the barriers identified in Task 1.2.
2 Background on Industrial Symbiosis and Eco-Industrial Parks

2.1 Definitions of Eco-Industrial Park

Much literature has been published about barriers to industrial energy efficiency since energy efficiency became an important policy aim in the second half of the 20th century. Most of the time energy efficiency within a single company is discussed and analysed.

In literature there are several names and definitions for companies (within industrial parks) cooperating in energy, resource and waste matters. Common ones are “Eco-Industrial Park” (EIP), “Industrial Symbioses” (IS), “Industrial Ecosystems”, “Eco-Industrial Networks” or “Eco-Innovation Park”. The latter one is a term for areas where not only industrial but also urban/residential, scientific or public topics are addressed [6, pp.10–12, 7, 8]. For a comprehensive tabular summary of the various terms based on literature refer to Massard et al. [6, p.13].

A common precondition for Industrial Symbiosis and Eco-Industrial Parks, is Chertow’s 3-2 heuristic approach [2, 7]: At least 3 companies are sharing at least 2 different materials, otherwise only linear exchanges are made.¹

Literature further distinguishes between Industrial Symbiosis and Eco-Industrial Parks:

- Industrial symbiosis has been defined by Chertow in 2000 [9]: “Industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity.”, this definition has been adopted by various others, for example Massard et al. in the Eco-Innovera Study [6], Bellantuono et al. [10], Marchi et al. [11] and Valenzuela-Venegas et al. [12].

- Eco-Industrial Parks have been defined by Lowe et al. in 1996 and 1997 [13] as “A community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only. The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impact. Components of this approach include new or retrofitted design of park infrastructure and plants, pollution prevention, energy efficiency, and inter-company partnering. Through collaboration, this community of companies becomes an ‘industrial ecosystem’.”, this definition has been adopted by the Eco-Innovera Study [6], Bellantuono et al. [10], Chertow [9], the World Bank Group [14] and others.

¹ In S-PARCS the definition is slightly different: At least two companies have to be involved in a cooperation concerning at least one energy-related product or service. Nevertheless, the principles and barriers are the same as for EIPs following the precondition of Chertow.
Furthermore, several different “eco-criteria” are defined, which can be used to identify an industrial park as eco-industrial, although there is still no generally accepted official framework for identifying such parks. However, in December 2017 “An International Framework For Eco-Industrial Parks” was presented by the Worldbank Group, United Nations Industrial Development Organization (UNIDO) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. In this framework they want to “[create] a common vision for eco-industrial parks, which countries can use and modify according to their own specificities” [14, p.5]. The framework describes requirements, which should be fulfilled by Eco-Industrial Parks and presents binding international and national frameworks, which have to be considered. The requirements are categorized due to regulations, park management, environment, social performance and economic performance. Barriers however are summarized quite briefly. Frameworks as well as case studies and international studies on several Eco-Industrial Parks show that the standards of the parks vary strongly from park to park and from country to country. The latter is owed to extreme variations in national, social, economic and environmental guidelines. Eco-Industrial Parks in transition countries may be assessed as “usual” in developed countries [6, p.15]. Waste separation for example is standardized in most developed countries while it is still seen as “ecological add-on” in industrial parks of some developing countries. Furthermore, most Eco-Industrial Parks only include some but not all of the following twelve eco-criteria, which are used to identify Eco-Industrial Parks according to the Eco-Innovera study [6, p.16]:

1) Energy Efficiency  
2) Renewable Energy Sources  
3) Waste management  
4) Water management  
5) Mobility, transportation  
6) Air pollution prevention  
7) Environmental management systems  
8) Cultural, social, health and safety  
9) Land use  
10) Noise prevention  
11) Material/Chemical flow  
12) Biodiversity

S-PARCS mainly aims at energy cooperation within industrial parks. Taking the criteria listed above into account, the intentions of the project mainly cover or include the bullet points 1) to 7) but may occasionally touches upon others. Consequently, the project actually aims on developing Eco-Industrial Parks with a focus on energy (efficiency) aspects.

There are many self-declared Eco-Industrial Parks around the world, which base their origin on several reasons. Some were planned right from the scratch, especially newer ones, e.g. the London Sustainable Industries Park, some changed their appearance over the years like the Eco-Industrial Park at the Kymijoki River in Kuusankoski2 and some had to be innovative during times of resource shortage like the Harjavalta Industrial Eco-Park3 or the industrial

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district at Kalundborg in Denmark\(^4\) [15], which is considered to be the “original” Eco-Industrial Park. Over the years the effort of various countries to establish Eco-Industrial Parks similar to Kalundborg led to very mixed results: From complete failure to planned Eco-Industrial Parks, which now are conventional industrial parks, to successful Eco-Industrial Parks [16]. The reasons for these developments were analysed in literature before, this report will seize these reasons, since they might base partly on a misjudgement of barriers for energy (efficiency) cooperation in industrial parks [5].

### 2.2 Identifying relevant barrier categories for S-PARCS

This report will present various barriers regarding energy cooperation. However, the pre-assessment of barriers and cooperation solutions has shown that the following barriers are frequently quoted in the related literature. The following listing shows the most frequently named barriers for the cooperation solutions from the pre-assessment ranked according to their commonness [Technical Annex, Section 1.3 from 15, pp.9–11].

1. High investments/financing problems
2. Complex business model
3. Missing technical guidelines/standardisation
4. Missing regulatory/legislative framework
5. Mismatch of load profiles
6. Lack of experience/knowledge
7. Lack of monitoring demand/consumption
8. Lack of metering of demand/consumption

Comparing these barriers with the survey results from the Eco-Innovera study [6], interestingly the most important success factors named of the Eco-Innovation Parks were “Organizational and Institutional Setups”, “Cooperation with Science and Technology Institutions”, “Economic Value Added” and “Clear Designation of the Park as Eco-Innovation Park”. These four factors directly relate to numbers 1), 2) and 6) to 8) of the barriers listed above. “Economic Value Added” is a precondition for S-PARCS, since the intended energy cooperation shall lead to reduced costs for the companies while having positive ecological impact.

The factors of “Policy & Regulation Frameworks” and “Financial Incentives”, which would tackle the barriers 1), 3) and 4), are ranked number 5 and 7 out of 8 success factors taking all kinds of Eco-Innovation Parks into account. Considering only industrial parks, the survey results shift marginally: “Policy & Regulation Frameworks” is then ranked number 7 and “Financial Incentives” number 6, which means they are even less important. Missing policies and regulatory frameworks as well as missing financial possibilities seem to be not as important in practice as initially thought, depending on the solution or technology, which shall be implemented.

Experiences with Eco-Innovation Parks, described and analysed by various authors in recent years, highlight the relevance of economic, technical and regulatory barriers. After the artificial

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4 http://www.symbiosis.dk/en/

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Project Start: 01/03/2018 | Duration: 36 Months
implementation of “brownfield” Eco-Innovation Parks (retrofit) and “green field” Eco-Innovation Parks (planned from scratch) with some of them failing to reach their goals [1], various research institutions began analysing the reasons behind these failures. The parks were planned and built target-oriented and reasonable, moreover being supported by public support schemes. Therefore, economic and regulatory barriers, as well as technical ones to some extent, were mitigated for the greater part. The reasons must therefore lie at least partially somewhere else.

Planned and “naturally” grown cooperation has to be distinguished. The first one is also called the “Build and Recruit” or “Planned Eco-Industrial Park” model, while the latter is “Self-Organizing Symbiosis” [16]. Chertow [2], Burström and Korhonen [17] and Ntasiou and Andreou [7] found that planned Eco-Innovation Parks tend to be less successful than parks that emerged over time by adding industrial symbioses step-by-step based on self-organization, like the industrial district at Kalundborg, Denmark. [4] There are also large differences in barriers in already existing parks, which are to be refurbished, and parks, which are newly planned and built. The model which describes the retrofitting of an existing industrial park, is called “Retrofit Industrial Park” model [16].

The differences between planned and self-organized industrial symbiosis and Eco-Innovation Parks are how long they need to develop and social and managerial aspects. Planned (and retrofitted parks to some extent) may have optimized technical preconditions and an elaborate infrastructure but the participating companies often do no form a social or business community. Self-emerged parks originate from good relationships, open communication, innovative ideas and commitment and grow slowly. When the first self-organized industrial symbioses emerged, the intention was rarely to establish Eco-Innovation Parks, but developments were owed to external circumstances, such as resource shortage. Until the systems get analysed there is often no awareness of the complex social, technical and economic networks. [2]

For planned and self-organized Eco-Innovation Parks, some barriers are the same, namely in legislative and normative regulations, availability of technical solutions and economic considerations. Other barriers they share, but tackle differently, are social and managerial issues. In literature the importance of social networking, communities and overhead institutions is discussed.

Velenturf and Jensen argue that “There is a pressing need to understand the social processes that underlie sustainable industrial development […] Proactive strategies are needed because it is likely that the availability of many natural resources, which are crucial to the ongoing functioning of a multitude of industries, will be increasingly impaired while, simultaneously, resource prices will continue to increase […] Allowing IS systems to develop organically would arguably take too long. For example, the IS system in Kalundborg initially developed over a period of at least 25 years […]” [18, pp.700–701]. Velenturf and Jensen base their arguments on various literature sources. Since geographic proximity plays a key role in various definitions of Eco-Industrial Parks (as well as Eco-Innovation Parks and Industrial Symbiosis), the understanding of such proximity in all its facets demands more research.

As mentioned above, the definition of “eco-industrial” depends strongly on national standards. The weighting of barriers depends also on regional and national standards, which has been shown by surveys of the United Nations Economic Commission for Europe (UNECIE) in 2017. Experts on energy efficiency investments throughout countries all over the world were
requested to select the three most important barriers concerning the improvement of energy efficiency in their country. Taking all countries into account, the lack of knowledge about non-energy benefits, followed by missing understanding about financing mechanisms for energy efficiency projects by financial institutions, low energy prices and administrative barriers, are most important. In Eastern Europe, the Caucasus, Central Asia and Russia, these four barriers are ranked equally as the most important barriers, except for the financing barrier. In South-East Europe the opposite is the case: The financing barrier is the most important by far, followed by bureaucracy, missing policies and standards as well as lack of implementation of such policies and standards. In Western Europe and North America the missing knowledge of non-energy benefits followed by low energy prices as well as financing problems, followed by bureaucracy and uncertainty about performance are crucial. Having a closer look on single countries, the results vary even more. [19, pp.20–22]

Concerning the S-PARCS project, this report intends to identify and describe all kinds of barriers. At the same time, its intention is to highlight the most relevant ones, especially with regard to cooperation. The S-PARCS Lighthouse parks are all existing industrial parks within Europe, which investigate opportunities to improve their established and in many cases well-working concept. Therefore, these parks pursue the Retrofit Industrial Park model. On the following page, an overview of the Lighthouse parks is given.
Table 2-1: Overview of characteristics of the Lighthouse parks taken from the project proposal [15, p.15]

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<th>Goitondo, Mallabia</th>
<th>Ponte a Egola, San Miniato</th>
<th>Vendas Novas, Vendas Novas</th>
<th>Ennshafen, Enns</th>
<th>Chemiepark, Linz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience in S-PARCS shall enable defining an energy efficiency strategy for all industrial parks in the Basque Country, which are all supervised by the same entity (SPRI). Partner BSI seeks learning about European best practice examples for designing future parks from scratch and wants to determine if the projects can finance the salary of an energy manager. Design &amp; implement a monitoring system able to manage the energy consumption of the park and reduce it by 10% Improve the global competitiveness of the companies installed in the park Come up of best practice guidance for Upper Austrian industrial promotion agency (Biz-up, LOI attached). Refining frontrunner position by learning from topic-specific best practices from other parks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economic Activities</td>
<td>rubber &amp; rubber-related products</td>
<td>wood pellets, metal processing</td>
<td>metal processing and services</td>
<td>tannery sector</td>
<td>cork production &amp; car manufacturing</td>
<td>wood, laundry, chem. industry</td>
<td>chemical industry</td>
</tr>
<tr>
<td>Energy costs/ total expenditures</td>
<td>1.5 – 2.5%</td>
<td>3%</td>
<td>4%</td>
<td>1 – 2%</td>
<td>~ 3%</td>
<td>&lt;10%</td>
<td>&gt;20% (incl. non-energetic uses)</td>
</tr>
<tr>
<td>Total annual energy consumption and ratio of fossil energy</td>
<td>20 GWh 85% fossil 100% RES in park offices</td>
<td>2 GWh 85% fossil</td>
<td>0.5 GWh 85% fossil</td>
<td>100 GWh 68% fossil</td>
<td>30 GWh 50% fossil</td>
<td>~ 0.5 TWh (~ 50% fossil)</td>
<td>&gt; 5 TWh incl. non-energetic uses (100% fossil/electric origin)</td>
</tr>
<tr>
<td># of companies</td>
<td>34</td>
<td>15</td>
<td>5</td>
<td>79</td>
<td>60</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td># of employees</td>
<td>296</td>
<td>112</td>
<td>21</td>
<td>3,000</td>
<td>1,200</td>
<td>2,200</td>
<td>2,000</td>
</tr>
<tr>
<td>Existing joint provision of services</td>
<td>waste water treatment, rain water collection, fuel management and provision</td>
<td>2 x 100kW rooftop PV panels (for joint on-site electricity consumption) installed</td>
<td>100 kW of PV panels installed</td>
<td>waste water treatment chromium recovery Fat/protein production from fleshing reuse in agriculture, training facility</td>
<td>waste water treatment</td>
<td>none so far</td>
<td>Total site utility management by Borealis (excl. biological sewer system and sewage plant)</td>
</tr>
</tbody>
</table>
3 Overview of Identified Barriers of Energy Cooperation

Literature research and workshops on barriers within industrial energy projects, and, more specifically, industrial energy cooperation projects, showed that categorising single barriers as well as distinguishing them is a complex task. Various research teams have found varying possibilities to cluster the barriers. Another aspect is which level of detail is presented or discussed. Most literature either presents general barriers [1, 19, 20] or individual case studies and best practises [5, 21, 22]. S-PARCS deals with several Lighthouse parks, which differ in their frameworks, current cooperation and commitments to future cooperation. In order to establish a joint basis for the development of intensified cooperation, and to provide boundaries for the development and utilisation of the S-PARCS Initial Assessment Tool (IAT), a detailed analysis of the barriers is undertaken here, based on literature, experts’ involvement and own research.

3.1 Approaches to the clustering of barriers

Cagno et al. [1] and Fleiter et al. [23] identified and clustered barriers to industrial energy efficiency. Although they dealt mainly with intrafirm barriers, their approach can be applied to industrial energy cooperation as well. At first they undertook a literature review on barrier classification schemes, such as the six categories developed by Blumstein et al. [24] in 1980: Misplaced incentives, Lack of information, Regulation, Market structure, Financing, Custom. The IPCC report from 2001 showcases eight sections for barriers: (i) Technological innovation, (ii) Prices, (iii) Financing, (iv) Trade and environment, (v) Market structure and functioning, (vi) Institutional frameworks, (vii) Information provision, and (viii) Social, cultural, and behavioural norms and aspirations. [1, 25, p.346]. They cite three more research teams, who all differ in their classifying approach. Own literature research identified Walsh and Thornley [26], who merged categories from surveys and literature. Another significant contribution has been made by Sorrell et al. [20], and has been acknowledged by Cagno et al., too. They base their classification on three perspectives: Economic, Behavioural and Organizational. Each perspective covers several categories, which involves several barriers. The Economic perspective e.g. covers non-market failure barriers (Hidden costs, access to capital, risk) and market failures (Imperfect information, split incentives, adverse selection, principal-agent relationships). [1] Fleiter et al. [23] adopt the taxonomy, which has been presented by Sorrell et al. Cagno et al. amend the Sorrell taxonomy by additional barriers such as energy price distortions, low diffusion of technologies, difficult access to external knowledge to name just a few.

Another approach is sorting barriers according to their internal or external origin, the size of the company/park, their technology dependency, the industrial sector or the stage of the decision chain at which they come into effect. Additionally, since this working paper deals with energy cooperation, barriers do either exist for industrial energy efficiency in general or only because two or more companies are involved. Furthermore, many barriers cannot be allocated exclusively to one category or they overlap or have causal relationships. This becomes clear, when barriers shall be allocated exclusively to one category. The barrier “too long payback times” for example is not only influenced by company rules but also market rules and personal
estimates of the responsible decision makers, which is connected to bounded rationality. For further information refer to Cagno et al., who explain this complex problem extensively. [1, pp.294–304] At this point Cagno et al. made interesting findings, since it is common that barriers not just overlap but are mistaken for another barrier. This may happen when the barrier “missing technical knowledge” leads to the conclusion that missing technical innovations available on the market restrict the company’s technical progress. The technical barrier is mistaken for the “knowledge barrier”. [1, p.306] Another common failure is that barriers are perceived in a wrong way, as can also be seen from Figure 3-1. For example the negative effect of a barrier can be valued much higher than it really is or the other way round. [1, pp.300–301] This phenomenon is kind of a barrier itself, because it can lead to discarded opportunities, although the proposed solutions could have been easily implemented.

Figure 3-1: Scheme showing the effects of too high (a) and to low (b) perceived values of a barrier compared to the real value. This figure is taken from Cagno et al. [1, p.301]

In this working paper, barriers are clustered according to five fields of research, respectively 4.1 Economic Perspective, 4.2 Social/Managerial Perspective, 4.3 Framework Perspective, 4.4 Technical/Engineering Perspective and 4.5 Information Provision Perspective. Because a very broad application field of the working paper’s findings shall be made possible, the other classification approaches mentioned above are not fully suitable. However, additionally to the basic analysis, barriers identified for this working paper were assigned to various cooperation solutions, which were identified in Task 1.1. These clusters can be found in the attached Excel file.
3.2 Barrier clusters

Thoroughly considering the various approaches to cluster the barriers, it is not possible to identify an objectively correct approach or one that avoids problems like ambiguous allocation. Thus, the authors decided that the categorization shall remain in the following Clusters I to V in Table 3-1 to Table 3-5 according to the original project proposal of S-PARCS [15, pp.7–9]. Each barrier identified is allocated to only one of the clusters, which correspond to five different fields of research, and will be discussed throughout the report.

It should be noted that the barriers will have a different relevance in the specific cases of application and in different framework conditions. Therefore, certain barriers may or may not apply to concrete situations or individual companies, parks or countries.

