Contentious Light: An Analytical Framework for Lighting Conflicts

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Abstract

This paper takes into view the broad range of contemporary conflicts regarding outdoor lighting. It proposes a working-definition that allows for differentiating lighting conflicts from other forms of lighting-related contention, as well as an analytical framework that allows for the structured description of individual lighting conflicts, and the comparative analysis of multiple cases. The analytical framework was developed based on the social-scientific analysis of media reports of existing conflict cases in Europe and North America, and informed by existing knowledge from the fields of lighting and conflict studies. A central challenge for developing such a framework is dealing with the high level of contingency and complexity of lighting conflicts. The framework reduces this complexity by focusing its field of vision to those aspects that are directly related to the lighting and its contestation. For each of these aspects, it provides sets of descriptive variables that allow for describing the conflicts' individuality in a standardized – and thus comparable – way. The framework strictly separates the regarded aspects from their judgment by the conflict parties, making it possible to contrast their views on one and the same lighting situation. A visual template supports the process of analysis. It allows for depicting individual cases in short, and for clearly identifying where perspectives differ. At the multiple-case level, the framework not only opens up possibilities for spatial and temporal comparisons of lighting conflicts and the subsequent development of typologies, but also for harnessing their potential for informing the development of more sustainable planning and policy approaches for artificial lighting.

Keywords: lighting, conflicts, contention, method, classification

1. Introduction

Since the earliest efforts to systematically illuminate the public realm, debates about the 'whether' and 'how' of artificial lighting have gone hand-in-hand with the expansion of outdoor illumination [1, 2, 3, 4]. Historical studies show that debates related to lighting intensified especially in times of transition, when new technologies were introduced and lighting practices changed [1, 2]. Today, we are witnessing a double-shift of fundamental change that affects not only the way lighting is produced and employed, but also the way it is perceived: For one, with the 'LED-revolution' new technology is rapidly spreading that comes with profoundly different characteristics and opens up new possibilities of application [5], bringing more and/or different light to a broad range of uses – from 'white' light on streets to animated building facades, from colorful illuminations in front yards to flashing storefront signs. For another, in the brightly lit countries of the global North, artificial light at night is increasingly being framed as a pollutant, the employment of which comes at a significant cost, ranging from the loss of darkness and the view of the night sky to effects on individual species, ecosystems and possibly human health [6, 7]. As a result, we are currently likely witnessing an increase in lighting conflicts.

The aim of this paper is to provide an analytical framework that facilitates the systematic description and comparative analysis of the diverse array of contemporary conflicts regarding outdoor lighting. It thereby complements existing in-depth studies of individual cases of contemporary lighting conflicts from the fields of political science, urban planning and sociology [8, 9, 10], with an instrument that allows for interdisciplinary inquiry across multiple cases. It foregrounds and makes transparent the oftentimes contradictory demands towards outdoor artificial lighting that come to a head in lighting conflicts [11]. As such, it can help harness the rich potential lighting conflicts hold as a resource for informing the development of sustainable planning and policy approaches for outdoor lighting.

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A framework designed specifically for the analysis of lighting conflicts is called for not only because lighting conflicts are, in themselves, highly differentiated, and existing categorizations such as functional or technical types of lighting do not suffice to grasp the differences between them, but also because they are distinctly different from related – and far more intensely studied – types of conflict. Land-use and locational conflicts share with lighting conflicts that they concern man-made physical interventions into the living environment, on which they can have near- and far-range effects, often by way of emissions [e.g. 12]. Amongst emissions, light shares numerous properties with sound, making the two phenomena comparable in many respects: both are sensory stimuli that are perceived subjectively and that can be interpreted ambivalently, whereby the terms 'light' and 'sound' generally express positive connotations, while 'light pollution' and 'noise (pollution)' are used to express negative views [13]. As such, lessons learned from attempts to control noise problems can provide important insights for the management of lighting issues. A key difference, however, is that man-made effects on our sonic environment are, just like many other conflictual emissions (e.g. particulates), often side-products of other activities such as production or transportation. As such, they can generally be assumed to be 'unintended' or 'unwanted', as is typically the case in analyses [e.g. 12, 14]. Artificial lighting, by contrast, is generally intentionally employed to fulfill a specific purpose in and of itself. Notwithstanding that portions of any emitted light may not be directly serving that purpose (e.g. stray light), this means that for lighting conflicts, an analytical approach is needed that takes into account both the 'positive' and the 'negative' views on a lighting situation.