Table 3-1: Barriers from pre-assessment part 1/5 [cf. 15, p.57] and additions

<table>
<thead>
<tr>
<th>Cluster I: Economic Perspective - Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Companies/Parks lack access to (long-term) financing or lack knowledge thereof</td>
</tr>
<tr>
<td>Internal competition for capital prioritizes non-energy related investments</td>
</tr>
<tr>
<td>No additional own funds available</td>
</tr>
<tr>
<td>Existing plants are not depreciated today, which hampers the investment in new ones</td>
</tr>
<tr>
<td>Long payback times are not in line with company guidelines</td>
</tr>
<tr>
<td>Energy costs are not a crucial cost factor</td>
</tr>
<tr>
<td>Existing structures are costly to change</td>
</tr>
<tr>
<td>Players fear hidden costs of first-of-kind investment projects</td>
</tr>
<tr>
<td>(Monetarized) economic, organizational and technical risks, including risk uncertainties</td>
</tr>
<tr>
<td>Companies/parks face high investment costs</td>
</tr>
<tr>
<td>Financial problems due to retroactive changes of renewable energy support schemes, which also create lack of trust among investors</td>
</tr>
<tr>
<td>Players lack substantial private (risk) finance</td>
</tr>
<tr>
<td>Costs associated with environmental damage/climate effects are poorly reflected in market prices</td>
</tr>
<tr>
<td>No or insufficient consideration of life-cycle costs in market prices</td>
</tr>
<tr>
<td>Fear of technological lock-in effects or obsolescence due to expected technological progress</td>
</tr>
<tr>
<td>Fear of competitive disadvantages through exchange of information, knowledge and data</td>
</tr>
<tr>
<td>Limited customer acceptance (fear of distorted, unreliable business relations)</td>
</tr>
<tr>
<td>Uncertainty about energy/resource price developments</td>
</tr>
<tr>
<td>Availability of risk insurance insufficiently offered on market</td>
</tr>
</tbody>
</table>
Table 3-2: Barriers from pre-assessment part 2/5 [cf. 15, p.57] and additions

<table>
<thead>
<tr>
<th>Cluster II: Social/Managerial Perspective - Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual</strong></td>
</tr>
<tr>
<td>Reluctance to change and adapt to potentially different working environments</td>
</tr>
<tr>
<td>Lack of time and resources to work on issues other than the core business</td>
</tr>
<tr>
<td>Lack of skills and competencies to deal with issues other than the core business</td>
</tr>
<tr>
<td>Staff is not motivated to deal with (their department’s) energy demand etc. / act according to the cooperation rules</td>
</tr>
<tr>
<td>Responsibility for energy topics is not clearly defined</td>
</tr>
<tr>
<td>Fear of distortions to core business</td>
</tr>
<tr>
<td>Uncertainty of effects on local population, communities where park/company is located</td>
</tr>
<tr>
<td>Success driven managers with short-term contracts need fast success</td>
</tr>
<tr>
<td><strong>Mutual</strong></td>
</tr>
<tr>
<td>Weak cross-sectoral co-operation</td>
</tr>
<tr>
<td>No prior relation between companies in an industrial park</td>
</tr>
<tr>
<td>Fear of security of supply in case of switching suppliers</td>
</tr>
<tr>
<td>Cultural barriers towards cooperation that relates to internal production processes</td>
</tr>
<tr>
<td>Different management/reporting levels at involved companies are responsible</td>
</tr>
<tr>
<td><strong>Organizational</strong></td>
</tr>
<tr>
<td>Problems due to split incentives may occur internally and/or externally</td>
</tr>
<tr>
<td>Absence of energy management systems (ISO 50001, also e.g. ISO 9001 and ISO 14001)</td>
</tr>
<tr>
<td>Lack of trust between companies and park manager / or service companies</td>
</tr>
<tr>
<td>Companies are direct market competitors</td>
</tr>
<tr>
<td>Fear of negative effects on workplace safety</td>
</tr>
<tr>
<td>No possibility or no willingness to make changes to a rented building</td>
</tr>
<tr>
<td>Uncertainty and lack of information about internal organization</td>
</tr>
<tr>
<td>Changes to managerial structures may become necessary, reduces acceptance of decision makers</td>
</tr>
<tr>
<td>Incentive structures in companies guiding objectives of decision makers reduce acceptance</td>
</tr>
</tbody>
</table>
### Table 3-3: Barriers from pre-assessment part 3/5 [cf. 15, p.58] and additions

#### Cluster III: Framework Perspective - Barriers

<table>
<thead>
<tr>
<th>Legal / Regulatory / Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of comprehensive and coherent political energy strategies increase investment risks</td>
</tr>
<tr>
<td>Industrial codes and standards are not aligned with proposed solutions</td>
</tr>
<tr>
<td>Infrastructure related uncertainties (e.g. regulations for HV and LV networks)</td>
</tr>
<tr>
<td>Regulation is counter-productive to some technologies/measures</td>
</tr>
<tr>
<td>Uncertainties in national legislation</td>
</tr>
<tr>
<td>Incoherence between local, regional, national, European legislation creates uncertainty</td>
</tr>
<tr>
<td>Legal complexity in the individual Member States</td>
</tr>
<tr>
<td>Big data management</td>
</tr>
<tr>
<td>District heating operator is not legally obliged to allow and remunerate a feed in into his network</td>
</tr>
<tr>
<td>Ineffective market based support instruments</td>
</tr>
<tr>
<td>Lack of appropriate incentives</td>
</tr>
<tr>
<td>Tax structures (such as depreciation periods)</td>
</tr>
<tr>
<td>Application for subsidies is too complicated</td>
</tr>
<tr>
<td>No legal claim for building heat pipes over private ground</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standardization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different safety issues (and yearly costs) according to different voltage supply</td>
</tr>
<tr>
<td>Energy taxes on individual energy carriers need to be harmonized in a local hybrid system</td>
</tr>
<tr>
<td>Registration as an energy supplier is needed if energy (especially electricity) is utilized externally</td>
</tr>
<tr>
<td>At the moment it is difficult to have more than one energy supplier, which makes selling infrequent residual/surplus energy difficult for companies</td>
</tr>
<tr>
<td>Prohibition of exchanging electricity between two customers</td>
</tr>
<tr>
<td>Lack of standardization about waste heat exchange (e.g. metering and measurement)</td>
</tr>
<tr>
<td>Frameworks prohibit technical/economical sound cooperation regarding gas &amp; electricity</td>
</tr>
</tbody>
</table>
Table 3-4: Barriers from pre-assessment part 4/5 [cf. 15, p.58] and additions

<table>
<thead>
<tr>
<th>Cluster IV: Technical/Engineering Perspective - Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of the energy efficiency potentials in the company have already been realized</td>
</tr>
<tr>
<td>Lack of knowledge for designing, developing, constructing, manufacturing, operating and maintaining new technologies or cooperation e.g. first of its kind</td>
</tr>
<tr>
<td>Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)</td>
</tr>
<tr>
<td>Missing link between supply/load profiles of the companies (no appropriate usage of by-products or waste streams possible)</td>
</tr>
<tr>
<td>Insufficient technology maturity (TRL evaluation)</td>
</tr>
<tr>
<td>Integration of energy management systems (microgrid EMS)</td>
</tr>
<tr>
<td>Intellectual property protection hampers the dissemination of technology relevant information</td>
</tr>
<tr>
<td>Long physical distances between enterprises (energy losses)</td>
</tr>
<tr>
<td>Lack of technical solutions for managing by-products</td>
</tr>
<tr>
<td>Outdated infrastructure does not allow efficient solutions</td>
</tr>
<tr>
<td>Hesitant to interfere within reliably running production processes (production disruptions, hidden costs)</td>
</tr>
<tr>
<td>Uncertainty of quality of exchanged energy (temperature level, continuity profile, volumes etc.)</td>
</tr>
<tr>
<td>Aligning intermittent energy production (load profiles) between processes</td>
</tr>
<tr>
<td>Lack of knowledge about technical options, their applicability and reliability</td>
</tr>
<tr>
<td>Lack of feasibility study, life cycle analysis or technological forecasting</td>
</tr>
<tr>
<td>Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities</td>
</tr>
<tr>
<td>Inappropriate technologies (as of weather conditions, intermittent source, capacity utilization not economical, incompatible)</td>
</tr>
<tr>
<td>Intermittency of some renewable energy sources (insufficient supply, storage systems or load shifting required to meet demand)</td>
</tr>
<tr>
<td>Lack of monitoring and measuring of energy consumption within enterprises</td>
</tr>
<tr>
<td>High demands on computer performance and IoT sensors/actuators for data analysis and optimization algorithms</td>
</tr>
<tr>
<td>Cyber security protocols to protect privacy issues for energy exchange are required</td>
</tr>
<tr>
<td>EDP (electronic data processing) equipment for data monitoring, storage and management and evaluation is required</td>
</tr>
<tr>
<td>Advanced communication infrastructure needed (bi-directional flow of energy and information like for smart grids, microgrids and prosumers)</td>
</tr>
<tr>
<td>Lack of infrastructure (physical space for new technologies, distribution infrastructure for the transportation of waste streams or by-products)</td>
</tr>
<tr>
<td>Building or reconstructing facilities to enable energy cooperation may imply the requirement of other measures to comply with the current “best available technologies” (BAT) standards.</td>
</tr>
</tbody>
</table>
Table 3-5: Barriers from pre-assessment part 5/5 [cf. 15, p.58] and additions

<table>
<thead>
<tr>
<th>Cluster V: Information Provision Perspective - Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing informational head of the park</td>
</tr>
<tr>
<td>Energy is not a strategic important issue</td>
</tr>
<tr>
<td>Lack of knowledge about successful demonstration projects and/or other references</td>
</tr>
<tr>
<td>Uncertainty about quantification of effects</td>
</tr>
<tr>
<td>Lack of knowledge about neighbor company’s energy demands/residuals</td>
</tr>
<tr>
<td>Lack of interest in the neighboring company’s energy demands/residuals</td>
</tr>
<tr>
<td>Lack of access to external competences</td>
</tr>
<tr>
<td>Lack of knowledge about financing, subsidy options</td>
</tr>
<tr>
<td>Provision of sensitive business data, e.g. energy data, is needed</td>
</tr>
<tr>
<td>Information exchange and communication between relevant persons does not work properly</td>
</tr>
<tr>
<td>Uncertainty about organizational issues of energy cooperation (e.g. who runs the new/joint plant)</td>
</tr>
<tr>
<td>Failure to recognize non-energy benefits of efficiency</td>
</tr>
<tr>
<td>Lack of knowledge about possible side-streams, collaborating partners, etc.</td>
</tr>
</tbody>
</table>
4 Analysis of Barriers

4.1 Economic Perspective

From an economic theory perspective, rationality (see also bounded rationality in Chapter 4.2) is always assumed in the decisions of the actors. When rational decisions are not made, the theoretically defined preconditions for rationality must be violated. These conditions include the availability of so-called “complete information” [27].

Complete information is not given if information asymmetries exist. [20, pp.17–21] This is the case when individual actors hold back their private information. For the opposing actor, there is also the risk (which is estimated by him/her) that private information is actually held back, which could make him worse off. In the area of lack of information, there is also a lack of knowledge of the actors about the current, specific opportunities for energy cooperation and about the technologies available. This lack of information is also addressed in economic theory as part of the “bounded rationality” concept [20, pp.31–33].

Both topics are described in the chapters on the disciplines 4.2 Social/Managerial Perspective and 4.5 Information Provision Perspective in more detail and are thus not dealt with in this chapter. Furthermore, there is an overlap with the discipline of 4.4 Technical/Engineering Perspective: New technologies can be too expensive to be implemented. This leads to the question of whether it is a problem of the specific technology or of the economic business case - in fact, the barrier can be attributed to both areas. This chapter focuses on the economic barriers of energy cooperation and mutualized energy services, i.e. the barriers allocated to the information and social/managerial perspective are excluded and only those topics of the techno-economic area are treated which can be directly assigned to the field of economics.

4.1.1 Cost-Benefit-Ratio

In industry, the economic perspective is usually the most influencing one and profitability is the decisive factor for the adoption of various measures in general, from technical innovations to employee healthcare. Energy efficiency or energy cooperation measures within an industrial park have to be economically sound as well, to be realized.

The following formula is based on the common investment decision. It shows that the net present value of an investment, taking into account interest and discount rates, must be larger than zero. As an illustration, the formula was rearranged in order to show and summarize the essential parameters of barriers for energy projects as described in literature and reported in expert interviews and expert workshops. It should be noted that this formula could also be presented in a different form, for example by detailing the individual variables. The abbreviations are given underneath the formula, in the following chapters the individual variables and their interactions are discussed.

\[
0 < - (I_{dir} + I_{hidden}) * (1 + ROI_{min}) + (S_{NPV,dir+indir} - C_{NPV}) - E_{Risks}
\]
The following sections of this subchapter list all barriers that are directly related to one of the parameters in this formula except the risks, which are analyzed in 4.1.2. Since the parameters of the relation of the costs and revenues are to be regarded as elementary and comprehensible, it is focused in particular on the condition for this relation which is the payback period. Generally, the formula is derived from business financing, but should be explained with its economic foundations in this chapter.

**Complexity of business models**

In the beginning, it is important to emphasize that the net present value must be greater than zero for the cooperation project. **The project must be beneficial in total, not necessarily for individual partners.** This means that individual companies which benefit from a cooperation may need to compensate those companies worse off due to cooperating.

Markets today normally work on the basis of providing a product against a payment, and compensation payments are a normal procedure when sharing raw materials, infrastructure or energy. On the other hand, for some types of energy cooperation, this implies setting up contractual agreements, to create a framework for specific applications. For energy cooperation projects of two or more companies, complex situations arise: investment, operation and maintenance costs have to be divided between the participants while benefits need to be shared. Except for electricity and gas, the exchange of energy or materials between companies is not subject to specific regulatory frameworks, giving flexibility to the partners but also leaving them the complexity of interacting parameters [28]. Fraccasia et al. present an overview of different business models for companies interested in industrial symbiosis [29]. Complexity is increased by the individuality of cooperation projects. Fair treatment of all partners may be difficult and may require very individual agreements and accurate calculations. From the point of view from many companies, the effort may be not worth the expected results, especially when short payback periods are demanded.

5 NPV = net present value
High investment costs vs. low savings

The basis for any economic calculation is the balance between the benefits achieved by a project and the associated costs. For some projects, investment costs or running costs are too high or associated benefits, e.g. additional revenues or avoided costs, are too low.

The ratio of benefits and costs is the starting point of many investment decisions. However, this barrier is to be mentioned, first, in order to set up a comprehensive list of hindrances, and second, in order to remind actors of this most crucial element. The latter is important as the barrier of a negative cost-benefit-ratio also applies for projects considered as advantageous for social or environmental aims, e.g. when savings are more likely to support sustainability than to add economic value.

Low savings can also be achieved when conventional energy sources are cheap. Often, costs caused by environmental damage and climate effects are not well or not at all reflected by market prices [30]. Therefore, joint energy efficiency investments and cooperation are held back, although they would make sense from a national economy perspective. Governments have the opportunity to internalize these costs through taxes on (fossil) energy carriers and subsidies on efficient technologies and renewable energy.

Financing

Financing problems or too high investment costs are often quoted as reason why measures are not realized. These general statements have to be seen more nuanced. Especially industrial companies within industrial parks are often very large and settled/stable enterprises, which can be expected to be financially strong. So why are there financing problems? From an economic theory point of view, capital is expected to be perfectly mobile. This means that capital is invested where it generates the highest revenues (i.e. interest rate). Especially for the industrial and commercial sector, literature and experts report payback periods of 5 years or less, corresponding to returns on investment of 20% and more [31]. This implies that it is likely that there are many non-implemented projects with payback periods of 10 years or less, corresponding to returns on investment of 10% and more. From the point of view of economic theory, the question arises why the assumedly completely mobile capital does not flow into these projects.

The interest rate to be paid by companies also includes a risk premium, i.e. it compensates the capital owner for market uncertainties, involved company’s bankruptcy, and other risks associated with the company. The higher the sum of externally provided capital, the higher is the risk, and the higher is the associated interest rate to be paid for the entire borrowed capital. The improving effect of borrowing costs on the return on equity is understood as leverage. For example, leverage can increase the return on equity of an investment. However, this only applies if an investor can borrow on more favorable terms than the return on capital returns. In order to maximize the interest rate for equity, the relation implies a cap for borrowed capital.

Below this cap, which complies with the assumptions of economics, the theory of capital mobility remains valid. In companies, the most profitable projects, i.e. those with the lowest...

---

6 This risk premium is to be distinguished from project-specific risks as described in 4.1.2.
payback periods, are selected. Long-term energy efficiency projects often have to stand back behind other (non-) energy (efficiency) projects, which pay off sooner [32].

Companies naturally tend to focus on their core business ("earn money by selling the product, not by saving costs"), prioritizing investments e.g. in process expansion. Internal funds of companies are limited, depending on the application area [1, 33, 34]. Venmans [35] found that energy efficiency is part of the core business for the ceramic, cement and lime sectors, which means energy efficiency projects are, in most cases, given similar priority as other projects, while according to Varmans earlier studies found opposite results [36, 37]. In other industries with much lower energy intensity, energy efficiency is still not part of the core business [34].

Another simple reason for not implementing energy efficiency measures is that there is no perceived need for lower energy demand. In many businesses, energy costs are a negligible cost factor [20, p.61, 38]. But there are also businesses, where energy costs matter a lot, depending on the business size, energy intensity and the location of the business, because of varying energy cost per country [38–40].

Long-term spending is primarily accepted in small to medium sized companies, which are managed by the owner, while large companies often act according to more short-term plans [41]. Projects like Open Heat Grid [42], Renewables4Industry [43, pp.3–4] and the Roadmap Energy Efficiency in Industry [44, p.3] have found in expert workshops that long payback periods are very problematic. This is also due to short-term employment contracts of managers, forcing them to achieve quick and visible success [1, p.293, 34].

In some cases investment costs are indeed simply too high to be financed by the company itself without external support [43, p.3, 44, p.3]. In these cases subsidies or loans can be the solution, depending on the project and the creditworthiness of the company. Consequently such projects are often not realized.

In some cases there is a lack of (risk) finance or long term finance. However, according to the European Commission [45] there is growing interest of banks and financial institutions in energy efficiency projects, since they realize that risks are lower than expected. Even so, assessing the real risks is difficult. The European Commission has therefore recommended the De-risking Energy Efficiency Platform (DEEP) [46] as well as the Underwriting Toolkit [47] released by the Energy Efficiency Financial Institutions Group (EEFIG). Projects like TrustEE (www.trust-ee.eu) or the investor Confidence Project (www.eeperformance.org/) are committed to standardize energy-related projects with regard to making them more attractive for the financial market.

Regarding subsidies, the application processes may are regarded as complicated and receiving subsidies implies to cope with strict requirements [44, p.4]. Moreover, for some countries retroactive changes to support and financing schemes are reported: Potential changes in financial support unsettle investors and have been realized in some countries before, such as Italy and Greece [48–50].

Depending on the energy cooperation measures, existing structures have to be changed to great extent, which may be costly and effortful, because of down-times of the plant, learning phases and demolition/construction costs. Taking the high investments into account the companies incurred in years ago when establishing their existing plants and structures, long
depreciation periods come into play. Facilities which would be subject to the measure now, maybe are not yet depreciated, which makes new investments preposterous [20, p.61, 34]. This can be a barrier for cooperation projects especially, if one of the partners would have to change relatively new or well-working equipment.

**Hidden costs**

Hidden costs or indirect costs represent the sum of all investment costs that are not directly related to the costs of the investment. A list based on Sorrell et al. [20] is provided in Table 4-1.

**Table 4-1: Hidden costs, which can increase the investment costs indirectly.**

<table>
<thead>
<tr>
<th>Possible components of hidden costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General overhead costs of energy management</strong></td>
</tr>
<tr>
<td>• Costs of employing specialist people (e.g. energy manager)</td>
</tr>
<tr>
<td>• Costs of energy information systems (including: gathering of energy consumption data; maintaining sub metering systems; analyzing data and correcting for influencing factors; identifying faults; etc.)</td>
</tr>
<tr>
<td>• Cost of energy auditing</td>
</tr>
<tr>
<td><strong>Costs involved in individual technology decisions</strong></td>
</tr>
<tr>
<td>• Cost of i) identifying opportunities; ii) detailed investigation and design; iii) formal investment appraisal</td>
</tr>
<tr>
<td>• Cost of formal procedures for seeking approval of capital expenditures</td>
</tr>
<tr>
<td>• Cost of specification and tendering for capital works to manufacturers and contractors</td>
</tr>
<tr>
<td>• Cost of disruptions and inconvenience</td>
</tr>
<tr>
<td>• Additional staff costs for maintenance</td>
</tr>
<tr>
<td>• Costs for replacement, early retirement, or retraining of staff</td>
</tr>
<tr>
<td><strong>Loss of benefits in individual technology decisions</strong></td>
</tr>
<tr>
<td>• Problems with safety, noise, working conditions, extra maintenance, reliability, service quality etc. (e.g. lighting levels)</td>
</tr>
</tbody>
</table>

The innovative character of energy cooperation projects can lead to uncertainties regarding hidden costs. First-of-its-kind investments may be considered as too risky to be in line with the company rules [43, p.3]. Hidden costs also play a role when several companies want to cooperate in energy matters, because of the high bureaucratic effort and the need to establish networks and supporting infrastructure.

**Running costs**

The running costs of technical equipment, technical personnel, service costs, overhead costs etc. add up to the investment costs. Sorrell et al. [20, 51] found that either running or investment costs are often not thought of, depending on which employee of a company is asked. The purchaser may take care of low initial investment costs, but not running costs. The maintenance personnel, which tries to keep the system running at low reinvestment costs, is not taking care of running (energy) cost either. This barrier is also connected to split incentives:
Different actors focus on different topics and face different incentives due to their responsibilities in the organisation. If their department will not profit from the decision, they are not likely to implement the measure [20, viii]. Furthermore, in case of highly innovative cooperation projects, it is much more difficult to account the running costs beforehand, due to shared responsibilities and few experiences in the field.

**Costly backup systems**

In addition to the investment and running costs of the new system, single companies may need to have a backup system to prevent down-times and/or security issues if the park infrastructure is out of order for some reasons. Depending on the type of energy cooperation or joint service, the installation of backup systems may be expensive. However, most of the time, especially in brownfield parks, backup systems are likely to be the old plants which are retired as the cooperation starts. Then, backup systems only need maintenance. On the contrary, as the prior systems remain in the company and need to be maintained, total average costs of the new plant compete with the variable costs of the old plant.