What constitutes a lighting conflict has, so far, not been defined. To allow for selecting the conflict cases on which the analytical framework is modeled, a working-definition was therefore developed that allows for distinguishing lighting conflicts from other forms of lighting-related contention.

Like any other type of conflict, lighting conflicts are a messy subject of inquiry: They are social processes that are embedded in societal, spatial and temporal contexts, making them complex and highly contingent [15, 16]. A key objective is therefore to reduce the complexity of lighting conflicts by identifying a limited range of aspects to be studied [17]. The proposed framework accomplishes this by focusing its field of vision on those aspects of the conflicts that are directly related to the lighting and its contestation, namely: the relevant lighting installation, the lighting-related conflict trigger, the conflict parties and their perspectives on the lighting. By setting these system boundaries and consciously disregarding the unique spatial and social context of each case, the framework extracts the key lighting-related parameters of the conflicts from the complex situations into which they are woven, thereby facilitating cross-case analyses. For each of the targeted conflict dimensions, the framework proposes a set of variables that allow for describing individual conflict cases in a standardized way – and thus for comparing larger numbers of conflicts such as to discover overarching patterns and develop typologies.

This article is structured as follows: In section 2, lighting conflicts are defined and differentiated from other types of lighting-related contention. Section 3 outlines the research design used for developing the analytical framework. In section 4, the framework's structure and its individual components are explained. In section 5, the framework is discussed, and conclusions are drawn in section 6.

2. Definition of lighting conflicts

Lighting conflicts are manifest disagreement between two or more actors regarding the existence and/or characteristics of artificial outdoor lighting in a given place and time.[2] This definition was developed based on a review of sociological conflict theories as well as on an empirical review of conflicts involving light.

The definition of conflict as "manifest disagreement" follows Luhmann's [18] notion that the mere existence of dissent (e.g. incompatible points of view or preferences) does not suffice to constitute conflict: Disagreement must be explicitly communicated. "Conflict, in other words, depends on someone saying 'no'" [19]. This allows for a clear distinction between *tension* and *conflict*, both of which describe situations of opposition between actors: While tension offers potential for conflict to erupt, only those cases are considered conflicts in which at least one party is not only conscious of the underlying disagreement, but also takes some form of action in relation to it [20, 21]. Following Glasl [22], a given situation can constitute a conflict even if not all parties involved perceive it as such: It is enough if one actor is conscious of existing dissent and acts upon it, even if the other actor may not (yet) be aware of the dissent.

This manifest disagreement, i.e. the contention itself, can take on many forms of expression and levels of escalation, and take place in different types of arenas, ranging from individual personal encounters to formal legal procedures, and from political and media engagement to violent and non-violent physical action. Actors, i.e. the conflict parties, can be individuals, groups or organizations of various types (public, private) and sizes.

[2] Outdoor lighting is understood as lighting that is either positioned outdoors (from where it may affect indoor spaces), or that affects outdoor spaces (even if it originates indoors).

Artificial lighting, i.e. the object of contention, includes any type of emitted light emitted from a man-made light source.

By determining the existence and/or characteristics of lighting in a given place and time as the object of contention, the definition focuses on conflicts about the 'whether' and 'how' of concrete elements of lighting, irrespective of whether these already exist or do not yet exist but are planned or desired. It simultaneously excludes a number of other forms of lighting-related contention, such as: conflicts that exclusively revolve around who should pay for lighting (e.g. for holiday lighting in shopping streets); so-called 'light wars', which are generally not conflicts but situations of rivalry in which lighting is used competitively as a means of attracting attention (typically by neighboring businesses)[3]; conflicts in which artificial light is used as a weapon (as was e.g. the case in colonial warfare, where arc lights were used to blind and confound rebels [4]).

Finally, lighting conflicts do not always revolve exclusively around light. As lighting installations are part of the built environment, the installations themselves as well as the light they emit can be part of a larger bundle of issues. An example is a conflict that erupted around a large-scale advertisement poster that was attached to a scaffolding in front of apartment windows – the fact that the poster was illuminated at night was one point of contention, next to the issue that the poster blocked the residents' view and limited the amount of daylight in their homes [23]. Conflicts that revolve exclusively around lighting and those that do so only in part can be differentiated as 'full' or 'partial' lighting conflicts. In the latter case, as in general, this paper regards only the lighting-related aspects of conflicts.

3. Research design

The analytical framework was developed using an explorative research design built on qualitative methods of empirical social research. The research design combined inductive and deductive elements, drawing upon documented cases of lighting conflicts in Europe and North America on the one hand, and existing concepts from the fields of conflict studies and lighting studies on the other.