**Lock-in effects**

When innovative technologies are used to gain higher energy efficiency, lock-in effects can occur due to missing competitors and alternatives of the used technology. Such dependencies are usually avoided by enterprises. Lock-in effects occur when a consumer depends fully on one supplier, because the products, such as innovative energy efficient technology, are not available from other suppliers or the costs of changing to another (similar) technology are very high [25, p.357]. Lock-in effects are not only a risk but a market-related issue. Contractual agreements must intend to avoid such potentially negative effects.

4.1.2 **Risks & Uncertainties**

The energy efficiency gap describes the difference of energy efficiency potential and realized energy efficiency projects. In many cases cost-effective projects are not realized, which contradicts logical economic decision making. The term was coined by Hirst and Brown in 1990 [52]. Although risks and uncertainties are often neglected in economic assessments, they are probably one reason for the energy efficiency gap. Many assessments showed that risks and uncertainties are essential barriers to energy technology improvements in general and, even more important, for energy cooperation. [52–54].

Risk insurances for innovative projects in the renewable energy and energy cooperation sector are hardly offered as own research by the authors shows. Insurance institutions face the problem of evaluating the risks of energy efficiency projects. Risks for such projects are difficult to estimate, as individual projects are hardly comparable, and thus insurances are costly due to a high uncertainty premium. Taking growing experiences and databases into account, future development should show a decrease of this barrier.
Unknown development of energy prices

Energy prices can hardly be forecasted. Profound forecasts of renowned institutions have proved to be wrong [55]. Energy markets are global markets and are subject to many distortions, which may result in drastic and long-term price changes. Cost-benefit analyses often find that the payback period is extremely sensitive to changes in energy prices (e.g. [56]). Energy prices fluctuate a lot. In case energy prices fall after the implementation of an energy efficiency measure the profitability of the measure can be drastically reduced or no longer be given [34]. Energy market risks are a crucial uncertainty, which negatively influence especially those projects/investments with a payback period close to its allowed limits.

On the other hand, many energy efficiency and cooperation projects offer the opportunity to stabilize end-use energy costs, and thus make business models more resilient. Decision makers may accept higher average costs then [57].

Risks of partner default

For any cooperation, there is the risk of cancellation. Most of the aspects summarized in the following list are true for both, the demand and the supply side of the contract.

- Modification of the plant or changes in the whole process
- Shutdown due to bankruptcy of the company
- Shutdown due to relocation of the site

Often, the contractual agreements between companies clearly define the process when partners decline the cooperation or go bankrupt. For example, some include pre-emptive rights for the supplying plant [28]. As observed in one of the parks involved in the S-PARCS project, bankruptcy led to another company buying the site but to remain within the cooperation, as the equipment is installed and it is still beneficial to cooperate.

Generally, starting cooperation is most appropriate as soon as possible after installation or modification of plants.

Cooperation between competing companies

The provision of detailed energy data may allow competitors to estimate the company’s processes and capacity utilization. Although cooperation could foster the competitiveness of the single companies, data exchange and supporting market competitors could lead to economic risks. This problem is also part of social barriers, discussed in section 4.2 Social/Managerial Perspective. Especially when similar companies cooperate, problems can arise. Companies fear disadvantages in the market competition.
Further risks

As has been shortly mentioned before, it is difficult to predict the indirect savings and positive effects of energy efficiency measures. Tightly linked to this barrier is the overlooking of benefits, which is discussed in section 4.5 Information Provision Perspective.

Several economic risks are directly linked to risks of technical nature, such as down-times due to the implementation of new technologies, follow-up down-times because of failed system integration and learning phases during the adoption of new technologies. Technical barriers are discussed in more detail in section 4.4 Technical/Engineering Perspective.
4.2 Social/Managerial Perspective

Concerning social and managerial as well as behavioural barriers, the concept of “bounded rationality” will be introduced shortly. Simply said individuals as well as organisations tend to not act according to ideal decision making and economic models but are heavily influenced by particular interests, access to and processing of information and personal values to name a few reasons [20, 51]. Sorrell et al. define bounded rationality as follows:

“Owing to constraints on time, attention, and the ability to process information, individuals do not make decisions in the manner assumed in economic models. As a consequence, they may neglect opportunities for improving energy efficiency, even when given good information and appropriate incentives.” [20, viii]

Linked to “bounded rationality” as a social barrier are also information and economic barriers.

4.2.1 Lack of Experience and Knowledge

Lack of experience and knowledge can be very versatile. Companies intending to take action with regard to their energy consumption are often confronted with a lack of knowhow about the detailed consumption of their various processes and equipment. Additionally there may be a lack of knowledge about state of the art energy technologies and solutions and how to apply them.

These barriers closely connect the clusters 4.2 Social/Managerial Perspective, 4.4 Technical/Engineering Perspective and 4.5 Information Provision Perspective [58].

Missing knowledge of energy demands

Technical innovations are only possible if a company deals with the topic of energy and tries to figure out where and how energy optimisation could be made. Since energy audits became mandatory in most Member States (MS), at least in large enterprises some basic knowledge should exist. The situation is different for smaller companies. The smaller a company is, the fewer resources can be provided for the topic of energy. On the other hand, the companies are often owner-managed and have a clearer internal structure. Trianni et al. [39] have shown in their study on manufacturing SMEs that energy audits indeed do have effects on the barriers and drivers of industrial energy efficiency. In general lack of knowledge often derives from lack of time and interest, which in reality is a problem of so called “hidden costs”, as paid employees would have to spend part of their working time building knowledge in energy co-operation and efficiency [20, 23, 33, 59].

Changes in working behaviour

In every company there are specific working routines, i.e. the organisation creates certain work routines or supports certain behaviour. Changes need to be adapted and the willingness of the employees to change their behaviour can be constrained because of a changed workflow and other reservations against the technology or measure [20, pp.34–36, 39]. Change of behaviour can be initiated by education and training courses.
Change of working environment and workflow

Even more difficult is the situation when the working environment itself shall be changed for the sake of the energy cooperation [44, p.3]. Consequently there is the fear of losing the focus on the core business [43, p.5] or to tarnish e.g. common working habits or workplace safety. The latter one could play a bigger role if companies with different safety guidelines cooperate.

Split incentives of lessors and tenants

Changing the working environment technically can also be hampered when rented buildings and structures come into play. High investments in rented property are much less attractive than in private property. Also the lessor can be spurning to physical changes of his or her property. Furthermore, according to Nagel [60], “[the] landlord normally has to pay for capital improvements (e.g. putting insulation in) but the tenant pays for operating expenses (e.g. electricity costs from heating). In this situation, neither party wins from efficiency projects. The landlord is reluctant to invest in structural improvements because the capital cost will be high and they don’t (sic!) feel the monthly pain from utility bills.” Nagel describes the situation for Australian businesses, but the problem is similar around the world. The barrier affects many companies, since it is very common to rent commercial premises. For example, in 2016 55% of commercial properties were the rented in the UK [61, p.10]. It is assumed that the situation is similar for other European countries. Furthermore, it is presumed that especially SMEs and retail companies rent their commercial properties, while large companies and industries tend to use their own premises. This assumption does not apply to all companies.

Lack of time and staff to deal with energy efficiency

Since in many companies the knowledge about possible positive (side) effects of energy cooperation is limited, it is a time intensive task to initiate changes. In most companies, especially in SMEs but also in larger companies, there is lack of time and (personnel) resources to work on topics, which are not directly connected to the core business [20, p.6]. Even if external help gets on board, the process is very time and cost intensive [44, p.4].

Generally, the responsibilities for energy topics may not be clearly defined within companies or industrial parks. This experience has also been made by Trianni et al. [39] when they surveyed various manufacturing companies. With regard to industrial parks this barrier depends also on regulations concerning e.g. the electricity and gas market.

Unknown effect on the surrounding area

There also can be uncertainties about possible effects on the local environment and neighbourhood such as the local population. The local population and community partially supply the companies with employees, so possible effects can alter the behaviour of workers. Possible effects could be: New industries occupying formerly green fields because of planned cooperation, changed public transport due to matched working times of multiple companies, shifted working times due to combined load profiles of cooperating companies etc. Such changes can be perceived positive or negative.
On the other hand, because energy efficiency measures usually have a direct or indirect positive effect on the environment, the consequences for the local environment and population are assumed to be positive most of the time.
4.2.2 Lack of Internal and External Relations (Trust)

The situation gets even more difficult when different companies shall merge their energy purchases or generation or plan to exchange materials and side products.

Coordination by an external institution

In this situation (but also in general for energy cooperation) an external coordinating and mediating institution without economic interests can be helpful. This role can be taken up by an independent institution, e.g. a public entity, a university or research organisation. The importance of such a facilitator or coordinating body has been shown in the Eco-Innovera survey before [6, pp.34–35] as well as by Mirata [5] and others [2, 62]. Coordination hereby reaches from local organizations responsible for one eco-industrial park or network, e.g. Infraserv Höchst [63] - which is the local park operator of the industrial park at Höchst, Germany but also a service provider for other industrial parks - up to national and international mediating bodies and networks like International Synergies, who are working on “information, support and systems to implement industrial symbiosis network(s) and other industrial ecology solutions at company, local, regional, national or international levels” [64].

A question which arises from a lack of trust or missing collaboration history is who the eventually newly built plants for joint energy production runs. Here, a third party can contribute as operator or to mediate in negotiations.

Such a facilitator can also be important in terms of data security and exchange. Companies may fear to share data about their internal processes, since there is the potential threat that competitors make use of them. In this case a neutral institution, which takes care of the data and prevents direct data exchange between the companies, can be helpful as well. (Big) data management is also a technical (see section Technical/Engineering Perspective) and a legal barrier (see section 4.3).

Distributed responsibilities and decisional power

Another aspect are split incentives of different departments of a company or further different actors involved. Depending on their responsibilities, they all focus on different aspects. Sorrell et al. define split incentives as follows:

“Energy efficiency opportunities are likely to be foregone if actors cannot appropriate the benefits of the investment. For example, if individual departments within an organization are not accountable for their energy use they will have no incentive to improve energy efficiency.” [20, viii]

The problem arises, when in different companies distinct management levels and departments are responsible for reporting and implementation of measures. For example in one company there might be a department for energy and resource procurement and another for operational energy use and efficiency. Additionally, the need to adjust contractual agreements with customers might also involve the legal or sales departments. As energy is concerned, also the

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7 For this example, the authors refer to two specific companies neighboring one of the parks involved in S-PARCS.
environmental department is to be involved. Departments’ responsibilities might differ as one is responsible for the site only and another is responsible for multiple/all sites. Some of the responsible persons can decide on their own while others need to report to their management. This creates the situation of information losses and split incentives inside one company, hampering constructive cooperation processes with others. This problem intensifies when subcontractors or affiliated firms of multinational companies shall be included into energy cooperation. The local executives of these firms may are not in the position to decide such far-reaching decisions such as symbiotic relations in energy matters with other companies on their own. This barrier has been described by Mirata for the Humber region industrial symbiosis programme [5].

In large companies the internal structure and distributed knowledge can complicate the transition towards a sustainable production even more, since information exchange may be limited, especially when it comes to topics that are not directly connected to the core business. If it comes to cooperation between companies, there is an even bigger lack of knowledge, since companies usually do not deal with the energy streams of their neighbours. Consequently potential collaboration pathways are unknown. Furthermore the particular interests of single departments or executives may contradict possible measures [43, p.4].

These problems can afford a change of the managerial structure of a company, which has far-reaching consequences. Companies may avoid organizational risks associated with these efforts (in the spirit of “Never change a running business”).

**Communication and good relationships**

To enable a successful collaboration, trust and good communication between the companies are an unalterable prerequisite [3, 6, p.17, 65].

Sometimes companies have a good relation ex-ante, e.g. when they were situated at the same site for a long time or had good business relations before. This can be a good starting point for energy cooperation, as continuous communication and persistence in the processing of complex interrelations of parameters is crucial.

If companies have shown no interest in each other before, it is more difficult, since there only be a vague idea how the companies could cooperate in energy topics. Even more important, representatives need to build up good relationships and find opportunities for communication.

The situation exacerbates if they are (possible) direct market competitors. In this case a very detailed and careful strategy has to be found. If the companies are part of different sectors there might be no market competition but also no knowledge of cooperation potential at all, since the production processes and workflows are unknown [3, 43, p.4].

**Fear of far-reaching dependences**

An essential threat for energy cooperation is that one or more participating enterprises modify their process or shut down the site due to relocation or bankruptcy. In this case, dependent on the kind of cooperation, the local energy system can be threatened, e.g. when the heat supply of another company is affected. Especially when the cooperation is created around an “anchor firm” (Gibbs [3, p.229]), the closure of this firm is disastrous to other participating companies.
Gibbs further explains that (over-)dependencies of companies may potentially fix them to one locality, which is good for the surrounding municipalities but could be something that leads to inertia and lacking further innovation within enterprises [3, p.229].

For such cases an independent coordinating body can be helpful. Such an institution can prepare backup plans and coordinate an orderly withdrawal of the leaving company, while preventing damage to the remaining ones.
4.3 Framework Perspective

Energy cooperation in the form of Industrial Symbiosis and Eco-Industrial Parks has been successfully implemented in different countries. [66] In Europe, the Roadmap for a Resource Efficient Europe recommends ‘Industrial Symbiosis’ to the European Union member states [67, p.6], taking reference to International Synergies Limited [64] and its National Industrial Symbiosis Programme (NSIP). Also, countries like China and South Korea have implemented eco-industrial programmes in the early 2000s [66]. Despite positive examples of energy cooperation projects in the EU and elsewhere, previous research effort in this area has shown that potentially beneficial projects are not realized, delayed or cancelled due to adverse framework conditions. In the following, we will be looking at these hindering factors and discuss relevant European Union law and legislation.

Technical and legislative regulatory frameworks as well as political decisions of different European Union Member States (MS) or regional governments are considered to be a significant barrier for successful energy cooperation and collaboration projects. This is either caused by missing regulatory frameworks, which causes a law-free bubble for companies, that would be technically, economically and socially capable of cooperation (i.e. in situations where there are no technical problems but economic ones like metering and billing energy) or due to obsolete frameworks, which hinder (or even forbid) energy cooperation where it would be possible and efficient [43, p.5, 44, p.4].

**Missing Legislative Regulatory Framework**

Inter-industrial energy cooperation is barely strengthened by policies up to now despite the recommendation of eco-industrial parks in various policies as mentioned above. The upcoming EU Winter Package emphasises self-production and consumption of energy, and also appreciates closed distribution networks. How much influence the Winter Package will have remains to be seen, especially since it is not enacted yet and since it takes time until all MS transpose it into national policies. Generally said, the legal complexity is very high for eco-industrial parks and energy (efficiency) cooperation between several companies, because many topics are addressed and regulations differ regionally, nationally and internationally.

**Discrepancies between legislation and policies**

In general there are discrepancies between local, regional, national and EU-wide legislations and policy goals, which create uncertainties and location-related disadvantages. Consequently there is also a lack of suitable subsidies and financial incentives, since the legal basis for joint energy projects is not given. There is the urgent need of developing normative and legislative standards, followed by international and national financial incentives as well as promotion [43, p.5, 44, p.4].

Unpredictable political decisions and short legislative periods might act as barriers as well. Companies cannot rely on political roadmaps only, since short legislative periods can lead to

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8 Especially the latter point was identified as crucial in the Austrian project Open Heat Grid which dealt with market, policy, regulatory and technical barriers for the different participating technologies of hybrid networks [42].
unpredictable political U-turns. Therefore, planning and investment security is not given, especially when a company relies on government-funding for their project, say for a technical measure with very high upfront investment costs, which the company cannot lift itself. Bardt and Schaefer [68] found that uncertainties in energy politics influence investments in Germany, Yi and Feiock [69] made similar observations for the USA.

In the following section a brief overview of EU legislation will be given on options for energy exchange and joint energy procurement in an industrial park. However, if such projects are implemented a detailed examination of the relevant national law is necessary after all.

4.3.1 Electricity – Legislative and regulatory perspective

Direct electricity exchange

With regard to the direct exchange of electricity between companies within the industrial park and the related possible barriers, the following section will cover both the “direct line” and the "closed distribution systems" within EU legislation. For a more detailed explanation and to illustrate the EU law requirements for direct lines, a brief overview of the Austrian and German assessments is given as example. Since Austria has not incorporated the possibility of closed distribution systems into national law, only selected German literature is consulted in this context. Finally, the exchange within existing public network will be briefly mentioned.

4.3.1.1 Direct line

The term direct ‘line’ was defined in Article 2 no. 12 Electricity Directive 1996 as a complementary electricity line to the interconnected system. An interconnected system means a number of transmission and distribution systems linked together by means of one or more interconnection lines. From these two definitions, it can be concluded that such a direct line is a parallel line to the public transmission and/or distribution system. It is not part of this public system. Thus, it does not only represent an additional line. Originally, it served to provide an alternative to the public system in the emerging energy market competition.

As a result the eligible customers were not only dependent on access to the monopolized network. In order to be supplied with electricity, they were also able to organize their electricity transport independently. [70, § 46, 13, 71, § 42, 1, 72, § 46, 14].

Since a direct line is not a network and is not used as such, there are various regulatory requirements. However, due to the liberalized market (which implies that any natural or legal person or registered partnership has a right of access to the system and that each extractor is

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9 On the other hand, a “small isolated network” and an “micro isolated system” are not discussed.
11 Art. 2 no. 11 Electricity Directive 1996.
free to choose his supplier) this original competitive advantage of the direct line may have faded now.

Today, energy market competition shall be fostered within the existing public grid, especially since the establishment of a dual system in the form of additional lines is associated with higher (economic) costs [72, § 46, 14, 73, § 9, 44, 74, 92ff]13. However, Article 21 Electricity Directive 1996 will not be discussed further here.

Now, according to Article 2 no. 15 Electricity Directive 200914 (as previously under Article 2 no. 15 Electricity Directive 200315), direct line means either an electricity line linking an isolated generation site with an isolated customer or an electricity line linking an electricity producer and an electricity supply undertaking to supply directly their own premises, subsidiaries and eligible customers. It is no longer necessary to add the adjective "eligible" when talking about customers, because all European end consumers have the right to freely choose their supplier and also to change it since July 1st, 2007.

The definition of terms includes two use cases [74, 92ff]16 which will be discussed in the following.

In the first alternative, the direct line represents a linking of an isolated generation site, i.e. a power plant, directly with an isolated customer. In this regard, at least in Austrian judicature and literature, it is argued that, because of the wording "isolated", neither the production site nor the referring customer may have a connection to the public electricity grid in addition to the direct line; it is a so-called an "island solution" [71, § 42, 3, 74, p.92, 75, p.124]17. This is justified by the origin of the Electricity Directive 2009: In the second draft, the terms "isolated production site" and "isolated customer" were proposed. According to K. Oberndorfer (also with regard to Article 2 no. 26 and 27 Electricity Directive 2009), this isolation implies a weak connection to the public system and therefore also a low practical relevance of the first alternative. On the other hand, according to German literature, it is irrelevant whether the public system exists or not [72, § 3, 76, 76, § 3, 56]18. The words "isolated" also suggest, according to the Austrian view, that a direct line in contrast to a network or a stub line, is only a combination of a single power plant with a single customer.

In contrast, the German literature does not want to limit the first alternative definition, despite the terms of the supply of a single customer. On the basis of a comparison with the definition of direct line in Art. 2 Z 18 Natural Gas Directive 2019, a limited number of individual customers should be able to be supplied via the direct line through the generating plant even in the

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13 Theobald, in: Danner/Theobald, EnWG Kommentar, Band 1, § 46 Rz. 4; Schneider/Theobald, Energiewirtschaft, § 9 Rz. 44.
18 Sajje, EnWG Kommentar, § 3 Rz. 56; Theobald, in: Danner/Theobald, EnWG Kommentar, Band 1, § 3 Rz. 76.
electricity sector [70, § 3, 25, 72, § 3, 77]\(^{19}\). Generally it is important that the direct lines do not get the character of a public network.