3.1 Data sampling: Finding and selecting conflict cases

Media reports of lighting conflicts were chosen as the empirical basis for the development of the framework. Conflict cases were selected following a strategic, information-oriented approach [24] that was guided by two criteria: Firstly, the data sample should maximize the variety of cases, i.e. capture a sufficiently broad range of lighting conflicts to approximate the spectrum of contemporary lighting conflicts in the brightly lit countries of the global North, in order to allow for grounding the framework in their plurality. Secondly, the conflicts should be documented in sufficient detail and completeness to allow for understanding who the main conflict parties are and their respective positions regarding the lighting situation in question.

Data was gathered in a step-by-step process that combined several different search strategies and tapped a variety of information channels in two different languages.

An initial set of articles was gathered via systematic keyword-searches in the online archives of three daily German newspapers[4] for the time span from 01/2000-02/2018. This resulted in 83 articles corresponding to 20 different cases of lighting conflicts as defined in section 2. For each case, further reports were queried via targeted keyword searches in the online archives of the same paper and, by way of online search engines, in other media outlets. Where available, published opinion pieces by conflict parties were included in addition to journalistic accounts. Cases for which data remained insufficient (typically because they were only featured in one very brief article) were subsequently excluded, resulting in 13 cases documented in 71 articles.

This basic sample was successively complemented by way of selected additional conflict cases from other regions in and outside of Germany in order to fill evident gaps and generally expand the sample's scope in terms of types of lighting conflicts[5], thereby increasing its overall coverage and variation. The additional cases were found via links to media reports posted in social media (twitter)[6] or featured in Google alerts[7] between 2013-2018, as well as via online search engines in targeted searches for conflicts regarding specific functional

[3] While 'light wars' are not lighting conflicts themselves, they may well lead to such conflicts when third parties take issue with the lighting.

[4] The archives were those of two major newspapers from Berlin (Berliner Zeitung, Tagesspiegel), which cover occurrences in the country's largest city, and the major newspaper of Leipzig (Leipziger Volkszeitung), which covers occurrences in Leipzig as well as it's peri-urban and rural surroundings. These cities and papers were chosen because conflict cases were known to exist in both regions, and the papers' archives are freely accessible. For the search, three groups of keywords were formed, which were systematically combined with each other. Group 1: Beleuchtung, Licht, künstlich (German: lighting, light, artificial); group 2: Laterne, (Leucht-)Werbung, Weihnachts-beleuchtung, Stadion, Arena, Leuchtschrift, Hafen, Kraftwerk, Flughafen (lamp, (illuminated) advertisement, Christmas lighting, stadium, arena, illuminated lettering, harbor, power plant, airport); group 3: Störung, Ärger, Konflikt, Streit, Protest (disturbance, trouble, conflict, dispute, protest).

[5] The functional types of lighting in question and the conflict issues were primarily decisive.

[6] In German and English; generally posted by users active in the fields of lighting and light pollution mitigation.

[7] The keyword for alerts was "Lichtverschmutzung" (German: light pollution).

types of lighting[8]. Additional media reports were again queried for each identified case that matched the definition and was included in the corpus.

The final sample consists of 203 media articles, which relate to a total of 28 conflict cases (see table 1). While 11 cases are only represented with one article, 8 are represented with 10 or more articles, with a maximum of 46 articles for one case, and an average of 7 per case. 18 of the cases are located in Germany, 6 in the United States, 2 in Switzerland and one each in Italy and Poland.

Nr.	Country	Place	Year (begin)	Functional type of lighting concerned
1	Germany	Aachen	2015	Infrastructural lighting: Street lighting
2	Germany	Bad Lausick	2010	Infrastructural lighting: Street lighting
3	Germany	Baunatal	2018	Safety & security lighting: Workplace safety lighting
4	Germany	Berlin	2013	Advertisement lighting: illuminated building wrap
5	Germany	Berlin	2005	Advertisement lighting: Illuminated sign
6	Germany	Berlin	2008	Architectural lighting: Media façade Advertisement lighting: Illuminated billboard
7	Germany	Berlin	2006	Architectural lighting: Accent lighting
8	Germany	Berlin	2016	Architectural lighting: Accent lighting
9	Germany	Berlin	2016	Infrastructural lighting: Pathway lighting
10	Germany	Berlin	2006	Infrastructural lighting: Street lighting
11	Germany	Berlin	2009	Infrastructural lighting: Street lighting
12	Germany	Freiburg i.Br.	2014	Architectural lighting: Accent lighting
13	Germany	Frotheim	2018	Infrastructural lighting: Street lighting
14	Germany	Gilching	2012	Festive & artistic lighting: Seasonal lighting
15	Germany	Grafenberg	2018	Infrastructural lighting: Pathway lighting
16	Germany	Leipzig	2013	Advertisement lighting: Illuminated sign
17	Germany	Travemünde	2013	Infrastructural lighting: Pathway lighting
18	Germany	Wiesbaden	2001	Safety & security lighting: Security lighting
19	Italy	Rome	2017	Infrastructural lighting: Street lighting
20	Poland	Bogatynia	2015	Productivity lighting: Greenhouse lighting
21	Switzerland	Jona	2018	Recreational lighting: Sports field lighting
22	Switzerland	Zürich	2006	Festive & artistic lighting: Seasonal lighting
23	USA	Davis, CA	2014	Infrastructural lighting: Street lighting
24	USA	East Mountains, NM	2015	Infrastructural lighting: Area lighting
25	USA	Ft. Myers, FL	2015	Advertisement lighting: Storefront lighting
26	USA	Great Neck, NY	2016	Infrastructural lighting: Street lighting
27	USA	Miami, FL	2015	Advertisement lighting: Illuminated billboards
28	USA	Washington, DC	2013	Advertisement lighting: Illuminated billboards

Table 1. Overview of conflict cases selected for developing the analytical framework

3.2 Data analysis: Studying the conflict cases and developing the framework

In analyzing data, the information in the media reports was taken at face value: actors' statements were interpreted to be correct and representative of their convictions, and the described conflicts were categorically considered to be "realistic" [25], i.e. truly about reaching a result regarding the lighting in question[9].

Data was interpreted using qualitative content analysis (QCA). An established method in the social sciences, QCA was chosen because it allows for dealing with large amounts of qualitative data and is particularly helpful for finding ways of describing and structuring phenomena when existing theory and knowledge are limited [26]. In QCA, the content of text data is interpreted through a step-by-step process of systematic classification that reduces complexity in order to identify overarching themes or patterns. From these, a system of categories is developed, that is then applied to the entire body of data [26, 27]. A key strength of QCA is that it is capable of combining concept- and data-driven approaches [27], thereby allowing for the integration of different types of knowledge.

Following a familiarization with the data by reading through the full corpus of media reports, relevant content was identified, namely sections of the articles containing information on the lighting-related aspects and basic parameters of the conflict. These segments were coded, thereby separating individual items of information. These items provided the empirical basis for the development of categories, which were brought into a hierarchical order. This system of categories was developed in an iterative process during which the categories themselves as well as their structure were increasingly consolidated and refined by way of a constant movement

[8] This strategy was applied equally in English and German.

[9] By contrast: In "nonrealistic conflicts", the conflict is an end in itself and serves primarily to release tension [25].

between concept and data [comp. 28]. The system of categories is rooted in the analysis of the media data on the one hand: categories and subcategories were defined and revised as needed while working through the diverse set of cases. On the other hand, the definition and sorting of categories was informed by existing knowledge from the fields of conflict analysis, conflict studies and lighting studies. The resulting system of categories provided the frame and, respectively, the content dimensions (see fig. 2 and 3) of the proposed analytical framework.

Based on the framework and on forms of representation regularly used in applied conflict analysis [e.g. 29, 30], a template was developed that aids the analysis of individual conflict cases and allows for visualizing them. The framework as well as the template were tested on sampled conflict cases to validate their applicability.

4. Introducing the analytical framework

The analytical framework makes different types of lighting conflicts readable and comparable in a standardized form. To this end, it reduces their complexity by taking into view a limited range of aspects, by separating aspects that are, in reality, closely intertwined, and by extracting key items of information, for which it provides a standardized vocabulary. It focuses on grasping what is at the root of lighting conflicts, namely the differing perspectives of actors on one and the same lighting situation.

This section firstly introduces the overall approach of the framework. Then, using an example conflict case to illustrate its application and functioning (fig. 1), it walks through the framework itself, explaining its individual components, their relations to each other, and the findings that underpin them.

4.1 Overall approach and layout of the framework

In the simplified view of the framework, every lighting conflict consists of at least one actor who is a defendant and one who is a complainant relative to existing or planned lighting. The conflict is triggered by an event of change that is caused by the defendant, or by the absence of such an event that is, however, desired by the complainant. It is rooted in the actors' differing interests regarding the effects of the lighting, which translate into what is at the surface of the conflict, namely their clashing positions regarding the concrete characteristics of the lighting.