According to the **second alternative**, a direct line can also be used to connect an electricity producer and an electricity supply for the direct supply of their own premises, subsidiaries and customers. Since the construct is also not described in detail in the recitals of the Electricity Directive 2009, the question arises how exactly these two alternatives should be interpreted. Firstly, this phrase might be grammatically wrong. So it should be saying "[...] which connects an electricity producer and an electricity supply for the purpose of direct supply with its own operating sites, subsidiaries and approved customers." However, on the other hand the question arises whether both "and" in this phrase are to be read as "or". Thus, by virtue of the "and", it could mean that the electricity supply must be connected to a producer of electricity with the direct line at first. Then it is able to directly supply its own premises, the subsidiaries and also the customers. On the other hand, it also seems possible to read the "and" as "or", so that both the electricity producer and the electricity supply can independently supply their own premises, subsidiaries or customers via a direct line. Also if considering Article 34 para. 1 Electricity Directive 2009, the "or" makes more sense [71, § 42, 4]\(^{20}\). According to the Austrian and the German opinion (because of the non-existent word "isolated") it is argued that in this second alternative, all participants may have a connection to the public system in addition to the direct line [71, § 42, 5, 72, § 3, 76, 77, p.9]\(^{21}\). In contrast, according to the Austrian view [66, § 42, 5, 70, p.124, 73, 95f, 74, p.162]\(^{22}\), this is usually not the case for the direct line itself, (according to the new definition), since the direct line continues to exist in parallel, i.e. in addition to the public system.

Therefore it is compulsory that there is at least no direct (galvanic) connection of this line to the public system. A clear separation between this dual supply system is required. On the other hand, if integration into the public system happened, there would no longer be a direct line. Therefore, it must be ensured that there is no direct exchange of electricity on the way between the electricity producer or the electricity supplier to the recipient. This means that there must not be a mix of electricity from the direct line and electricity from the public system. As a result, the recipient withdraws from a direct line “for the purpose of direct supply” physically and economically the exact same electricity which the producer has previously fed in.

The consumer from a public power grid uses - figuratively speaking - a so-called "electricity lake", in which as much electricity is taken out as is fed in at all times. However, the electricity

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\(^{19}\) Hellermann, in: Britz/Hellermann/Hermes. EnWG Kommentar, § 3 Rz. 25; Theobald, in: Danner/Theobald, EnWG Kommentar. Band 1, § 3 Rz. 77.


\(^{21}\) VwGH 04.03.2008, 2007/05/0243, VwSlg 17397 A/2008; K. Oberndorfer, in: Hauer/Oberndorfer, ElWOG, § 42 Rz. 5; Rihs, Systemdienstleistungsentgeltpflichtig?, RdU 2010/3, 7, 9. Theobald, in: Danner/Theobald, EnWG Kommentar, Band 1, § 3 Rz. 76.

is not "identical". Since it is true that there is no connection between the direct line and the public system and thus not an immediate power exchange on the transport route, mixing within the customer's facility is very well permitted. Both parties need two meter points to measure the fed-in and taken electricity within the direct line separately. In Germany, however, this seems to be inconsistent: The point of origin of the supply via a direct line may also be the public distribution or transmission network [71, § 3, 56]23. This could make sense in the case where an electricity supplier that does not generate electricity wants to set up a direct line to supply its customers. For this electricity company it would probably be necessary to extract from the public system at some point. Others stipulate that direct line and public system coexist in parallel and are not interconnected [72, § 110, 40]24. Therefore, in both Member States a producer or electricity supplier may supply through the direct line its entire establishment, its subsidiaries and all customers (several recipients), especially since the construction of several direct lines is likely to be uneconomic. [65, §3, 78, 74, p.157]25.

Under Article 34 para. 1 Electricity Directive 2009 (formerly Article 22 Electricity Directive 2009), Member States shall take adequate measures to enable that all electricity producers and all electricity supplier can supply their own premises, subsidiaries and eligible customers via a direct line (lit. a) and all eligible customers can be supplied by a producer and a supply company via a direct line (lit. b). Article 34 para. 2 Electricity Directive 2009 states that the Member States lay down the criteria to get authorizations for the construction of direct lines within their territory.

Those criteria must be objective and non-discriminatory. With these requirements, the EU legislator obliges the individual Member States to establish not only the possibility but also the corresponding criteria for the construction and operation of direct lines. So that all customers can be supplied by producers26 or electricity supply companies via a direct line. This supply should be in addition to the supply via the public system. According to Oettinger27, "neither the number of eligible customers who can be supplied with electricity via a direct line, nor the number of direct lines a power plant operator can operate (...) are restricted by the Directive."

According to this non-binding statement, the scope of direct lines is very wide-ranging from a European Union perspective. Even if special regulation is laid down by each Member States, it can be assumed that the limit on the construction of direct lines is likely to be reached if they assume the character of a distribution system and thus of a parallel network structure [73, 244f]28. However, in this context, the EU legislator also gives the Member States the option to restrict the approval of direct lines: Therefore, Article 34 para. 5 Electricity Directive 2009 has to be

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23 Salje, EnWG Kommentar, § 3 Rz. 56.
24 Jacobshagen/Kachel, in: Danner/Theobald, EnWG Kommentar, Band 1, § 110 Rz. 40.
25 Pirstner-Ebner, Lieferungen über Direktleitungen, ZÖR 2016, 157, 163; Theobald, in: Danner/Theobald, EnWG Kommentar, Band 1, § 3 Rz. 78.
26 There must be no entrepreneurial connection between these two parties, Oettinger, Parlamentarische Anfrage hinsichtlich Konzessionsregeln für Direktleitungen bei Kleinwasserbetreibern, ABl. 2014/C 42 E/581.
27 Parlamentarische Anfrage hinsichtlich Konzessionsregeln für Direktleitungen bei Kleinwasserbetreibern, ABl. 2014/C 42 E/581.
28 P. Oberndorfer, Von zulässigen Direktleitungen, ZVG 2015, 238, 244 f.
watched in detail. Furthermore, terms to get an authorization must not obstruct the provisions of Article 3 Electricity Directive 2009. The refusal must be reasonably justified. In addition, the authorization to set up a direct line can be bound on either a dispute settlement procedure being carried out or network access (i.e. the use of existing public lines) is being refused by the network operator (Article 34 para. 4 Electricity Directive 2009). “This means that electricity generators and electricity suppliers may be required to use the local or national network of the designated network operator in their supply area to transport electricity to their customers, provided that the operator of that network provides the necessary capacity.” If the network operator does not provide the required capacity and denies access to the grid, the respective producers or electricity suppliers can set up a direct line. Therefore, it can be concluded that the operation of such a direct line should rather be the exception compared to the use of the existing public electricity system. However, the reasons for refusal referred to Article 34 para. 4 and para. 5 Electricity Directive 2009 do not necessarily have to be transposed into national law. Because of the 'can' this lies within the decision of the Member States, it would be necessary to examine the relevant rules of each Member State. In accordance with Article 34 para. 3 Electricity Directive 2009, in addition to the supply of electricity via a direct line, it is possible to conclude network access and electricity supply contracts for supply via the public system.

Conclusion:
The limits of the legal feasibility of such a direct line are on the one hand quite broad, but on the other hand also very restrictive. So it is conceivable that a company within an industrial park installs a power plant and subsequently sells this electricity to the other companies and thus supplies the customers "directly", but this approach also afflicts some uncertainties or barriers: These could be, for example:

- It is true that the producer or supplier and manager of the direct line does not become a network operator, but an electricity company, which is likely to be more burdensome and therefore a barrier.
- Article 34 para. 2 Electricity Directive 2009 leaves the design of the criteria for the construction of direct lines to the individual Member States, so that no general statement can be made here. For example, Electricity Directive 2009 does not provide any information
  - whether and to what extent a connection of the direct line to the public distribution system may exist,
  - how many customers can actually be supplied via a direct line,
  - how many direct lines a producer in an industrial area can actually build and operate, or
  - whether foreign or public cause may be claimed in connection with the transfer of such a direct line.

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29 Public service obligations and customer protection.
30 Oettinger, Parlamentarische Anfrage hinsichtlich Konzessionsregeln für Direktleitungen bei Kleinwasserbetreibern, ABl. 2014/C 42 E/581.
• Article 34 para. 4 and para. 5 Electricity Directive 2009 also leaves individual Member States free to set up and operate a direct line, e.g. of refusal of access to the network or the outcome of a dispute settlement procedure. If a Member State makes use of this option, it will probably make the proposed project virtually impossible.
• It is therefore necessary to take an overall view of each individual case, taking into account the relevant national legal provisions.

4.3.1.2 Closed distribution systems

In addition to the direct line, the Electricity Directive 2009 also regulates the so-called closed distribution systems. Although there is no legal definition, there is a provision in Article 28 para. 1 Electricity Directive 2009. The EU legislator then leaves it up to individual Member States (“may”) to allow a system to be classified as a closed distribution system by the competent national (regulatory) authority. This system would distribute electricity either in a geographically confined industrial, commercial area or in an area where services are shared. It should be noted, however, that apart from a few exceptions, no household customers can be supplied via this closed distribution network. Unlike a direct line, a closed distribution system is a public distribution network sub-station, which is not intended to serve all, but only a defined group for supply. Therefore, the operator of this system is also exempted from some obligations [65, §110, 5, 75, p.94]. However, not excluded, is the granting of free network access and the associated free choice of supplier based on a judgment of the ECJ. This means that every user within a closed distribution system is allowed to choose his own supplier. If the regulatory authority does not classify this network as a closed distribution system, it is a “normal” public system, which must be open to all final consumers and whose operator has to fulfill all regulatory obligations. To this end, the requirements of Article 28 Electricity Directive 2009 are exclusively directed to operators of such a privileged distribution system.

At first, this network would have to distribute electricity either to an industrial or commercial area or to an area where services are shared. An industrial or commercial area already exists on the basis of the wording if it serves mainly industrial or commercial use [78, p.3]. In an area where services are shared, this goes beyond sharing public infrastructures such as roads [70, §110, 18]. This also includes the use of certain services, infrastructures or integrated facilities. Airports, hospitals, train stations and large campsites, but also chemical industry sites may serve as an example [72, §110, 18]. In both of these areas, a recognizable geographical boundary like a certain spatially closed unit needs to be present [72, §110, 43]. Although the individual plots in this geographically limited area do not necessarily have direct contact with each other or belong to the same owners. Public roads that lead through this area

31 BT-Drucks. 17/6072, S. 94; Jacobshagen/Kachel, in: Danner/Theobald, EnWG Kommentar, Band 1, § 110 Rz. 5.
32 ECJ 22.05.2008, C-439/06 – citiworks.
33 BNetzA/Regulierungsbehörden der Länder, Positionspapier, S. 3.
34 Bourwiege, in: Britz/Hellermann/Hermes, EnWG Kommentar, § 110 Rz. 18.
35 Recital 30 Electricity Directive 2009; Jacobshagen/Kachel, in: Danner/Theobald, EnWG Kommentar, Band 1, § 110 Rz. 42 m.w.N.
36 Jacobshagen/Kachel, in: Danner/Theobald, EnWG Kommentar, Band 1, § 110 Rz. 43 m.w.N.
are not necessarily a hindrance, but connection of companies only through the electricity network is not enough [70, § 110, 19, 78, p.3]. Finally, it must be noted that through this closed distribution network no household customers, i.e. users who buy electricity for purely private purposes, may be supplied. However, Article 28 para. 4 Electricity Directive 2009 provides an exception for a small number of household customers, who have to have something like an employment relationship or a comparable (dependency) relationship with the network operator. There is no specification which number of household customers may be fine in order to qualify for the derogation. In Germany, the upper limit is 20 households (at least from the view of the regulatory authorities) [76, 4, 13f].

If the above-mentioned basic requirements are fulfilled, the system can be classified as a closed distribution system, whereby further specifications must be observed. For example, according to Article 28 para. 1 lit. a Electricity Directive 2009, the activities or production processes of the users must be linked, either for specific technical or safety reasons. From a technical point of view, this may be given if users of the network operate connected production processes that technically build up on each other [70, § 110, 24, 78, p.11]. Due to the special nature of business operations this may work like a ‘value chain’ between suppliers and customers [78, p.11]. For example, the German regulatory authorities designate the procedure whereby a respective company produces a chemical substance or an industrial product that is then further processed in another company or that one manufacturing company uses the waste heat from another company [78, p.11]. An alternative safety-related issue may be required if the users have similar special requirements regarding the technical quality of this network, which a public system cannot fulfill (e.g. emergency power supply, black start capability, common network control room or similar) [78]. However, if individual companies (such as a canteen) do not require any of these links, this does not preclude their classification as a closed distribution system [78, p.12]. Due to the wording, it is not enough to have a purely economic link or merely a central supply with electricity of the individual companies [70, §110, 24].

In addition, Article 28 para. 1 lit. b Electricity Directive 2009 also provides the possibility of self-supply if electricity is distributed only to the network company itself via this closed distribution system. However, this should not be addressed here.

If the network is classified as a closed distribution system, each Member States may decide on its own whether the respective regulatory authority exempts the operator of that system from the obligations under Article 25 para. 5 Electricity Directive 2009, namely the procurement of energy to cover energy losses and spare capacity (Article 28 para. 2 lit. a...
Electricity Directive 2009) as well as the obligation to approve the tariffs or the method for calculating those tariffs acc. to Article 32 para. 1 EItRL 2009 (Art. 28 para. 2 lit. b Electricity Directive 2009).\textsuperscript{45} Because of using the system, the network charges are to be paid. The exemption from certain obligations should reduce the administrative burden (compared to the operation of a traditional public distribution network).\textsuperscript{46} However, as already mentioned no exceptions for network access or unbundling requirements exist. Therefore, it could be problematic if the operator of the closed distribution system wants to provide users with self-generated electricity or centrally purchased electricity. In this respect, it matters if the respective Member State has made use of Article 26 para. 4 Electricity Directive 2009. This paragraph would give the possibility that vertically integrated electricity companies\textsuperscript{47} do not need to unbundle if their network supplies less than 100,000 customers. In general, when analyzing whether the conditions mentioned above are given in the respective area it is necessary to take into account the overall concept as well as the relevant national legal provisions.

Table 2: Overview of main characteristics of direct lines and closed distribution networks

<table>
<thead>
<tr>
<th>Direct line</th>
<th>Closed distribution network</th>
</tr>
</thead>
<tbody>
<tr>
<td>The direct line must be implemented by the Member States as a matter of principle</td>
<td>The implementation of EU legislation on closed distribution networks is at the discretion of the individual Member States (e.g. implemented by Germany, not by Austria)</td>
</tr>
<tr>
<td>The Member States have the discretion as to how it is to be implemented.</td>
<td>The closed distribution networks, however have a network’s character, but they are not open for supply purposes to everyone.</td>
</tr>
<tr>
<td>The direct lines exist in parallel to the public network, however, they do not have the character of a network themselves</td>
<td>Requirements are:</td>
</tr>
<tr>
<td>Households can also be supplied as a customer with the generated power via a direct line.</td>
<td>o a geographical limit and moreover</td>
</tr>
<tr>
<td></td>
<td>o Industrial or commercial use or</td>
</tr>
<tr>
<td></td>
<td>o a sharing of services (infrastructure, services)</td>
</tr>
<tr>
<td></td>
<td>▪ connected users must be linked with each other for specific technical or safety reasons,</td>
</tr>
<tr>
<td></td>
<td>▪ basically no supply of household customers possible</td>
</tr>
<tr>
<td></td>
<td>▪ classification as a closed distribution network by the regulatory authority</td>
</tr>
</tbody>
</table>

\textsuperscript{45} However, Article 28 para. 3 Electricity Directive 2009 provides for the possibility of subsequent review and approval at the request of a user.

\textsuperscript{46} Recital 30 Electricity Directive 2009.

\textsuperscript{47} such would arise if distribution in combination with the generation and / or distribution of electrical energy is offered.
Conclusion:
The limits of legal feasibility of such a closed distribution system are very strict. However, there is the possibility that the corresponding geographical limit is met within the respective industrial plant. Successive activities of the individual companies, like in the form of a value chain, are quite common in an industrial or chemical park. The same applies to special protection systems connected with the power supply. However, it is always necessary to analyze each individual case, as it is up to individual Member States to legally integrate the possibility of closed distribution systems. This would also go along with the clarification of certain uncertainties due to the provisions of EU law. This includes, among others:

- What exactly is meant by a small number of household customers?
- When does the presence of companies that do not have a concrete (safety) technical link (for example, canteen) hamper privileges?

4.3.1.3 Using the public system

In addition to the supply of electricity via a direct line or a closed distribution system, it could also be considered to manage supply through the existing public system. In such a scenario the company generating electricity could feed it into the public grid. Subsequently, as a supplier it may supply other settled industries. Another option is that individual companies could bundle together and buy electricity (for example through a joint purchasing company) on the open market in order to achieve more favorable electricity prices.

Joint electricity purchase

Joint electricity purchase or generation is limited by different fixed costs of power supply, which are caused by different supply voltages and different electricity demands [79]. Merging various consumers and establishing one contract, demands a changed calculation of fixed costs. Another problem arises when different safety standards are in use because of different voltage and current levels, as has been shortly mentioned above. At the moment such mixed networks are not envisaged of norms and regulations. Since security at the work place is a very delicate and important topic, companies will not take the risk to implement measures if they are not legally secured.

Another problem are existing tax structures such as depreciation periods. If several companies make use of the same energy network and have all partially paid for installations and joint contracts, the calculation of separate taxes and depreciation periods becomes complicated depending on national regulations. Energy taxes on diverse energy carriers, such as gas, oil, electricity etc., have to be harmonized within a local hybrid system. This allows a fair distribution of costs and transparency.

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48 without necessarily generating electricity themselves in the industrial park
4.3.2 Gas Sector

4.3.2.1 Direct line

As in the Electricity Directive 2009, the direct line is also defined in the current Gas Directive 2009\(^49\) (Article 2 no. 18) as a natural gas pipeline complementary to the interconnected system. According to Article 2 no. 16 of the Gas Directive 2009, an interconnected system is to be understood as a number of systems which are linked with each other. According to these specifications the direct line is a separate line next to the public natural gas system.

Further regulation can be found in Article 38 Gas Directive 2009 and is largely identical to the one in Art. 34 Electricity Directive 2009 (with the exception of Article 34 para. 3 and 5 Electricity Directive 2009, which are not integrated in the gas sector). At this point we refer to the statements mentioned above (regarding the direct line in the electricity sector).

4.3.2.2 Closed distribution systems

The requirements for closed distribution networks in Art. 28 Gas Directive 2009 and recital 28 are also almost identical to those from the electricity sector, so that here we refer again to the statements mentioned above.

4.3.3 Heat – Framework for DHN and WHE

District Heating Sector

In the DHN sector is not regulated, but individual frameworks depending on the local requirements and conditions are in place. Usually the participation of industrial waste heat producers is not regulated by these frameworks, which makes it necessary to develop contracts and conditions for each new case individually. If general technical frameworks can be established depends on the requirements of the industry, while it is also likely that the various requirements and heat sources in industrial parks complicate the process.

Trade Law, Building Law, Environmental Law

In the following, a few selected aspects, i.e. from the areas of commercial, building and environmental law, which are to be considered in the planning and implementation of heat pipelines in the industrial park.

Depending on the local development and spatial planning, various tests and permits must be obtained for the construction of waste heat pipes, temporary storage tanks and transfer stations.

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With spatial planning and the building plans based on it, municipalities can set guidelines for land use. Under certain circumstances, there may be hurdles for the construction of pipes in the spatial planning.

Building permits may be required for the heat pipe construction on the company premises, on the premises of the customer and on public land.

The Environmental Impact Assessment describes the direct and indirect effects of a project on the environment. Such tests must - unless the entire industrial park requires an EIA - be in accordance with. Art. 4 para. 1 Directive 2011/92 / EU for thermal power stations and other incinerators with a heat output of at least 300 MW. In many countries, it is also necessary for heat storage above a certain size and for district heating pipes. Depending on which substances are used as transport or storage medium, the corresponding environmental regulations must be observed. For example, in accordance with water law the use of water-polluting substances must be prevented against the danger of a possible escape of the media.

Within cross-plant heat exchange i.e. legal provisions for pipelines as well as legal operational plant requirements are to be fulfilled. Depending on whether it is a steam or thermal oil line or a line with ionic liquids, the relevant safety regulations must be adhered to.

If a heat transfer pipe is laid over third party-owned land, it is important to consider whether it is crossing private or public land.

**Heat pipe crossing private land**

For example, in Austria, it should be borne in mind that without anchoring the heat line right as a servitude in the Register of Deeds, a new purchaser of a property must not tolerate the existence of the heat line. Accordingly, the district heating company would have to lay the heat line at its own expense. There is no compulsory justification of heat line rights, unless the heat line was grounded as a service/servitude. By concluding a service order for a supply line in Austria, the right for the servitude is entered in the C-sheet of the Register of Deeds (load sheet). For this, a concrete plan of the course of the pipeline on the property must be available. In case of a possible renovation of the house, the district heating company basically has no obligation to relocate the heat line. The deletion of the service from the Register of Deeds is only possible with the consent of the beneficiary.