The framework is built to analyze these aspects in three steps, each of which targets a different dimension of the conflict in question. In the first step, the basic situation of the conflict is identified in terms of the type of lighting installation in question, and of what led to the conflict. In the second step, the main conflict parties are identified and separated into two groups according to their basic positions regarding the disputed lighting situation. This differentiation provides the backbone for the third step, in which the actors' perspectives on the lighting situation are systematically contrasted to identify the key points of contention in terms of the light's characteristics, and to examine how the actors' underlying interests relate to each other.

In each of these steps, information is first extracted from the case material. It is then interpreted with the help of sets of descriptive variables. These are provided for each targeted aspect (fig. 2 and 3) and allow for classifying the information within these aspects into the abstracted categories of functional and technical types of lighting, types of conflict trigger and types of actors, as well as types of debated change, characteristics and effects. Thereby, case-specific information is captured in a reduced and standardized way that allows for comparing the findings from individual cases amongst each other. The template for the visual analysis of cases supports this process of extraction and abstraction: for each analyzed dimension, it provides a section for case-specific information and for its translation into the variables, which can then be transferred to a database for multiple-case analyses.

It is key to the framework that these variables are principally kept purely 'neutral' and separated from any valuation by the actors. It is through the allocation of the variables to the relevant side of the conflict – and thus to the 'positive' or 'negative' perspective on the lighting situation – that their valuations are captured. This is visualized in the template by way of separate columns, in which the perspectives of each side are represented. In doing so, the framework maintains an impartial stance vis-à-vis the conflict parties and their perspectives. This impartiality is paramount for dealing with the highly ambivalent perceptions of lighting and its effects[10], which take center-stage in lighting conflicts.

[10] For example, street light entering homes through windows may be seen as a nuisance by one person (e.g. because it disturbs their sleep), but welcomed by another (e.g. because they needn't switch on their lights to find their way at night). The framework thus grasps this as a question of 'spatial distribution' rather than of 'light trespass', which already contains a valuation and thus would not allow for describing the positive view.

Finally, conflicts are social processes that evolve over time. Neither the set of actors that engage in them nor their positions and points of view are set in stone. The framework does not aim to capture this evolution. Rather, actors' arguments are regarded in sum and independently of the point in time at which they are made, so long as actors do not fundamentally change their positions or argumentations.

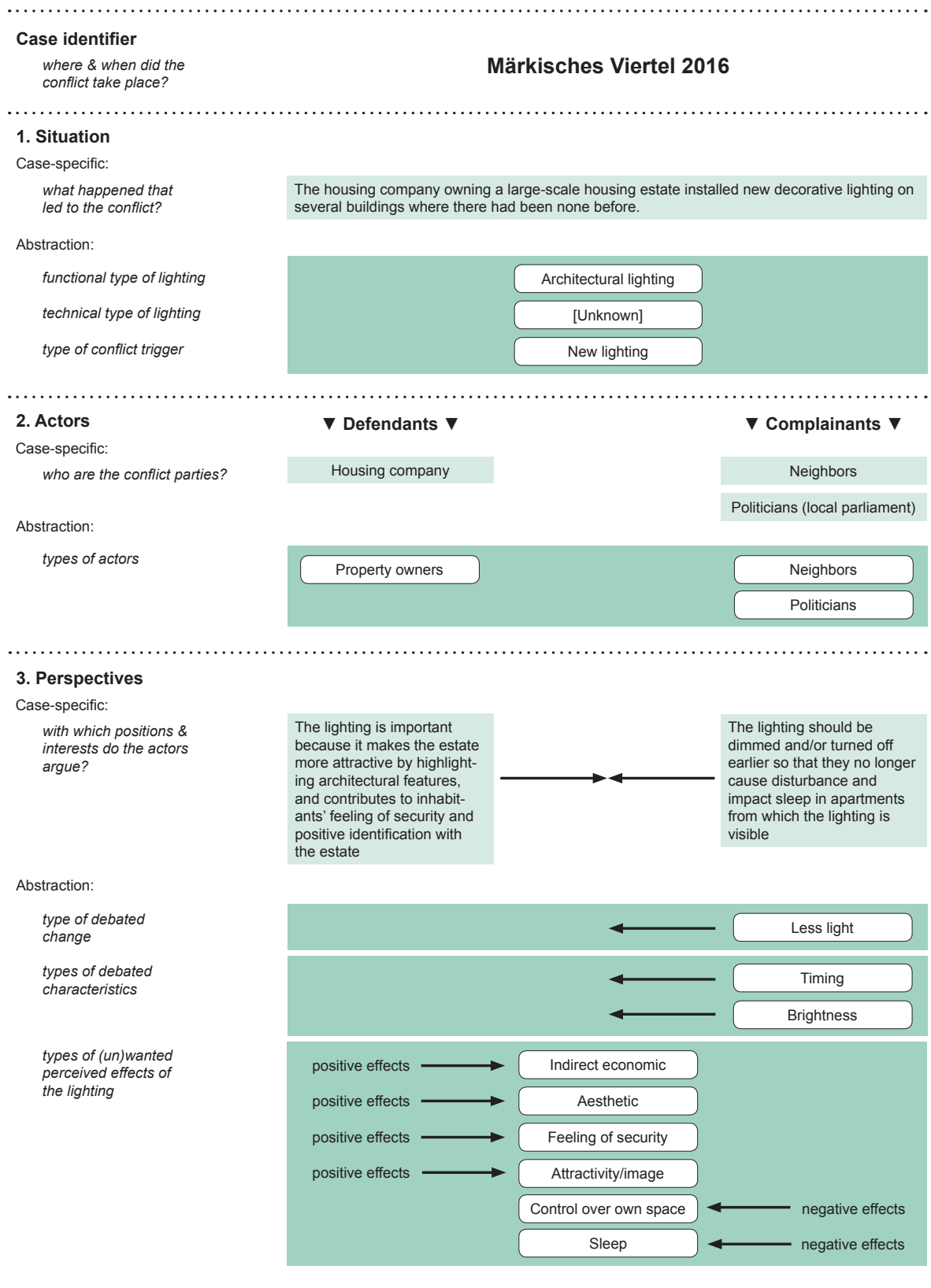

Fig. 1: Visual template for the analysis of lighting conflicts applied to an example case

Functional types of lighting	Types of lighting technology	Types of conflict triggers	Types of actors
Infrastructural lighting: • **Street lighting** (esp. for roads including/focused on motorized vehicle traffic) • **Pathway lighting** (e.g. in parks, esp. for foot/cycle traffic) • **Area lighting** (e.g. of parking lots or public squares) *Safety & security lighting:* • **Workplace safety lighting** (e.g. on construction sites or at fire departments) • **Security lighting** (intended to deter criminal activity, e.g. floodlights on buildings) *Productivity lighting:* • **Greenhouse lighting** (grow lights shining out from within greenhouses) *Advertisement lighting:* • **Illuminated billboards** (large lit advertisements; incl. internally, externally lit & digital varieties) • **Illuminated building wraps** (typically attached to scaffoldings) • **Illuminated advertisement signs** (internally or externally lit, including neon signs) • **Storefront lighting** (e.g. on shops, restaurants; including window lighting) *Architectural lighting:* • **Accent lighting** (decorative lighting on/of buildings, whether exterior or interior) • **Media façades** (large-scale lighting installed on/in building façades whose content can be flexibly adapted) *Festive & artistic lighting:* • **Seasonal lighting** (temporary decorative lighting installations, e.g. holiday lights in shopping streets) • **Light art** (applied art using light as a medium in projections or sculptures) *Recreational lighting* • **Sports field lighting** (e.g. for football grounds/stadiums)	• **Gas** • **Incandescent** • **Halogen incandescent** • **Fluorescent** • **Metal halide** • **Low pressure sodium** • **High pressure sodium** • **Mercury vapor** • **Neon** • **Xenon arc** • **LED** • **OLED**	• **New lighting** (new install-ation where there was none before) • **Replacement** (of existing lighting) • **Temporary switch-offs** (of existing lighting) • **Removal** (de-installation of lighting) • **Existing situation** (no change)	• **Property owners** (e.g. owner of a building to which lighting is attached) • **Property operators** (if not simultaneously property owner, e.g. of a business) • **Public administrations** (e.g. planning, immission control or heritage preservation authority) • **Politicians** (e.g. local parliamentarians or mayors) • **Neighbors** (to the lighting installation in question; whether private individuals or e.g. owners of a neighboring hotel) • **Residents** (of a town, settlement in general; not acting as part of an interest group) • **Interest groups** (e.g. environmental organizations or neighborhood associations) • **Public utility companies** (whether publicly or privately owned; e.g. an energy company respon-sible for installation and maintenance of street lighting) • **Ordering customers** (e.g. a firm booking illuminated advertisement)

Fig. 2: Descriptive variables (bold) for functional types of lighting (developed from the analyzed cases and further informed by existing systematizations [31, 32], sorted by families); types of lighting technology (developed from the analyzed cases and existing indexes [33]); types of conflict triggers (developed from the analyzed cases); and types of actors (developed from the analyzed cases).