52 Access line is only considered if property owner is connected
Heat pipe crossing public land

In order to be able to transport heat to neighboring companies, public grounds usually have to be crossed. For this purpose, it is necessary to conclude contracts for trespass rights with the public owners. Contracts for trespass rights are private-law contracts. The municipality gives the right to the company to use its infrastructure to build heat lines. For example, contracts with trespass rights for DH pipelines are referred to be a licensing agreements ("Gestattungsvertrag") in Germany. This clarifies linguistically that the legal framework differs significantly from the legal framework applicable to electricity supply and gas networks\(^53\).

By contrast, the term "concession contract" ("Konzessionsvertrag") is mainly used in Germany for these contracts with trespass rights. According to the German Federal Cartel Office in Germany, contracts with trespass rights that grant a DH utility the exclusive right to set up DH pipes in one municipality violate the cartel ban [80, p.113].

Since the municipality owns the local road network, it holds a monopoly right. Therefore the municipality must not abuse this position. Accordingly, the German Federal Cartel Office stated that in principle there is a right against the municipality to grant a right of way. The "allowance", which can be demanded by the municipality, can basically be freely designed or negotiated between the municipality and the company. [80, 112ff].

Feed-in or transit to DH network

In the current situation, the DH network operator is like a price-regulated monopoly to the local DH end-user. That is why the DH network operator is usually the only DH supplier with significant customer access. For an industry with waste heat potentials, the construction of its own DH network is therefore not lucrative and negotiations are required with the DH network operator. The latter has thus a strong negotiating position due to its position as sole option for feed-in. The contracting parties are free to make provisions regarding backup capacities, load and generation profiles, entry points, temperatures, etc.

Depending on the overall contract design (i.e. defining the partner who bears the costs of the components of the waste heat feed-in as well as the definition of feed-in profiles, backup capacities, etc.) between the industry and the DH network operator, the use of waste heat must prove to be economically more favourable for the DH network operator than using its own generation units.

Unlike the electricity and gas network, there is basically no feed-in or transit claim to the DH network for third parties. In this cycle system water or steam cannot easily be fed-in. Special technical requirements are necessary. This mainly means high technical effort, which is caused by the inhomogeneous equipment. Under certain circumstances, a feed-in claim can be derived for antitrust reasons (if there is a particular environmental advantage and no or minor burden for the line operator).

First of all, it is necessary to clarify whether the operator of the respective geographically limited DH network has a dominant market position according to antitrust law. If there already a DH network exists in a certain area, there is usually only one, which is run by a single operator.

\(^{53}\) Vgl. § 46 Abs. 2 EnWG
Unlike the electricity and gas networks, DH networks are not interconnected supra-regionally. The operator is a vertically integrated company that not only operates the DH network, but also generates heat and delivers it to consumers. Consequently, in the absence of competition, this operator is a monopolist holding a dominant position in its network operation, especially as the creation of competition through the establishment of parallel DH networks would be economically questionable. This dominant position will most likely be maintained by long-term supply contracts.

For the DH market, there are no special provisions that go beyond the general civil provisions (Civil Code, Consumer Protection Act etc.), which would prohibit or limit long contract periods. Consequently, as the operator of a local DH network has a dominant position, the question arises whether he can be compelled to grant third parties access to his network for the purpose of supply. There may be an obligation to contract resulting from antitrust law if one party has enough power to determine the decision of others, so in particular when holding a monopoly position. If the conclusion of the contract is reasonable, the owner of a monopoly position must have a good objective reason for refusing to conclude a contract. The DH network operator as a monopolist could be obliged to allow the feed-in of third parties, since according to antitrust law the abuse of a dominant position is prohibited.

However, it must be taken into account that antitrust law can only be applied if someone wants to act as a competitor to the DH network operator on the upstream or downstream market. That means, i.e. if the third party heat generator seeks to supply other consumers with its generated heat. However, due to the lack of other options to feed-in and transport the heat, the use of the existing DH network is necessary to act as competitor on the market. In any case, the heat generator is an actor in the upstream or downstream market and thus a market participant. The DH network operator is to be regarded as a dominant company with regard to the integration of heat sources, since the potential heat generator that wants to feed-in usually has no other possibility to sell his heat.

The network operator is only obliged to open its network to other market participants, if that is factually possible. [81, p.279]

The inclusion of public interests, such as environmental protection, security of supply, etc., is difficult to being argued in the view of antitrust law. Parts of German literature see this differently and include public 'interests, such as nature conservation, in the antitrust review [80, 94ff]). However, antitrust law addresses business-related and thus business-relevant behaviour, and according to this principle, the inclusion of public interests in antitrust investigations is precluded [82, p.330]

That is why technical and economic reasons regarding the impossibility or unreasonableness of the feed-in of third parties are examined below.

Impossibility of feeding-in

The technical possibilities are considered differently in the literature. One part of the literature [81, p.280] considers the connection of the third party heat generators to an existing DH network operator or directly to the consumer.

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54 Two options: third party heat generator is selling to the DH network operator or directly to the consumer
network as technically possible if the necessary financial effort is done. Different feed-in temperatures as well as missing capacities do not represent a reason for a technical impossibility. The network operator is to be expected to reduce its own use or to raise capacity by efficiency increase.

Another part of the literature [83, p.19, 84, p.376] sees the technical impossibility as given when the third party heat generator wants to feed in a pressure, temperature or aggregate state, which does not correspond to the condition of the conduit pipe of the DH network. It may also be “impossible” if the access to the DH networks is not technically possible at the desired local site. In terms of lack of capacity, there is a technical impossibility if all objectively available capacity has already been allocated to third parties in order to supply their own customers and if capacity cannot easily be expanded. [84, p.376]. In the DH sector an increase in efficiency is not possible simply by temperature monitoring or anything similar. Usually network extension is necessary, which often fails due to lack of space or high investment costs. [83, p.21]

Due to the strong necessary conjunction of the heat generation and the DH network, technical impossibility for the operator may also be given if the third party heat cannot go along with the heat already in the network - because of different pressure, temperature or physical state. Impossibility is given if this obstacle cannot be overcome with an economically feasible effort. [83, p.15, 84, p.372] Geographical limitations and the lack of space for a further expansion of the DH pipes also lead to technical impossibility. However, this decision on the technical possibility must be considered individually for each DH network and must be decided on a case-by-case basis.

With the necessary financial effort, a technical impossibility can be solved in many cases and then a lack of technical possibility is difficult to be argued. In any case, the effort that is necessary for the implementation of technical solutions to grant access must be assessed. This effort is to be included in the economic possibility and subsequently the reasonableness of these changes for the DH network operator are to be evaluated [83, p.21]

**Unreasonableness of the feed-in**

It should also be taken into account that the DH network operator, who also acts as a supplier for his own customers, must secure his long-term relationship and for that very reason has already created the corresponding generation capacities itself. Due to the closed heat cycle, the additional heat would mean that the own generation of the DH network operator would have to be throttled in order to balance out the total quantity. Other conceivable reasons of unreasonableness would be, for example, the amortization interest [81, p.283] (elimination of customers limited calculated revenues, endangering the profitability of the supply), a possible threat to the supply of the own customers through the opening of the DH network or even ecological reasons. [85, p.234] For the DH network operator, the high entrepreneurial risks as well as the high investment costs in the local DH network have to be taken into account. This justifies an interest of the DH network operator in the amortization, which requires long contract periods as well as reliable pricing. [84]

Such long-term contracts, which may use all available DH network capacity, will help the operator to maintain its dominant position, but also to create incentives to invest in the service. It is not reasonable for the DH network operator to terminate these long-term contracts in order
to free capacities needed by the competitor. Thus, only the amount of remaining capacity in the DH network is free for third party requests. However, the long-term supply contracts protect the operator’s interests only with existing customers, but not with new customers or with expired contractual relationships. Due to the strong connection between heat generation and the DH network, it is also unreasonable for the DH network operator to throttle its own generating plants for the purpose of “heat transit” by third parties. It is also not reasonable for the operator having the sudden need to buy heat from elsewhere because of an unexpected missing or reduced heat feed-in by the third party (e.g. production downtime). The reason that the operator would incur massive customer losses as a result of a new entrant is not an objectively justified reason for excluding the feed-in request, as this would be contrary to the very purpose of the law.

In addition, due to further feed-in from third parties, efficient DH network control and system operation could be required – that would also be a justified reason for the refusal of network access.

Heat generation systems, which cannot produce regularly, may not cover the entire heat demand of the customer. This would mean that the DH network operator or another third party would need to provide backup, meaning that the operator has another “additional” DH network user. However, it is not reasonable for the DH network operator to reserve capacity for third parties or to buy missing heat.

At this point, it can be assumed that it is not per se economically feasible for the DH network operator to provide reserve capacity.

The DH network operator could also be obliged to take heat from third party heat generators for ecological reasons. De lege lata, however, this is not justifiable because the network operator would be limited in his freedom of access and freedom of occupation without sufficient substantive justification. It should be noted that the network operator has a legitimate interest in ensuring the supply of heat to his customers or to choose his own third party.[85, p.234]

Due to frequently lacking technical and economic reasonability, a claim of the heat generator according to antitrust law on the feed-in or transit of generated heat (for a fee) into an existing DH network is likely to fail due to existing justification reasons.

Since there is no legal claim in the heat sector to access the network, private-contractual agreements between the heat generator and the DH network operator are possible. Those agreements regulate the purchase of heat generated by third parties if this is technically feasible (among others with regard to pressure and temperature). However, due to missing regulation, the DH network operator does not have to get involved in this. Because of the policy of freedom of contract, the DH network operator can decide on its own from whom he buys heat and under what conditions he does so.

Therefore, it is usually the best alternative, to talk and discuss terms with the network operator and try to reach a private agreement for selling the waste heat to it.
For this purpose, the Commission's proposal for the recast of the Renewable Energy Directive would have provided specific regulations. In the Commission's original proposal DH networks operators would have been obliged to feed-in third-party heat from renewable sources into their network.

However, in contrast to the Commission's original proposal, the European Parliament has now changed the conditions. Feed-in now only has to happen if it is technically and economically feasible for the district heating network. According to Art. 24 para. 5 leg. cit. an operator of a district heating or cooling system may refuse access to suppliers where the system lacks the necessary capacity due to other supplies of waste heat or cold, of heat or cold from renewable energy sources or of heat or cold produced by high-efficiency cogeneration.

Thus, the realization of the feed-in of industrial waste heat into the existing DH network has to result in a positive present value for the two actors (this includes the possibility of one actor compensating the other). In contrast to electricity networks, for example, which have to fulfill certain technical conditions (voltage, frequency), DH networks differ from network to network - but there are also differences within the network in terms of pressure, temperatures, capacities, etc. Thus, there need to be negotiation about different, interrelated parameters. Negotiating the determination of one parameter automatically influences the others. This often leads to a high complexity, resulting in frustration and perplexity of the negotiators and, finally, in a stop of negotiations.

**Security of supply**

The public law system currently does not specifically regulate the security of supply of district heating networks. Guaranteeing the security of supply results in any case on the basis of contractual obligations or economic self-interest of the heating network operator.

**External waste heat utilization – private agreement**

When a company cannot make use of its waste heat internally, it is obvious to generate indirect energy savings and financial profit by injecting the heat into a DH network or delivering it directly to a large customer, e.g. another company within an industrial park. At this point problems arise, since there has to be a contractual framework established. Metering, energy prices and load profiles have to be thought of. Additionally there are no norms, which regulate how heat as an energy carrier is defined. There are no regulations about pressure and temperature levels, heat amounts are usually calculated via temperature differences. In case of direct heat exchange between companies there are no regulations, e.g. as mentioned before there is no legal claim for building heat pipe lines over private ground. The legal status of the participating companies is unclear as well as the declaration of waste heat as green or

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conventional energy, depending on the initial energy source, which has impact on the emission trading market [42, pp.8–9].

The classic business model of the "cross-border" exchange of heat is the conventional district heating. The network operator (and often the heat generator) is a company outside the regulated area. In conventional DH, the investment is primarily refinanced by the amount of energy supplied. Therefore also other parameters, mainly an initial connection fee, are also taken into account. Compared to the Electricity Market Directive or the Gas Directive for the energy sources of electricity or gas, a private contract is the basis for heat supply. This reflects due to the absence of relevant regulations.

DH contracts represent the situation in which the provider positions itself with relatively clear specifications to a large number of customers. However, the transfer of operational heat in the form of steam or water at different temperature levels requires a more specific regulation which takes into account each individual case:

- When it comes to the cross-company exchange of energy, especially with regional business settlements, significantly very low - usually only two - players act in the game.
- The heat-generator may be an operation that generates a certain heat quality and quantity in the interests of both (the generator and the consumer). But most of the time it will be waste heat, which is at a sufficiently high temperature level for the second operation.

Heat is not subject to any regulation or relevant laws. This results in a far-reaching freedom of contracting between the operational partners and any third parties (contractors).

**Heat supply contract**

Since there are hardly any legal regulations for the field of waste heat, detailed regulations in the private law contract between the individual parties are very important. Here are some important points that may lead to problems and disputes if the contract is not properly regulated.

From a legal point of view, a commercial heat supply is district heating. The delivered quantity or transport distance is irrelevant for this assignment. The basis for the heat supply is usually a heat supply contract. Contractual partners are on the one hand the heat supplier and heat network operator and on the other hand the heat consumer. The resulting legal framework offers legal certainty for the use of waste heat, but also some hurdles, which should be considered in the project planning.

With a long-term purchase agreement risks can be minimized. At the same time, consumer protection law often sets limits for the duration of the contract. That is because consumers should be regularly enabled to switch to cheaper competitors. Therefore, usual contract terms

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57 Which also applies in individual cases to contracts between two entrepreneurs of different strengths.
last around 10 years. If longer supply times are agreed, there is a risk of the contract being invalid.

To this end, the Commission’s proposal for the recast of the Renewable Energy Directive\textsuperscript{58} would have provided specified provisions.

However, in contrast to the original proposal of the European Commission, the originally proposed right of end customers to deregister from "inefficient" district heating networks has been changed. Deregistration is now only possible if the district heating operator does not invest within 5 years to increase efficiency.\textsuperscript{59}

If the construction of the heat line or of the transfer station shall be built on the customer’s property, the corresponding approvals must be obtained in the contracts. This also includes any repayment obligations after expiry of the contracts.

A supply guarantee and liability for supply failure should be noted. This warranty can be used to define when the company is actually liable. For example, defects caused by force majeure can be excluded. In addition, regular maintenance intervals can be arranged in which the supply is interrupted or replacement heat is provided.

For the construction, operation and maintenance of the heating network, access rights should be guaranteed. This is mainly necessary if the transfer point is not within the boundary of the customer’s property.

If waste heat is used for heating up a company’s own but rented premises, the connection costs may possibly be allocated to the renting parties. The possibilities must be examined individually from the perspective of law of tenancy.

If the original consumer wants to (re)sell the received heat to third parties, such as to other companies in the Industrial Park, the (original) supplying company also has rights and obligations against the third party. The contract should therefore specify the permissible scope for forwarding the heat.

In the event of a default, an accurate approach should be agreed on; especially if the waste heat is supplied for critical processes. A price change clause which is to be exactly determined may allow a price adjustment in the event of changes in the economic environment.

However, these are only a few points which may be taken into account when drawing up a heat supply contract, but paying attention is important.

4.3.4 Other Framework Barriers

**Big Data Management – Privacy problems arise**

When establishing a hybrid energy network with various participants, such as in an industrial park, collection of various data sets is needed, to ensure a trouble-free operation of the


network. Therefore not only a complex EDP infrastructure is needed, which is a technical barrier, but also data management, processing and backup have to be clarified. Legally seen, big data management is very complex as well.

Compliance for business with data regulation and privacy concerns is now a huge issue. It must be ensured compliance with privacy law, data security, confidentiality and data protection for each organisation, customers and employees.

This is a rapidly changing area as new technological developments become current and are overtaken by others. Big data requires a significantly greater level of compliance for companies and where businesses are using large scale analytics. Security of data is essential.

Specific solutions to ensure compliance with obligations through this technical process are to be identified.

The new EU General Data Protection Regulation (EU GDPR)\(^{60}\) substantiates and extends the previous requirements of the Data Protection Directive 95/46/EC\(^{61}\). Companies and organizations that collect or process personal data must prove that their activities comply with the regulation. This shall be done with a comprehensible data protection concept. The EU-GDPR brings changes in the areas of legal bases, dealing with data subjects' rights, documentation requirements, IT security, outsourcing, employment data and liability. Infringements are subject to severe fines, which in extreme cases can go up to € 20 million or up to four percent of global annual turnover.

With the new EU GDPR, a comprehensive data protection concept is indispensable. The associated requirements are manifold. Although the term 'management system' does not explicitly fall within the scope of the Regulation, a comprehensive and systematic data protection management system is necessary due to the sanctioning and liability risks associated with its implementation. That is the only way to implement the accountability or accountability required by the regulation. Furthermore, it also helps to detect possible violations in advance and avoid them.

However, how should an industrial park meet the requirements of the new EU GDPR? At the beginning an inventory is inalienable. Among other things, the following questions have to be clarified:

- In which processes is personal data processed? Is there existing documentation for this?
- What are the respective underlying legal bases (law, regulation or actual consent)?
- How is the protection of personal data currently organized? Are there any precautions or measures?
- Are there any data processing contracts with service providers?
- What documentation has been available so far? Are there directories, prior checks, IT

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\(^{60}\) Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).

\(^{61}\) Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data.
security concepts and so on?

- Are there rules in the company agreements for dealing with the employee's data?

In order to identify the need for action, aspects such as legal bases, data subjects' rights, documentation obligations, reporting obligations and data security must be included. Additionally for the implementation of the claims, i.a. the adaptation of processes, the implementation of information requirements, the creation of concepts for deletion and much more is required. In order to keep track, all data protection-relevant activities should be brought into a transparent structure at first. This can hardly be done without a suitable software solution for mapping electronic management systems.

This is of course an extensive task, but is more than important to ensure compliance with data protection law.

**Funding and Subsidy “Jungle”**

One important barrier is the complexity of regional, national and international funding and subsidy schemes with their various conditions, maturities, exemptions etc. If you do not treat these issues in your day-to-day business, as most companies do, because it is not their core business, it is no surprise that they are overwhelmed by the topic. [44] It is therefore quite possible that companies are quickly frustrated, especially if they try to deal with the issue of energy efficiency without professional support. In case the right funding scheme has been identified, in some cases the application process itself can be very effortful and time consuming, which can be seen as another barrier. In case of several companies cooperating and therefore applying jointly, the whole process gets even more complex and protracted.
4.4 Technical/Engineering Perspective

Economic and legal barriers are key aspects for industrial firms as they hamper the advancement of adopting energy technologies and the realisation of energy cooperation among enterprises. However, technical/technological and engineering barriers also play an essential role, especially for the first and the final decision to implement energy technologies or energy cooperation [87, p.1446]. Therefore, this chapter deals with identified technical barriers, which are clustered in four groups: technical information, technical performance, energy management systems and infrastructure.

Note that it is not always possible to strictly classify a barrier. Overlaps to other categories are unavoidable due to the interdisciplinary character of many barriers.

4.4.1 Information and knowhow on new energy technologies

The clustered barrier technical information deals with hindrances related to the innovative character of a technology, service or energy cooperation. Since in many cases expertise and experience are rarely available yet, various barriers concerning the future utilisation of technologies and energy cooperation services appear.

Note that some of the barriers identified are also described in sections 4.2 and 4.5 from the social/organisational and informational perspectives.

Knowledge of and access to technology

Up-to-date information of the state of development and standardised benchmarks of established technologies and energy cooperation services would lead to multiple adoption of energy efficient equipment and cooperation services by other firms and therefore to reduced energy consumption in general. Sharing information of established technologies or best practices between companies is rarely established as they otherwise lose their strategic advantage against competitors. Inadequate information and communication can lead to lost opportunities for cooperation. In the worst case, efficient technologies and potential energy cooperation services are driven from the market and inefficient technologies and cooperation services are still used as state of the art [20, p.6, 88, p.3667, 89, p.1303].

In some instances, intellectual property protection is an obstacle for sharing technology relevant information too. The access to patents or the licensing of technologies takes time and investment. In addition, an expert in the field of patent issues maybe is required [90, p.198].