Types of debated change	Debated characteristics of the given lighting	Perceived effects of the given lighting
• **More light** • **Less light** • **Different light**	• **Existence** of lighting (whether or not there is lighting at all) • **Brightness** • **Glare** • **Timing** • **Dynamics** (e.g. changing colors, brightness) • **Hue** (e.g. green, purple) • **Color temperature** (as can be expressed in Kelvin) • **Spatial distribution** (spatial reach of the light)	*Effects on safety & security:* • **Effects on Safety** (prevention of accidents in traffic, at workplaces etc.) • **Effects on Security** (prevention of crime) • **Effects on the feeling of security** • **Effects on legal security** (e.g. regarding insurance coverage) *Economic effects:* • **Direct economic effects** (e.g. costs of lighting installation and/or operation) • **Indirect economic effects** (e.g. economic benefits due to increased visibility of a business) *Environmental effects:* • **Effects on the living environment** (esp. regarding plants, animals, ecosystems) • **Effects on energy consumption** • **Effects on greenhouse gas emissions** *Effects on human health and well-being:* • **Effects on sleep** • **Effects on eyes** (e.g. retinal damage) • **Effects on nervous system** (esp. headaches) • **Effects on control over own space** (e.g. in cases of nuisance) *Effects on culture and science:* • **Effects on the visibility of the night sky** • **Effects on the experience of the night** *Effects on aesthetics and atmosphere:* • **Aesthetic effects** (in terms of e.g. 'ugly' or 'beautiful') • **Effects on the character of place** (e.g. in terms of heritage preservation, development of the local lightscape) • **Effects on attractivity/image** (of a place, brand, etc.)

Fig. 3: Descriptive variables (bold) for types of debated change (developed from the analyzed cases); debated characteristics of the given lighting (developed from the analyzed cases); and perceived effects of the given lighting (developed from the analyzed cases, sorted by families).

4.2 Dimension 1: The conflict situation – identifying basic coordinates

The first step of applying the analytical framework takes into view the outset of the conflict. It identifies basic fixed points that play a defining role in the conflict and provide relevant context information for understanding it. Importantly, these aspects are undisputed and thus allow for impartially describing the conflict situation, which is grasped via three aspects. Two of these relate to the object of conflict, and one to the conflict trigger:

- the *functional type of lighting*, which describes the main purpose and basic form of the lighting;
- the *type of lighting technology* used to produce the emitted light; and
- the *type of change* to the lighting situation that did (not) occur, bringing the conflict to erupt.

These three aspects were chosen because they constitute relevant points of reference in lighting and conflict studies. The first two aspects are categories that are regularly used in academic and professional discourses to describe lighting. Together with other basic coordinates (place, year) of the conflict, they provide helpful parameters for systematizing larger numbers of conflict cases. The third aspect builds on the insight from studies on land-use conflicts that these "arise from changes or projects of change, perceived by some actors as contrary to their interests or their wishes" [21]. It allows for following up on how and to what extent this also applies to lighting conflicts.

For the analysis, information is gathered to answer the question "what happened in terms of the lighting situation that led to the conflict?", and extracted by summarizing it in a short statement. In the example case of

Märkisches Viertel[11], this is: "The housing company owning a large-scale housing estate installed new decorative lighting on several buildings where there had been none before." This case-specific information is then abstracted by identifying the relevant variables – in this case: "architectural lighting" for the functional type, "unknown" for the type of technology, and "new lighting installation" for the type of trigger.

In the analyzed cases, the functional type of the lighting was always identifiable. It frequently appeared as an important reference point not only in the description of the situation, but also in the conflict parties' argumentations in terms of whether and what kind of lighting is suitable or justified for a given purpose. In the case of Märkisches Viertel, for example, the complainants argue that since the lighting only fulfills decorative or promotional purposes and is not relevant for safety and security, they should not have to live with the disturbances they perceive[12].

The type of lighting technology went without mention in the media reports for several of the cases, including that of Märkisches Viertel. The fairly frequent non-inclusion of information on the type of lighting technology indicates that it is not a standard point of reference for actors in lighting conflicts. In some cases, however, the type of technology features prominently. This can e.g. be because the debate includes the question of whether a specific choice of technology is suitable as such, as in the Berlin gaslight controversy [see 10 for a detailed account], or in which contested aspects of the lighting are attributed to a specific type of technology, as is typically the case in conflicts over the introduction of LED street lighting as occurred e.g. in Aachen, Germany [35].