Low adoption rate and lack of technical knowledge

The adoption rate of new energy efficient technologies and mutual energy services is usually slow [53, 91]. Most companies are waiting before investing in new technologies or agreeing in an energy cooperation unless other firms have successfully adopted it and reliability, quality and profitability are proved [35, p.137]. As a result, low diffusion rates reduce the chance of gathering useful information about new concepts and thus lead to missed opportunities for people to gain valuable technological experience. Several studies state that experienced people with appropriate skills are essential for designing, developing, constructing,
manufacturing, operating and maintaining energy efficient technologies or mutual energy services [89, p.1300, 92, pp.478–479]. Therefore, a low adoption rate also results in a shortage of trained and skilled technical personnel within companies. This is especially true for small and medium enterprises (SMEs), where maintaining daily production may be more important than identifying and implementing energy efficient technologies or energy cooperation services [20, p.1, 93, p.194, 94, p.844]. Moreover, low adoption rates bring about a lack of external technical support. If any malfunctions of highly innovative technologies or energy cooperation services occur, there are rarely product services available to solve the problem [88, p.3667, 94, p.844].

**Lack of feasibility study**

The implementation of new energy efficient technologies or mutual energy services among companies require proper feasibility studies, life cycle analysis, technological forecasting, etc. If no feasibility study regarding the new technology or cooperation is conducted, the uncertainty of the expected technical success lets companies hesitate and can hamper a potential implementation [20, pp.49–50, 95, p.249].

**4.4.2 Technical performance**

The clustered barrier *technical performance* discusses issues regarding suitability, performance characteristics and reliability of energy technologies and energy cooperation services. Installing new energy equipment confronts companies with more challenges than just buying [96, p.76]. Hereafter, such problems are compiled and discussed.

**Suitability of technical parameters for cooperation**

Energy cooperation projects may offer opportunities to increase energy efficiency and cost reduction of enterprises through cogeneration, by-product usage, reusing of diverse residue streams, etc. Reported barriers are summarized in the following [9, p.330].

One of the essential stages for the evaluation if energy cooperation is promising is to identify the input and output streams of energy and waste of possibly participating companies. Thereby, the technical suitability of residuals such as by-products or heat streams for further usage are analysed and potential fields of application evaluated. Companies expect the quality and reliability supply of by-products and waste streams to be at least as good as to the supply from conventional sources [4, p.75, 9, p.329]. Moreover, in some cases, no appropriate use of waste streams can be derived and thus no cooperation can be established, e.g. if company A produces waste heat with a certain temperature, but company B cannot use it as it does not meet their required temperature range [3, 26, p.141, 97].

Compared to green field planning of industrial parks, working with existing facilities is more difficult. At a green field park, quantities of waste streams and by-products can be designed to meet down streaming processes with the required attributes, e.g. by inviting the right companies or discussing their exact process design. Whereas at existing facilities, the quantities and attributes are hardly flexible [9, pp.329–330]. Additionally, firms must be in proximity to avoid transportation cost and energy degradation. Thus, through green field
planning, an optimal arrangement of enterprises within an industrial park to minimize transport distances of by-products and waste streams can be achieved [4, p.75].

**Insufficient technology maturity**

Unproven new technologies and untested solutions and examples hamper their potential implementation within a company [26, p.141, 93, p.194]. Before a new technology is adopted by an enterprise, a thorough analysis concerning its maturity is conducted to prove functionality and reliability in order to avoid malfunctions and downtimes. To support the maturity measurement of a technology, Mankins has introduced the technology readiness level (TRL). In the TRL measurement scheme, nine readiness levels (TRL 1 to TRL 9) serve as support for the maturity assessment [98].

According to Shove [99, pp.1106–1107], technologies are only successful if they manage to overcome the stages of research, development, demonstration and dissemination. In addition, hindrances resulting from information blockage as well as non-technical barriers have to be conquered. A term that is often used in innovation literature associated with technology maturity is the “valley of death”. The valley of death symbolizes the capitalization of a new technology on the path of development: Firstly, sufficient resources are available in basic research. Also towards the end of the development, when the technology has proven its maturity and enters the market, sufficient funds are available again. In between, potential users are reluctant to invest in prototypes or demonstrators. In some cases, promising technologies fail to overcome the valley of death due to low investments, which result from high technical risks and uncertain markets. As a result, there is an underinvestment in these technologies and promising technologies suffer a premature death [100, pp.154–156].

**Production disruption**

Production disruptions imply monetary losses due to lost production volumes and may have negative implications on product quality. A continuous operation without any production disruptions is one of the most important factors for enterprises; this especially applies when new technologies or energy cooperation are planned or implemented. The implementation of a new technology or energy cooperation within an existing and reliably running system of a company implies numerous risks. During the retrofitting work, a temporary disconnection of heat, power or water systems can result in downtimes of a plant and hence to a loss of profit [20, p.49, 26, p.139, 93, p.196, 101, p.512]. Moreover, a failure in supply could damage the functionality of existing production equipment and therefore imply hidden cost [20, p.49]. After installation, new technologies have to be monitored and reconfigured regularly to meet disruption free and high quality production [40, p.27].
Inappropriate technologies & intermittency

Not all renewable energy systems like solar, hydro, wind or biomass are always applicable at a certain plant or for a certain production process [102, pp.1035–1036]. Some renewable energy sources like solar or wind are intermittent and do not deliver continuous energy supply. Other renewable energy sources like biomass or hydro can be seen as constant in energy supply but may not support economic capacity utilization of intermittent energy production technologies. [92, p.478]. Therefore, efficient planning includes the interaction of natural, economic and technical viewpoints [93, pp.195–196].

In general, renewable energy technologies have a lower energy flux (energy output per unit floor area), compared to fossil fuel fired technologies. Furthermore, the fluctuating supply of some renewables like solar or wind, which requires additional energy storage devices to provide continuous energy supply, is a further disadvantage [92, p.478]. In addition, factors like the performance of technologies as well as their corresponding lifetime and reliability create uncertainty in potential energy savings and energy efficiency investments. Compared to the implementation of a new technology, keeping the existing one provides more reliable information regarding energy consumption and performance characteristics. As a result, existing and conventional technologies are prioritised in decisions due to the lower technical and financial risk [20, p.35, 87, p.1437, 92, p.478].

According to Venmans [35, p.137], there can also be a lack of compatibility among different technologies. This so-called “technology lock-in” prevent enterprises from adopting new and more efficient technologies.

Demand Response

Renewable energy sources such as solar or wind depend on weather conditions. This leads to fluctuations during energy production and therefore in energy supply. Thus, a balance between energy supply and demand is required to ensure a secure energy provision [92, p.478, 103, 104, p.677, 105].

One way to deal with intermittent energy sources is load adjustment of consumers. By adjusting the load of consumers corresponding to the fluctuation of energy generation, a reliable energy provision can be guaranteed. As the manufacturing industry belongs to the biggest energy consumers worldwide [106], their processes can help to balance supply and demand. Moreover, adjusting their loads to times of low energy prices may help them to save energy cost. However, companies may do not know which flexibilities they actually have in energy matters. Moreover, flexible load management is risky and can cause production disruptions if the required energy demand is not available when needed [104, p.677, 107].

Another way of solving the intermittency problem of fluctuating renewable energy resources are so-called microgrids. A microgrid is defined as “a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode [108, p.84].” Microgrids intend to improve reliability and resilience of power grids and to reduce the uncertainty of insufficient energy supply [109, p.402]. Thus, the concept of microgrids is a possible energy supply
solution for energy cooperation of industrial parks, which can handle fluctuating renewables and provide sufficient electricity in either grid-connected or island mode [102, pp.1033–1037].

**Energy storage**

During times of no or low energy production, the energy storage provides sufficient and reliable energy supply, and stores excess energy in times of high energy production. Many energy storage technologies have evolved over the last century. In general, their aim is to store energy for use on demand. However, as of the intermittency of some renewable energy sources like solar or wind, energy storage technologies play a key role in providing continuous energy supply of such energy sources. With the combination of an energy storage and a volatile renewable energy source, the problems of fluctuating supply can be removed [102, pp.1033–1035, 110, p.3, 111].

A wide range of energy storage systems exist. Based on their various characteristics, they are classified in physical, energetic, temporal, spatial and economic viewpoints. Commonly, the physical classification is used as differentiation and is therefore applied in the following. This means that energy storages are categorized in electrical, mechanical, thermal and chemical storages. It has to be mentioned, that also some physical mixtures such as electrochemical storages occur [112, p.36].

Figure 4-1 shows a comparison of several storage systems, which are plotted over discharge time and storage capacity. The different colours of the clouds illustrate the corresponding physical characterisation. In addition, the clouds show application areas, in which storage systems are currently in operation in Germany [112, p.654].

Besides the technical parameters of discharge time and storage capacity, further essential technical and economic parameters for storage evaluation exist. Efficiency, volumetric energy density, number of cycles as well as specific investment cost are key characteristics of storages [112, p.658]. However, energy storage systems exist for various application areas, which have different requirements regarding efficiency, energy density or cost. Thus, a possible and meaningful comparison among storage systems is only possible to a limited extend [112, p.661].

Most energy storage systems still have a big development potential. Only a few of them such as pumped storage plants or some types of batteries can be seen as fully mature [112, p.663]. For a detailed list of strengths and weaknesses as well as opportunities and barriers to each storage system see Sterner [112, pp.665–670].
Smart grid, microgrid and prosumer communication

Since communication equipment for different energy sources, storages and consumers gets more important for their management, advanced communication technologies are developed [113, p.1677]. Currently, a conventional power grid is only designed for distribution and transmission of energy and the consumer is not actively involved. In contrast, a smart grid is “an advanced power system with integrated communication infrastructure to enable bi-directional flow of energy and information [113, p.1675].” This concept leads to a more flexible power system and an active involvement of consumers. On the one hand, an advanced metering infrastructure allows utilities to gather consumption patterns of their consumers for better meeting energy demand. On the other hand, consumers get information like energy availability and current energy prices. Besides, renewable energy produced by consumers is a new energy source for utilities and can be shared with the grid to cope with increasing energy demand. Thereby, a consumer turns into a so-called prosumer. That means, prosumers do not only consume energy anymore, but generate energy for their own usage too and share excess energy via the grid. If many prosumers form an energy sharing network like a microgrid, smart communication technologies help to interact between several prosumers [113, pp.1675–1676, 114, p.1].

The performance characteristics of used communication technologies differ from wire or wireless connections, frequency bands, coverage range and data rates. Typical communication technologies are GPRS, GSM, Bluetooth, ZigBee, WiMAX, DASH 7 or PLC. Depending on the respective application field (generation, transmission, distribution or...
consumer), each communication technology has a certain field of activity. However, research is conducted to spread the application range of communication technologies [113, pp.1677–1678, 115, p.197]. As state of the art communication protocols are not designed to meet prosumer needs in a smart grid, new communication protocols have to be developed to better fulfil the system requirements [113, p.1683].

### 4.4.3 Energy management systems

With the support of an energy management system (EMS), a better management of energy use in enterprises and for cooperation among firms is achieved. This might include the implementation or sharing of new and more efficient technologies, by-product usage, smart energy communication or waste stream reduction. The aim of such management systems for an organisation is a) to reduce cost, b) to protect the environment, c) to use sustainable resources, d) to improve public image, e) to use legal advantages and f) to help reaching the climate goals of the respective state [116, p.18]. The clustered barrier energy management systems deal with issues of energy monitoring, measuring, analysing, forecasting, optimisation and controlling to increase energy efficiency and to decrease energy consumption.

### ISO 50001 – energy management system

With the support of an energy management system (EMS), a better management of energy use in enterprises and for cooperation among firms is achieved. This might include the implementation or sharing of new and more efficient technologies, by-product usage, smart energy communication or waste stream reduction. The aim of such management systems for an organisation is a) to reduce cost, b) to protect the environment, c) to use sustainable resources, d) to improve public image, e) to use legal advantages and f) to help reaching the climate goals of the respective state [116, p.18].

In everyday usage, the term "energy management system" includes two different things: On one hand a management system in the form of a manual for an organizational procedure (as described here), on the other hand an electronic optimization (measurement and switching) of equipment, devices, storage and consumers (as described in 4.4.3).

The ISO 50001 (International Organisation for Standardisation) defines an energy management system (EMS) as “a set of interrelated or interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve those objectives” [117]. This means that ISO 50001 specifies requirements for an EMS, so that organisations can implement an energy policy, and define objectives and plans of how they improve their energy performance. To achieve the energy objectives, ISO 50001 is based on the continual improvement framework of plan, do, check and act and is applied in everyday organisational practices [117].

This framework allows companies to follow a systematic approach for continuous improvement of energy performance with respect to energy efficiency, energy use and consumption. For example, ISO 50001 specifies requirements for the measurement and documentation of all energy consuming processes and systems. Although ISO 50001 does not prescribe specific performance criteria or which technologies for achieving energy savings should be used, it
forces its operators to deal with and monitor the company’s consumption and to be informed on technical and economic alternatives [117].

As ISO 50001 is based on broadly applied ISO management system standards such as ISO 9001 (quality management systems) and ISO 14001 (environmental management systems), compatibility between the standards is ensured [117].

According to the International Electrotechnical Commission (IEC), an energy management system is defined as "a computer system comprising a software platform providing basic support services and a set of applications providing the functionality needed for the effective operation of electrical generation and transmission facilities so as to assure adequate security of energy supply at minimum cost [118, pp.7–8]." In case of a microgrid, an EMS has the same features and consists of modules like load forecasting or human machine interfaces for making strategic decisions for each generation, storage and load unit. Thus, the system is capable of optimising a microgrid in terms of energy and cost efficiency by offering a variety of functions such as monitoring, analysing, and forecasting of power generation, load consumption, energy market prices and meteorological factors [102, p.1036].

As shown in Figure 4-2, a variety of information can serve as input to determine the optimal compilation of energy sources to provide reliable, cost-effective and efficient supply. The first stage within a microgrid EMS is to gather all energy relevant information such as load demands, the power generation of renewables or conventional technologies, weather forecasts and consumption patterns of consumers through monitoring and measuring. After gathering the relevant information, the ongoing stages of the microgrid EMS deal with the compilation of the collected data, its analysis, and forecasting of energy demand, and with the optimisation stage of the system for providing constant energy supply at a minimum of costs [102, pp.1036–1038].

![Microgrid energy management system](image)

**Figure 4-2: Microgrid energy management system. This figure has been taken from Zia et al. [102, p.1038].**
Lack of energy monitoring and measuring

According to Sorrell [20, p.44], various papers have pointed out that enterprises do not have information about energy consumption within their company. A reason is that many firms have a lack of energy monitoring and measuring equipment as well as no tools that show them the benefits of efficiency improvements. This can be attributed to the fact that the cost of monitoring and measuring performance are not covering financial benefits [20, p.50]. However, sub-metering and sub-monitoring have been identified as useful tools to find energy efficiency opportunities within companies. Especially departments with high energy consumption can be detected and their efficiency can be enhanced [35, p.138].

Because of energy cooperation, companies are not only consumers of energy anymore, but provide own generated energy for jointly usage, too [114, p.1, 119, p.1]. Consequently, the calculation of the net energy consumption of each company gets more complicated and many sub-metering and sub-monitoring points are necessary. As a result, the lack of smart sensors, actors and meters and thus the missing information on structured energy consumption, represent a technical barrier, as these data are required for a thorough analysis [102, p.1036, 120].

Complexity of big data analysis, forecast and optimisation

Due to the enormous volume of information which is gathered during monitoring and measuring, high demands on computer performance like computational time and stability are made. In particular this is true for microgrid EMSs, where a two-way communication to other controllers is required. Presently, two ways of how supervisory controllers are arranged exist. One possibility is to install a central controller, which sends commands based on information such as weather forecasts and planned consumption directly to the respective energy source. However, this system faces the highest problems concerning stability and computational time. The other possibility is to use a decentralised controller, where an additional local controller always responds regarding local conditions and derives specific commands in coordination with the decentralised controller. This system is currently given more research focus, due to its lower performance demands [102, p.1037].

Currently, many approaches for the optimisation of EMSs of microgrids exist. They use diverse algorithms for linear or nonlinear programming, heuristic and stochastic methods, model predictive control, as well as artificial intelligent attempts. However, all management approaches are still in development stage which has to be considered as a technical barrier. Nevertheless, energy enterprises like General Electric, Siemens, Schneider Electric, Tesla are currently developing and deploying EMSs for microgrids [102, pp.1037–1053].

See also Chapter 4.3.4 for barriers concerning big data.

Cyber Security and privacy issues

Through the application of EMSs among enterprises, the indispensable transfer of sensible energy information between enterprises has to be protected. Therefore, it is unavoidable to use appropriate security and privacy methods to secure the data of each party. For example, currently applied cyber security protocols are smart metering security, data transfer security
protocols for communication among enterprises as well as cryptographic techniques. However, further research to improve and to better meet security requirements is needed [113, p.1683]. This topic is also touched by Chapter 4.3.4.

4.4.4 Infrastructure

The clustered barrier infrastructure discusses hindrances resulting from a non-physical fitment and a non-existing distribution infrastructure for a new technology or mutual energy service. Moreover, missing electronic data processing (EDP) infrastructure for the coordination of energy issues is part of the analysis.

Physical fitment and distribution

The implementation of new technologies for energy cooperation may requires additional infrastructure on-site. Enterprises cannot generate clean energy, if they have no space left for installing renewable energy sources like solar, wind or biomass [113, pp.1682–1683]. Moreover, a new technology cannot be integrated in an existing production system, if there is insufficient physical space available. Thus, the non-availability of sufficient space can hinder the replacement of obsolete technology with a more energy efficient one [94, p.844].

For the exchange of by-products, waste streams and electric power among enterprises, a form of transportation infrastructure is necessary. This can be a piping network such as used in district heating with steam or water, or an additional power grid infrastructure. However, long distances between firms have to be avoided, since they lead to energy losses and thus to an inefficiency in the overall system [26, p.141, 89, p.1300, 121, p.604].

Chew et al. [122, pp.18–21] reported a detailed list of key issues for on-site heat integration for industries, which addresses design, operation and reliability issues. For design issues such as plant layout, fluid characteristics and construction materials are considered. Operation addresses issues like start-up and shut-down, operating scenarios and controllability. Reliability, availability and maintenance issues relate to the whole system including all technical components such as heat exchangers, pumps and turbines. Especially for industrial parks, where transfers of heat to other firms are planned, these issues can become difficult to bring in line for several parties.

As already discussed in the energy storage barrier, for dealing with the intermittency of some renewable energies such as solar or wind, an additional storage equipment is needed to guarantee the reliability of continuous energy supply. Therefore, besides the construction space for the energy source, extra space for an energy storage is required [113, p.1683].

Missing EDP infrastructure

Considering the massive coordination and management effort, which occurs when companies engage in energy, by-product or waste stream exchanges, their data management and evaluation is a further barrier. For this purpose, own EDP (Electronic Data Processing) equipment helps to meet the high requirements, but causes infrastructure and personnel cost. Besides investing in general information technology (IT) infrastructure like computers and
servers, infrastructure in form of smart monitoring and measuring devices such as sensors, actuators and meters as well as communication technologies is beneficial [102, 113].

4.4.5 Utilization of renewables for process heat

One of the approaches to decrease CO₂ emissions and increase ecological sustainability of industrial parks is to use renewables instead of fossil fuels. In traditional industrial processes, renewables often face barriers for application, which are discussed in the following sections.

Process (temperature) requirements

For some renewable technologies it is challenging to fulfil the temperature, pressure and quantities of heat required for some industrial processes [123]. Solar collectors in the northern part of Europe, high-temperature heat pumps and hydrothermal geothermal heat can only provide heat at rather low temperatures (less than 150°C) [124]. As shown in Figure 4-3, industrial temperature requirements are often higher than 150°C.

Another disadvantage of solar collectors is their decreasing efficiency with increasing integration temperature. Therefore solar heat should be integrated for low process temperatures. However, in these temperature levels these sources compete with other heat sources like e.g. excess heat [125]. Furthermore it shows that process heat under 100°C as well as space heat and hot water only have a share of 12% and 14% of the total heat demand [126]. This context limits the utilization of solar- and geothermal heat to specific branches, reduces the use to preheating processes or requires additional heat pumps.

![Figure 4-3: Process heat demand across all industry branches in EU 28 [126]](image-url)
**Complexity and design effort**

Every project has to be analysed individually, as there are no standardized solutions. This increases the expenditures on design and results in a major barrier [124]. For the integration different parameters have to be considered. E.g. it has to be distinguished between integration into the supply - (e.g. centralized boiler) or into the process level (e.g. pasteurization process). Furthermore the utilized heat transfer medium at supply as well as the type of heat load at process level has to be taken into account [127]. These complex circumstances require experts, which have specific knowledge about the processes [124]. In the case of solar heat, critical processes require an additional conventional backup system for bypassing times of low radiation. Out of this reason the conventional system cannot be replaced fully and the site has to amortise by lowered fuel cost [125].

**Lack of supply chains**

Some renewable technologies cannot be installed due to the lack of supply chains for fuel like for example biomass from agricultural residues [123].

**Structural circumstances**

Integration into grown structures is mostly more costly than into new constructions. If for example an existing steam network should be supplied by renewable heat, the temperature requirements are too high, as it was designed for conventional heat supply [124]. One restriction on the integration of solar heat is the lack of available roof- or open area. Furthermore, industrial rooftops may not be designed for additional loads, the subsequent effort for reinforcement represents another barrier [125]. Geothermal heat supply is depending on the location of the plant and its access to a hydrothermal aquifer.

**Lack of efficiency**

Low efficiency in technology and building stock results in higher heat peak loads [123]. It has been shown that the integration of a solar heating system for process heat supply after total exploitation of all available conventional efficiency measures is even more reasonable than in the residential sector. To achieve the latter, efficiency measures (e.g. insulation of pipes, heat recovery systems, optimisation of hydraulic components) have to be conducted before the integration of a renewable heat source [128].

4.4.6 Utilization of excess heat

**Material constraints**

Contaminations in the excess heat stream can limit the opportunities of utilization [129]. The composition and temperature of the excess heat stream have a high impact on the technical and economic feasibility of the project. Highly reactive compounds as well as stringent hygiene condition may require more advanced materials for heat exchangers, which increases the costs significantly. Additionally, large heat exchanger areas are needed for low temperature heat recovery which also has a negative impact on costs [130].
The equipment and installation cost for large-scale heat recovery systems are typically lower than for small scale systems. Therefore recovery units like for example in the food or beverage industries are more expensive and less attractive. [130]

When it comes to transportability of excess heat, most of the excess heat streams occur at atmospheric pressure, which hamper the transport to the end user without additional energy effort. [130]

**Lack of suitable end-users**

The temperature level of the process heat demand (Figure 4-3) varies widely in the different industrial sectors, between approximately 60°C for cleaning processes and far above 1000°C in iron, steel, glass or ceramics industry [129]. For low quality excess heat a lack of on-site demand is quite common.

There are technologies to create possible end use options, e.g. electricity production from low temperature excess heat with ORC or Kalina cycle. They are either less developed or lack expertise and are still not cost-effective. Another possibility to expand the portfolio of utilisation of low-quality excess heat is to upgrade the quality with heat pumps, from low temperature to medium temperature. Higher capital cost compared to the direct use of the excess heat hamper the implementation of these measures [130].
4.5 Information Provision Perspective

When talking of information provision barriers, it has to be distinguished between information regarding potential cooperation partners, information exchange, which is needed to establish energy cooperation and it them running, and information from/about external factors, for example available technologies or measures. Furthermore, information and knowledge about technical possibilities as have been described in section 4.4.1 are crucial. These barriers are also connected to (lack of) knowledge and trust issues, which have been discussed in section 4.2, the latter concerns e.g. external experts.

As has been mentioned before in section 4.1 Economic Perspective, information barriers are connected to economic barriers to a great extent. Concerning information, usually problems due to incomplete and/or imperfect as well as asymmetric information arise.

4.5.1 Provision of park-internal information (energy data)

Incomplete information practically means that actors, such as ESCOs and potentially cooperating companies, do not fully understand the other actors and their intentions [27]. If all actors would have perfect information, they would have access to the same information as all other actors [131]. The theorem of imperfect information or asymmetric information applies, when not all actors have the same information but at least one actor has information not known to the others [132]. Obviously, this situation is virtually everywhere in practice; this implies that decisions are expected to be better, the better the information exchange is. Some information, such as the intentions or the stimulus of companies, is likely to be no secret in case of energy cooperation. The intentions usually are economic value added, such as reduced energy and waste costs, sustainability and a positive corporate image.

However, load profiles, true costs and true potential revenues from cooperation remain private information. It is very likely that information barriers occur, when two or more companies are planning energy cooperation, e.g. concerning internal company data. Sorrell et al. [20, pp.17–21, 51] extensively discuss imperfect information and asymmetric information concerning energy service markets and energy efficiency. The following section gives an overview of information connected barriers identified within S-PARCS.

Provision of Energy Data

The provision of the companies’ energy data to identify for example complementary energy demands and excesses is a barrier linked to information provision and trust. Such data are needed to establish successful cooperation projects and keep it running.

For the company providing the data the provision means that others, for example competitors, may estimate the production costs or volume. Sensitive business information include “trade secrets, acquisition plans, financial data and supplier and customer information, among other possibilities” according to [133]. Other sensitive information are energy demand data and load profiles of companies. The availability of such data is not always given, since many companies do not have detailed metering infrastructure installed. If such data exist, it is questionable, if enterprises reveal them without hesitation. Other companies withhold their energy data for other reasons, e.g. for fear of being confronted with legal requirements. For the second
company that may want to cooperate, this means that energy data to identify for example complementary energy demands and excesses are not available.

**Missing Collaboration History**

Probably in most cases, there is no knowledge of possible cooperation projects and potential positive effects thereof due to missing collaboration history and a lack of interest in surrounding companies. Especially joint energy projects have no tradition in individually emerged enterprises.

The reason is that there has never been interest into these data due to missing business and social links between the companies. On the other hand there are studies, which found that information provision barriers are not as important as usually assumed. Some studies are shortly explained in Lombardi et al. [66].

**Disturbed Communication Channels**

Communication is part of social barriers but also information barriers since only a well-functioning communication enables successful information exchange. Communication is important from the development of ideas to the implementation of definite measures to the operation phase. In case responsibilities are not clearly defined, information can get lost due to incomplete information chains or scarce communication skills by key actors, such as energy and technology providers, as has been identified by Hirst and Brown [52] and Cagno et al. [1]. This barrier applies to company-internal and inter-company measures.

**Overlooking of benefits**

The quantification of direct and indirect positive effects is often uncertain. In many companies there is no detailed monitoring of energy consumption and energy costs so a potential change in consumption seems ungrounded at first, especially when energy costs are not very high compared to other costs. This means energy matters and costs are not a part of the strategic company plans. Non-energy benefits associated with an investment rarely influence the calculations preceding the decision making of energy efficiency investments. Potential non-energy benefits are [26, 40, 134]:

- Positive publicity
- Motivated and proud employees based on an innovative sustainable corporate image
- Participation in the emission trading market
- Attractiveness to commercial partners, public entities and NGOs
- Possibly healthier employees due to better pollution standards etc.

The possibility of making additional profit with a side business, i.e. selling surplus energy, is rarely thought of as well.

**4.5.2 Provision of external information**

In this subchapter, barriers are summarized which are associated with the lack of provision of information that are due to park- or company-external matters.
Insufficient information on available technologies and measures

Companies are reluctant to implement technologies and measures that are still in development, as this implies risk to the production process. This also applies to those in the field of energy cooperation. At the same time, the dissemination and knowledge of technologies and measures which have already been successfully demonstrated is considered to be low [87].

For proven technologies and measures, companies, or more specifically, the people responsible for utilities or facilities, lack information to compare the applicability and the costs & benefits [44]. Companies face difficulties in obtaining information compared to the perceived simplicity of buying conventional, stand-alone energy technologies [87]. This barrier also relates to 4.2 Social/Managerial Perspective, as not investing is linked to avoiding uncertainties.

Insufficient information on financing & funding

The lack of knowledge about financing mechanisms by financial institutions has been identified as one of the most important barriers for investments in energy efficiency projects throughout Europe by UNECE [19, p.21]. As has been mentioned before in section 4.3.4, workshops with representatives of different industries found that opaque funding and subsidy schemes are another barrier [44, p.4]. It is likely that due to this non-transparency many energy cooperation solutions are not even taken into account by decision-makers of companies.

Access to External Competences

Some authors like Cagno and Trianni [135], Cagno et al. [1] and Sandberg and Söderström [136], explicitly mention the barrier in respect to access to external competences and knowledge. Since energy investments and connected topics such as energy audits, subsidy schemes, financing mechanisms for renewable energies etc. are not part of the core business, external experts have to be consulted. In some cases it might be difficult to get information about the availability of such experts. Furthermore, the trustworthiness of such external information can be problematic, since it is difficult for the companies to spot inconsistencies outside their core competences. National and international networks and platforms of industries, renewable energies and energy efficiency can provide support in getting access to external experts such as qualified energy auditors. Sandberg and Söderström [136] stress the importance of (external) support for energy efficiency investment decisions in industry to ensure such decisions are made wisely.
5 Opportunities and Possible Success Factors

Opportunities and solutions for industrial energy cooperation will be discussed in later Tasks and Deliverables of the project S-PARCS. Here, an overview of opportunities and possible success factors is provided. This overview is based on the identified barriers, as many of these logically imply approaches to overcome them.

5.1 Coordination and Management

Looking at existing Eco-Industrial Parks, a functioning management body, who is responsible for planning and managing the energy and energy efficiency measures throughout the park, is one of the most important success factors. This has been shown in the Eco-Innovera study [6] and extensively explained by Mirata [5]. Mirata further extends the scope by declaring that coordination is also responsible where “[…] there is limited coordination, dependence, or communication among regional parties, operations are diverse and traditionally not related, or where institutional barriers to cooperation are particularly strong. Coordination function retains its importance in cases where a web of synergistic linkages is developed (as indicated for documented examples from Styra62, Austria and Jyväskylä, Finland), and should focus on the diversification of interactions and providing further improvement potentials. To sum up, an (sic!) IS63 coordination body has crucial roles to play in facilitating the development and assisting in its operation.”64 [5, p.971]

Mirata refers to the UK’s National Industrial Symbiosis Programme (NSIP), which is still successfully active and a project directly linked to International Synergies Limited [64].

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62 Mirata means Styria, which is a federal state of Austria.
63 IS stands for industrial symbiosis
64 Mirata originally refers to several sources in this paragraph. Please check with the original paper for more information on these sources.
5.2 (Self-)Declaration, Promotion and Awareness

Taking the general barrier of “missing knowledge” into account, the self-awareness and promotion of an industrial park and its companies is very important. If all direct and indirect participants – from the single worker up to executives, customers and neighbours but also national and international communities – are aware of the meaning of and the positive consequences of energy cooperation and are convinced of the concept, such projects will succeed more easily. It is not just about implementing technically and financially reasonable measures, but also about implementing a kind of philosophy, boosting interest and commitment.

Taddeo et al. [137] analysed the potential role of so called innovation poles, which “[…] are government-sponsored consortia created within the EU regional policy guidelines 2007–2013 and specialized in one industry or in specific value-chains. […] Each Pole involves firms, SMEs, innovative start-ups and research institutions. A minority partnership in the Poles can also be extended to research institutions and enterprises that are not located in the same region or territory. They have the specific purpose of stimulating innovation activity, promote interaction among organizations, joint use of research facilities, exchange of know-how, knowledge transfer and information diffusion.” [137, pp.8–9]

Innovation Poles were not designed for promoting industrial symbiosis and EIPs but innovation in industry. Since EIPs are characterized by innovation and the need for networking and knowledge exchange, such innovation poles indeed could have positive impact.

Chertow and Ehrenfeld [16] defined three stages of development for industrial symbiosis and EIPs, which are (1) Sprouting, (2) Uncovering and (3) Embeddedness. To strengthen the development of EIPs it would be of advantage to support stage (2) Uncovering. According to Chertow and Ehrenfeld “[…] the net benefits become known to and are voiced by some advocate in the public sphere, and “stick” in the form of an incipient institution, then further institutionalization can lead to additions to the network beyond those first few exchanges created by economic efficiency alone, as the new norms and beliefs are dispersed. The further growth of the network “caused” by such institutional processes is, then, some form of intentional industrial symbiosis.” [16, p.21]

5.3 Business Models/Economic Value

For waste and energy cooperation various business models exist. Fraccascia et al. [29] present a collection of industrial symbiosis business models for companies. They mainly focus on waste exchange but some of their insights can be adapted for energy cooperation as well. They distinguish between internal and external reuse of materials as well as between waste producing and requiring companies. For S-PARCS waste heat producing and heat demanding companies are essential as well as enterprises producing waste materials suitable for waste-to-energy systems, such as CHP. Another aspect are PV and solar thermal installations. These installations can be placed on rooftops of one company while the electricity/heat is utilized by another company. Therefore, S-PARCS takes more possible exchanges into account but on park-level. Fraccascia et al. distinguish between internal and external exchange for waste producing firms and input replacement, co-product generation and new product generation for
waste demanding firms. Due to energy cooperation mainly input replacement (of energy) is of interest for S-PARCS, while it is unlikely that waste (energy) demanding companies will develop new products or co-products in the course of S-PARCS. However, waste and waste energy producing companies as well as companies providing e.g. rooftops for PV, may expand their business by providing new resources.

In all cases economic value will be added, for example due to less waste disposal costs, less raw material costs, less energy costs, revenues from selling waste energy or waste-to-energy or selling electricity produced by PV.

5.4 Financial Incentives

In Europe various financial support schemes for energy efficiency and renewable energy exist, as can be seen from various National Energy Efficiency Actions Plans for instance. Examples would be Germany [138], Austria [139], Italy [140], Spain [141], France [142], Portugal [143], Belgium [144] and also Turkey [145, 146]. The knowledge of these financing schemes is not always given. According to Chai and Yeo [147, p.462] voluntary agreement schemes of a country’s industry and government can increase the awareness about available subsidies and financing schemes. Furthermore, there are already many institutions around, which hold knowledge about such incentives and which inform and advise various industries in energy and efficiency matters. Examples are the Austrian Energy Agency65, the German Energy Agency dena66 and Förderdatenbank67, the Italian Agency for new technologies, energy and sustainable economic development (ENEA)68 and the International Energy Agency IEA69. These institutions could inform about these incentives in connection with EIPs and industrial symbiosis. See also section 5.5 Policies for further information.

According to a study from UNECE [19, pp.20–24] banks and financial institutions lack knowledge of energy efficiency financing. Furthermore, tax incentives, low-interest loans for energy efficiency projects, de-risking of investments through governmental support and improved access to commercial financing are listed as possible success factors for industrial energy efficiency. Improving the knowledge of financial institutions on one hand and versatile governmental support on the other hand could therefore lead to higher energy efficiency implementation rates.

5.5 Policies

As has been introduced in Chapter 2, various kinds of EIPs and industrial symbiosis are differentiated. The main difference is the origin of the EIP, such as self-organized or planned. In both cases the necessary legislative and regulatory framework has to be given, to establish a successful system. However, history has shown that planned EIPs tend to be less successful. These planned EIPs were often based on a centralized top-down approach by diverse

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65 https://www.energyagency.at/
66 https://www.dena.de/en/home/
67 http://www.foerderdatenbank.de/
68 http://www.enea.it/en
69 https://www.iea.org/
governments, who created the required policies. Desrochers [148] argues that centralized planning always lacks detailed knowledge of the manifold actors as well as materials and processes and markets involved. He compares centralized planning of post-war Hungary and the industrial symbiosis evolving in Victorian England. Although these systems were much bigger than the industrial parks aimed at in S-PARCS, similar principles can be applied. Desrochers suggests that political and academic engagement should not result in centralized planned cooperation within parks but in identifying and removing existing barriers, such as misplaced subsidies and regulations forbidding re-use (or sharing) of materials etc. Another aspect is the “development of institutions that would more effectively force firms to “internalize their externalities” while leaving them the necessary freedom to develop new and profitable uses for by-products.” [148, p.1108] In this context, the principle “helping people to help themselves” is a good comparison. As previously cited from Velenturf and Jensen [18], self-organizing EIPs take too long to develop, most of the time. It would therefore be helpful, to emphasise such developments in national policies by creating frameworks, which pave the way, and by informing and supporting the industry through (academic) institutions. In S-PARCS the already existing Lighthouse parks have strong intentions to develop energy cooperation. During the project these developments are supported by various institutions. Thus, first steps following Desrochers’s suggestion are made. This mixed approach of planned and self-intended development towards industrial symbiosis and EIPs is also taken up by a study from the European Commission from 2017 [149, p.93].

Furthermore, like it has been mentioned before in section 4.3 Framework Perspective EIPs and industrial symbiosis have already been implemented into several national and international roadmaps and frameworks, such as the Roadmap for a Resource Efficient Europe, which recommends industrial symbiosis to member states [67, p.6], taking reference to International Synergies Limited [64] and its National Industrial Symbiosis Programme (NSIP). According to [149, p.93], countries like China (see Wang et al. [150]) and South Korea (see Behera et al. [151]) have been very successful in implementing eco-industrial programmes in recent years, while former attempts have not been as successful worldwide. However, according to [149] these successes base at least to some part on policies and instruments, which differ much to the framework in Western countries.
6 Barriers and Opportunities of Cooperation Solutions

In this section a short overview about the barrier cluster I to V, with added origin, decision phase and influence of the barrier, as well as the barriers assigned to the solutions inventory will be given. The tables can be found in the Appendix due to their large size.

The barriers, which have already been presented in Chapter 3, were completed by adding their source of origin, such as internal and external. *Internal* (I) refers to barriers, which originate within a single enterprise, or in a broader sense, within the industrial park. *External* (E) refers to barriers, which originate from outside the industrial park. Furthermore, as far as possible, the barriers have been classified according to the decision-making phases, in which they become important. A flowchart is added, which visualizes the barriers connected to the decision making steps. The barriers in the flowchart are color coded according to type: On the one hand, if they concern cooperation between companies, and on the other hand, if they concern energy efficiency in general or a single company. Lastly, the barriers are classified according to their influence on energy efficiency: They can be general barriers (G) or intervention-dependent (D), which means they do only occur for specific energy cooperation solutions. Some barriers become important in more than one category and have double classification. These classification schemes shall support decision-making processes and raise awareness for barriers, which have not been thought of before. Nevertheless, there is no claim for completeness of the identified barriers.

Additionally to these clusters the identified barriers have been assigned to the solution’s inventory prepared by the project partner RINA-C in collaboration with the other S-PARCS partners in Task 1.1 in tabular form. These tables present an overview of various cooperation solutions and the barriers, which can be expected. Again, there is no claim for completeness. Furthermore, the phrasing of the barriers is kept very general and not adapted for every solution. The tables can be found in the Appendix and in the digital attachment of the working paper.
7 Summary and Conclusion

This working paper intends to identify, summarize and cluster the manifold barriers associated with various solutions of energy cooperation and mutualized energy services. It is assumed that barriers towards renewable energy and energy efficiency measures, which apply within one company, also apply to energy cooperation of two or more companies. However, the scope was expanded to include and focus those barriers that are created by the collaboration of two or more companies. The listing includes technical as well as non-technical barriers.

The intention of the analysis of the barriers is not to remain focused on the problems. One aim of this paper is to provide a comprehensive list of barriers allowing companies and park managers to actively avoid or avert them. Another intention is to identify opportunities, which are often directly derived from a detailed discussion of the barrier.

About barriers to energy efficiency measures in industry an extensive amount of literature has been published since energy efficiency became an important policy aim in itself in the second half of the 20th century. Most literature deals with barriers to energy efficiency within a company, while this project deals with energy (efficiency) cooperation between two or more companies. This approach leads to the principle of Industrial Symbiosis and Eco-Industrial Parks. There is a significant amount of literature and a considerable number of projects referring to Industrial Symbiosis and Eco-Industrial Parks, which are connected to energy efficiency cooperation. The working paper is based on pre-assessed barriers and barriers that have been allocated to pre-assessed cooperation solutions. Furthermore, barriers that have been identified by literature research and by conducting expert workshops are presented.

One attempt of this working paper is to cluster individual barriers and, by doing so, structure and understand them more clearly. Different approaches of categorization were elaborated, for example by type of origin, time of occurrence, research discipline or energy carrier. It was found that due to the barriers’ comprehensive and cross-thematic characteristics, there is no clear distinction, no matter which categorization is chosen. In this working paper, it was decided that the categorization in disciplines fits best, i.e. barriers were categorized for economic, social/managerial, framework, technical/engineering and information provision barriers. These clusters enclose many barriers, which are described in detail in Chapter 4 and its subsections.

Furthermore, a detailed analysis of barriers was conducted. Barriers were clustered to disciplines, steps of implementation, and type of origin. Identified barriers were associated to their potential appearance during the implementation of potential energy cooperation solutions in parks which were elaborated in other tasks of S-PARCS.

The working paper shows that the implementation of energy cooperation or mutualized energy services is a multi-stage process involving manifold disciplines. Therefore, barriers are allocated alongside these stages and are referring to all disciplines, being definitely not linked to a dominant discipline, for example the technical one. Although social and informational barriers also occur inside single companies, they play a more crucial role for energy cooperation and mutualized energy services. As compared to internal measures, which converge in a central decision-making point (board), cooperation implies additional efforts to exchange information, advance in specific factual issues and complex negotiations and set up bilaterally accepted contractual agreements. Nevertheless, since conditions for potential
energy cooperation vary greatly, not only between countries but also between regions within a single country, no general statement can be made, which barriers are the most challenging ones.
8 Appendix

The Appendix contains the barriers' clusters I to V together with the identified origin of the barrier, the decision making steps they are important for and the influence of the barrier on efficiency measures, as has been described in chapter 6.

The clusters are followed by the flow chart for decision-making steps (see Figure 1-1), together with the assigned barriers. The barriers in blue shapes are arising (mainly) from cooperation, while the others are general barriers for energy efficiency. For better readability the flowchart was divided into several sections. The whole flow chart can also be found in the digital appendix.
# Barrier Clusters 1/4

<table>
<thead>
<tr>
<th>Origin of Barrier</th>
<th>Decision-making Step</th>
<th>Influence of Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal</td>
<td>External</td>
</tr>
<tr>
<td>Companies/Parks lack access to (long-term) financing or lack knowledge thereof</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Internal competition for capital prioritizes non-energy related investments</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>No additional own funds available</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Existing plants are not depreciated today, which hampers the investment in new ones</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Long payback times are not in line with company guidelines</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Energy costs are not a crucial cost factor</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Energy structures are costly to change</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Energy costs associated with environmental damage/climate effects are poorly reflected in market prices</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>No or insufficient consideration of life-cycle costs in market prices</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Fear of technological lock-in effects or obsolescence due to expected technological progress</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Fear of competitive disadvantages through exchange of information, knowledge and data</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Limited customer acceptance (fear of distorted, unreliable business relations)</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Uncertainty about energy/resource price developments</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Availability of risk insurance insufficiently offered on market</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Reluctance to change and adapt to potentially different working environments</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Lack of time and resources to work on issues other than the core business</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Limitation of skills and competencies to deal with issues other than the core business</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Staff is not motivated to deal with (their department’s) energy demand etc. / act according to the cooperation rules</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Responsibility for energy topics is not clearly defined</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Fear of distortions to core business</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Uncertainty of effects on local population, communities where park/company is located</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Success driven managers with short-term contracts need fast success</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Weak cross-sectoral co-operation</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>No prior relation between companies in an industrial park</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Fear of security of supply in case of switching suppliers</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Cultural barriers towards cooperation that relates to internal production processes</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Different management/reporting levels at involved companies are responsible</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Problems due to split incentives may occur internally and/or externally</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Absence of energy management systems (ISO 50001, also e.g. ISO 9001 and ISO 14001)</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Lack of trust between companies and park manager / service companies</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Companies are direct market competitors</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Fear of negative effects on workplace safety</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>No possibility or no willingness to make changes to a rented building</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Uncertainty and lack of information about internal organisation</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Changes to managerial structures may become necessary, reduces acceptance of decision makers</td>
<td>I</td>
<td>E</td>
</tr>
<tr>
<td>Incentive structures in companies guiding objectives of decision makers reduce acceptance</td>
<td>I</td>
<td>E</td>
</tr>
</tbody>
</table>
### Cluster III: Framework Perspective - Barriers

<table>
<thead>
<tr>
<th>Origin of Barrier</th>
<th>Decision-making Step</th>
<th>Influence of Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>External</td>
<td>1) Generation of interest</td>
</tr>
<tr>
<td>Lack of comprehensive and coherent political energy strategies increase investment risks</td>
<td>E</td>
<td>1</td>
</tr>
<tr>
<td>Industrial codes and standards are not aligned with proposed solutions</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Infrastructure related uncertainties (e.g. regulations for HV and LV networks)</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Regulation is counter-productive to some technologies/measures</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Uncertainties in national legislation</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Incoherence between local, regional, national, European legislation creates uncertainty</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Legal complexity in the individual Member States</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>District heating operator is not legally obliged to allow and remunerate a feed in into his network</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Ineffective market based support instruments</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Tax structures (such as depreciation periods)</td>
<td>E</td>
<td>2</td>
</tr>
<tr>
<td>Legal / Regulatory / Policy Standardisation</td>
<td>E</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Case Studies

- Different safety issues (and yearly costs) according to different voltage supply
- Energy taxes on individual energy carriers need to be harmonized in a local hybrid system
- Registration as an energy supplier is needed if energy (especially electricity) is utilized externally
- At the moment it is difficult to have more than one energy supplier, which makes selling infrequent residual/surplus energy difficult for companies
- Prohibition of exchanging electricity between two customers
- Lack of standardization about waste heat exchange (e.g. metering and measurement)
- Frameworks prohibit technical/economical sound cooperation regarding gas & electricity
<table>
<thead>
<tr>
<th>Cluster IV: Technical/Engineering Perspective - Barriers</th>
<th>Origin of Barrier</th>
<th>Decision-making Step</th>
<th>Influence of Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of the energy efficiency potentials in the company have already been realised</td>
<td>Internal</td>
<td>1) Generation of interest</td>
<td>G</td>
</tr>
<tr>
<td>Lack of knowledge for designing, developing, constructing, manufacturing, operating and maintaining new technologies or cooperation e.g. first of its kind</td>
<td>Internal</td>
<td>2) Investigation/Data acquisition on inefficiencies and partners</td>
<td>G</td>
</tr>
<tr>
<td>Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)</td>
<td>External</td>
<td>2) Investigation/Data acquisition on inefficiencies and partners</td>
<td>D</td>
</tr>
<tr>
<td>Missing link between supply/load profiles of the companies (no appropriate usage of by-products or waste streams possible)</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>G</td>
</tr>
<tr>
<td>Insufficient technology maturity (TRL evaluation)</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>D</td>
</tr>
<tr>
<td>Integration of energy management systems (microgrid EMS)</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>D</td>
</tr>
<tr>
<td>Intellectual property protection hampers the dissemination of technology relevant information</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>D</td>
</tr>
<tr>
<td>Long physical distances between enterprises (energy losses)</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>D</td>
</tr>
<tr>
<td>Lack of technical solutions for managing by-products</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>D</td>
</tr>
<tr>
<td>Outdated infrastructure does not allow efficient solutions</td>
<td>External</td>
<td>3) Investment analysis and intervention implementation</td>
<td>D</td>
</tr>
<tr>
<td>Hesitant to interfere within reliably running production processes (production disruptions, hidden costs)</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>G</td>
</tr>
<tr>
<td>Uncertainty about quality of exchanged energy (temperature level, continuity profile, volumes etc.)</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Aligning intermittent energy production (load profiles) between processes</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Lack of knowledge about technical options, their applicability and reliability</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Lack of feasibility study, life cycle analysis or technological forecasting</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Inappropriate technologies (as of weather conditions, intermittent source, capacity utilization not economical, incompatible)</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Intermittency of some renewable energy sources (insufficient supply, storage systems or load shifting required to meet demand)</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Lack of monitoring and measuring of energy consumption within enterprises</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>High demands on computer performance and IoT sensors/actors for data analysis and optimisation algorithms</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Cyber security protocols to protect privacy issues for energy exchange are required</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>EDP (electronic data processing) equipment for data monitoring, storage and management and evaluation is required</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Advanced communication infrastructure needed (bi-directional flow of energy and information like for smart grids, microgrids and prosumers)</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Lack of infrastructure (physical space for new technologies, distribution infrastructure for the transportation of waste streams or by-products)</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
<tr>
<td>Building or reconstructing facilities to enable energy cooperation may imply the requirement of other measures to comply with the current &quot;best available technologies&quot; (BAT) standards.</td>
<td>Internal</td>
<td>4) General on energy efficiency</td>
<td>D</td>
</tr>
</tbody>
</table>
## Barrier Clusters 4/4

<table>
<thead>
<tr>
<th>Cluster V: Information Provision Perspective - Barriers</th>
<th>Origin of Barrier</th>
<th>Decision-making Step</th>
<th>Influence of Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal</td>
<td>External</td>
<td>1) Generation of interest</td>
</tr>
<tr>
<td>Missing informational head of the park</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Energy is not a strategic important issue</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Lack of knowledge about successful demonstration projects and/or other references</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Uncertainty about quantification of effects</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Lack of knowledge about neighbour company’s energy demands/residuals</td>
<td>E</td>
<td>I</td>
<td>1</td>
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<tr>
<td>Lack of interest in the neighbouring company’s energy demands/residuals</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Lack of access to external competences</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Lack of knowledge about financing, subsidy options</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Provision of sensitive business data, e.g. energy data, is needed</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Information exchange and communication between relevant persons does not work properly</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Uncertainty about organizational issues of energy cooperation (e.g. who runs the new/joint plant)</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Failure to recognize non-energy benefits of efficiency</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
<tr>
<td>Lack of knowledge about possible side-streams, collaborating partners, etc.</td>
<td>E</td>
<td>I</td>
<td>1</td>
</tr>
</tbody>
</table>
## Economic Perspective

### Financial
- Companies/Parks lack access to (long-term) financing or lack knowledge thereof
- Internal competition for capital prioritizes non-energy related investments
- No additional own funds dedicated for energy matters
- Energy costs are not a crucial cost factor
- Existing structures are costly to change, so there is no interest in doing so
- Long payback times are not in line with company guidelines

### Social/Managerial Perspective

#### Individual
- Reluctance to change and adapt to potentially different working environments
- Lack of time and resources to work on issues other than the core business
- Lack of skills and competencies to deal with issues other than the core business
- Staff is not motivated to deal with (their department’s) energy demand etc.
- Responsibility for energy topics is not clearly defined

#### Mutual
- Weak cross-sectoral co-operation, there is no existing network
- No prior relation between companies in an industrial park
- Cultural barriers towards cooperation that relates to internal production processes
- Different management/reporting levels at involved companies are responsible

### Framework Perspective

#### Policy
- Lack of comprehensive and coherent energy related strategies increase investment risks

#### Standardisation
- Different safety issues (and yearly costs) according to different voltage supply
- Energy taxes on individual energy carriers need to be harmonized in a local hybrid system
- Registration as an energy supplier is needed if energy (especially electricity) is utilized externally
- At the moment it is difficult to have more than one energy supplier, which makes selling infrequent residual/surplus energy difficult for companies

### Technical/Engineering Perspective

#### In the beginning
- Long physical distances between enterprises (energy losses)
- Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)
- Lack of monitoring and measuring of energy consumption within enterprises
- Lack of infrastructure (physical space for new technologies, distribution infrastructure for the transportation of waste streams or by-products)

- Lack of technical solutions for managing by-products
- Outdated infrastructure does not allow efficient solutions
- Most of the energy efficiency potentials in the company have already been realized
- Hesitant to interfere within reliably running production processes (production disruptions, hidden costs)
- Lack of knowledge for designing, developing, constructing, manufacturing, operating and maintaining new technologies or cooperation e.g. first of its kind
- Insufficient technology maturity (TRL evaluation)
- Integration of energy management systems (microgrid EMS)
- Intellectual property protection hampers the dissemination of technology relevant information
- Lack of knowledge about technical options, their applicability and reliability
- Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities

### Information Provision Perspective

#### In the beginning
- Missing informational head of the park, who could initiate cooperation ideas
- Lack of interest in the neighbouring company’s energy demands/residuals

- Lack of knowledge about successful demonstration projects and/or other references
- Energy is not a strategic important issue
- Lack of access to external competences
- Lack of knowledge about possible side-streams, collaborating partners, etc.
Stage 2: Will of investing and cooperation

Action 2: Investigation/Data Acquisition on inefficiencies and partners

Stage 3: Knowledge of inefficiencies and cooperation opportunities

**Economic Perspective**
- **Financial**
  - Existing plants are not depreciated today, which hampers the investment in new ones
  - Limited customer acceptance (fear of distorted, unreliable business relations)
- **Market-related**
  - Fear of competitive disadvantages through exchange of information, knowledge and data
  - Costs associated with environmental damage/climate effects are poorly reflected in market prices
  - No or insufficient consideration of life-cycle costs in market prices

**Social/Managerial Perspective**
- **Individual**
  - Lack of skills and competencies to deal with issues other than the core business
  - Fear of distortions to core business due to occupied (human) resources
  - Staff is not motivated to deal with (their departments) energy demand etc.
  - Responsibility for energy topics is not clearly defined, so data acquisition is difficult
- **Mutual**
  - Weak cross-sectoral co-operation, cooperation opportunities may be overseen
  - No prior relation between companies in an industrial park
  - Different management/reporting levels at involved companies are responsible
- **Organizational**
  - Problems due to split incentives may occur internally and/or externally
  - Lack of trust between companies and park manager / or service companies
  - No possibility or no willingness to make changes to a rented building
  - Absence of energy management systems (ISO 50001, also e.g. ISO 9001 and ISO 14001)

**Framework Perspective**
- **Legislative/Regulatory**
  - Industrial codes and standards are not aligned with proposed solutions
  - Infrastructure related uncertainties (e.g. regulations for HV and LV networks)
  - Uncertainties in national legislation
  - Incoherence between local, regional, national, European legislation creates uncertainty
  - Legal complexity in the individual Member States
  - Big data management
  - No legal claim for building heat pipes over private ground
- **Standardisation**
  - Prohibition of exchanging electricity between two customers
  - Lack of standardization about waste heat exchange (e.g. metering and measurement)
  - Frameworks prohibit technical/economical sound cooperation in the gas & electricity market

**Technical/Engineering Perspective**
- **During acquisition**
  - Uncertainty of quality of exchanged energy (temperature level, continuity profile, volumes etc.)
  - Aligning intermittent energy production (load profiles) between processes
  - Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)
  - Lack of feasibility study, life cycle analysis or technological forecasting
  - Missing link between supply/load profiles of the companies (no appropriate usage of by-products or waste streams possible)
  - Lack of monitoring and measuring of energy consumption within enterprises
  - High demands on computer performance and IoT sensors/actuators for data analysis and optimisation algorithms
  - Cyber security protocols to protect privacy issues for energy exchange are required
- **Further**
  - Most of the energy efficiency potentials in the company have already been realized
  - Lack of knowledge about technical options, their applicability and reliability
  - Lack of knowledge for designing, developing, constructing, manufacturing, operating and maintaining new technologies or cooperation e.g. first of its kind
  - Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities
  - Insufficient technology maturity (TRL evaluation)
  - Inappropriate technologies (as of weather conditions, intermittent source, capacity utilization not economical, incompatible)
  - Intermittency of some renewable energy sources (unsufficient supply, storage systems or load shifting required to meet demand)
  - Integration of energy management systems (microgrid EMS)
  - Intellectual property protection hampers the dissemination of technology relevant information

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Project Start: 01/03/2018 | Duration: 36 Months
### Information Provision Perspective

<table>
<thead>
<tr>
<th>During acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>► Lack of knowledge about possible side-streams, collaborating partners, etc.</td>
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<td>► Provision of sensitive business data, e.g. energy data, is needed</td>
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<td>► Failure to recognize non-energy benefits of efficiency</td>
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<tr>
<td>► Energy is not a strategic important issue</td>
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<tr>
<td>► Lack of access to external competences</td>
</tr>
</tbody>
</table>
Project Start: 01/03/2018 | Duration: 36 Months

### Economic Perspective
- **Financial**
  - Players fear hidden costs of first-of-kind investment projects
  - Companies/Parks lack access to (long-term) financing or lack knowledge thereof
  - Internal competition for capital prioritizes non-energy related investments
  - Long payback times are not in line with company guidelines
  - Companies/parks face high investment costs
  - Financial problems due to retroactive changes of renewable energy support schemes, which also create lack of trust among investors
  - Players lack substantial private (risk) finance
  - No additional own funds available
  - Existing plants are not depreciated today, which hampers the investment in new ones
  - Energy costs are not a crucial cost factor
  - Existing structures are costly to change
  - (Monetarized) economic, organizational and technical risks, including risk uncertainties

- **Market-related**
  - Fear of technological lock-in effects or obsolescence due to expected technological progress
  - Limited customer acceptance (fear of distorted, unreliable business relations)
  - Costs associated with environmental damage/climate effects are poorly reflected in market prices
  - No or insufficient consideration of life-cycle costs in market prices
  - Uncertainty about energy/resource price developments
  - Availability of risk insurance insufficiently offered on market

### Social/Managerial Perspective
- **Individual**
  - Fear of distortions to core business
  - Uncertainty of effects on local population, communities where park/company is located
  - Success driven managers with short-term contracts need fast success

- **Mutual**
  - Different management/reporting levels at involved companies are responsible
  - Fears of security of supply in case switching of suppliers is limited

- **Organizational**
  - Problems due to split incentives may occur internally and/or externally
  - Lack of trust between companies and park manager / or service companies
  - Companies are direct market competitors
  - Fear of negative effects on workplace safety
  - Uncertainty and lack of information about internal organization
  - Changes to managerial structures may become necessary, reduces acceptance of decision makers
  - Incentive structures in companies guiding objectives of decision makers reduce acceptance
  - No possibility or no willingness to make changes to a rented building/ lessor does not allow implementation

### Framework Perspective
- **Legislative/Regulatory/Policy**
  - Industrial codes and standards are not aligned with proposed solutions
  - Infrastructure related uncertainties (e.g. regulations for HV and LV networks)
  - District heating operator is not legally obliged to allow and remunerate a feed in into his network
  - Uncertainties in national legislation
  - Incoherence between local, regional, national, European legislation creates uncertainty
  - Tax structures (such as depreciation periods)
  - Legal complexity in the individual Member States
  - Big data management
  - Regulation is counter-productive to some technologies/measures

  - Lack of comprehensive and coherent energy related strategies increase investment risks
  - Ineffective market based support instruments
  - Lack of appropriate incentives
  - Application for subsidies is too complicated
### Standardisation
- Different safety issues (and yearly costs) according to different voltage supply
- Prohibition of exchanging electricity between two customers
- Lack of standardization about waste heat exchange (e.g. metering and measurement)
- Energy taxes on individual energy carriers need to be harmonized in a local hybrid system
- Registration as an energy supplier is needed if energy (especially electricity) is utilized externally
- At the moment it is difficult to have more than one energy supplier, which makes selling infrequent residual/surplus energy difficult for companies
- Frameworks prohibit technical/economical sound cooperation in the gas & electricity market

### Technical/Engineering Perspective

#### Realisation
- Uncertainty of quality of exchanged energy (temperature level, continuity profile, volumes etc.)
- Aligning intermittent energy production (load profiles) between processes
- Crossing private ground of neighbours with e.g. heat pipes
- Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)
- Lack of feasibility study, life cycle analysis or technological forecasting
- Advanced communication infrastructure needed (bi-directional flow of energy and information like for smart grids, microgrids and prosumers)
- Lack of monitoring and measuring of energy consumption within enterprises
- High demands on computer performance and IoT sensors/actuators for data analysis and optimisation algorithms
- Cyber security protocols to protect privacy issues for energy exchange are required
- Lack of infrastructure (physical space for new technologies and distribution infrastructure for the transportation of waste streams or by-products is required)
- Long physical distances between enterprises (energy losses)
- Lack of technical solutions for managing by-products
- Missing link between supply/load profiles of the companies (no appropriate usage of by-products or waste streams possible)
- Building or reconstructing facilities to enable energy cooperation may imply the requirement of other measures to comply with the current “best available technologies” (BAT) standards.

### Information Provision Perspective

#### Realisation
- Outdated infrastructure does not allow efficient solutions
- Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities
- Insufficient technology maturity (TRL evaluation)
- Intermittency of some renewable energy sources (unsufficient supply, storage systems or load shifting required to meet demand)
- Integration of energy management systems (microgrid EMS)
- Hesitant to interfere within reliably running production processes (production disruptions, hidden costs)
- Provision of sensitive business data, e.g. energy data, is needed
- Information exchange and communication between relevant persons does not work properly
- Uncertainty about organizational issues of energy cooperation (e.g. who runs the new/joint plant)

### Technical/Engineering Perspective

#### Realisation
- Lack of knowledge about financing, subsidy options
- Uncertainty about quantification of effects
- Failure to recognize non-energy benefits of efficiency
9 References


[41] Kaempfer, J. (2011) ‘Where Have All the 10-Year Strategies Gone?: Short-term thinking has become the strategy of choice for many executives as they fixate on today’s breakneck speed of change. However, in the race to stay on top in uncertain times, the undisputed champions are those who take the long view’, *Executive Agenda - Ideas and Insights for Business Leaders*.


[140] ENEA and Ministry of Economic Development Italy *Italian Energy Efficiency Action Plan: June 2017*. 

Project Start: 01/03/2018 | Duration: 36 Months