The type of change could generally be identified fairly directly from the outline information or the actors' arguments provided in the media reports. A key insight here was that lighting conflicts do not only occur when change has happened or appears imminent, as suggested by Torre et al. for land-use conflicts – but also when change does not occur, but is desired by the complainants, such as in Grafenberg or Berlin, Germany, where residents demand lighting for unlit park paths [36, 37]. Furthermore, change does not have to be a sudden or singular event: it can also occur gradually and cumulatively, until a tipping point is reached at which opposition is sparked, such as in Ft. Myers, FL, where the historic preservation commission became active against restaurant operators in the city's River District, who increasingly installed LED lights to their fronts [38].

4.3 Dimension 2: The conflict actors – separating perspectives

The second dimension of the analytical framework takes into view the conflict parties, i.e. the actors who engage in a conflict. While the conflict parties themselves are not at the focus of the framework, the differing perspectives they hold are. This section therefore serves to identify the conflict's basic layout in terms of 'who is arguing against whom', so that the perspectives of these actors can then be studied and contrasted.

The first step is to identify the main actors[13], namely the disputants that are particularly formative for the conflict and typically hold the largest stakes. In the case of Märkisches Viertel, these are the housing company that installed the new lighting, several residents of the housing estate who became publicly vocal with complaints about it, as well as several members of the local parliament who are themselves also residents and feel disturbed by the light and/or whose constituents include irritated residents and who thus became engaged in the dispute.

These actors are then allocated to one of two groups that take on fundamentally different roles in the conflict:

- the *defendants* who – at least initially – find the lighting situation suitable. The main actor in this group is generally in some form of control over the contested lighting.
- the *complainants* are those who take issue with the lighting situation – thereby initiating the conflict – and demand some form of change.

These two categories essentially define the 'two sides of the fence' that emerged as a constant in the studied cases. The dividing line between them is their differing basic positions regarding the given or planned lighting: whether it is or is not suitable, and thus whether or not change is called for. Importantly, this dividing line is independent of the concrete lighting situation and of the positions these actors hold in terms of *what* about it is or is not suitable, and thus what should or should not be changed, which are studied in the next step of analysis. This approach of adopting the roles in a given conflict as a container and thus as a sorting criterion for variable actor-types and perspectives provides the necessary flexibility for dealing with the finding that the same type of

[11] Märkisches Viertel is a large housing estate of high-rise buildings in Berlin, Germany.

[12] In the words of a member of the local parliament: "The inhabitants and their children should not be exposed to this nuisance only for the purpose of achieving a night-time silhouette for promotional purposes." (own translation) [34].

[13] The framework grasps the actors by way of the position or function through which they engage in the conflict. For example, if a person engages in the conflict as a private individual living in a community planning a street lighting change, s/he would be classified as a 'resident' – whereas if s/he engages as a member of the town council or as a representative of a local environmental organization, she would be classified by this function, irrespective of the fact that s/he is also a resident.

actor can appear on either side of the fence, and that actors of the same type can hold very different views on what constitutes a suitable lighting situation from one case to the next.[14]

Furthermore, summarizing the actors and their perspectives into two groups (and, within these, into subgroups such as 'neighbors') is a central step of simplification that helps deal with a significant portion of the complexity that makes many lighting conflicts difficult to read: Often – as also in the example of Märkisches Viertel – far more than two actors are involved, each of whom has their own views and concerns. By grouping them into defendants and complainants, these individual perspectives are melded into one perspective per side, on which the further analysis is then based.

It is therefore key to ensure that the perspectives that are combined in each of the two groups are compatible. This, in turn, has implications for the selection of actors that can ultimately be included in the analysis. As the main two or three conflict parties generally emerge clearly, this especially concerns third parties, i.e. actors "that become involved in transforming the conflict" once it is already ongoing [30]. A typical example for such third parties in the studied conflict cases were experts called in by the main disputants. Whether or not the perspectives of such third parties (or of any other actors that become engaged at some point in the conflict) are included in the further analysis is ultimately a matter of case-by-case judgment that can only be passed following an initial review of the various actors' arguments: Actors whose points of view cannot safely be assumed to be shared by the main opponents, and of whom it cannot be safely assumed that they would allocate themselves to the one or other side, are excluded from further consideration.

4.4 Dimension 3: The actors' perspectives – identifying and comparing positions and interests

The third section is at the heart of the analytical framework: It serves to analyze and contrast the actors' differing perspectives on one and the same lighting situation, and to thereby carve out the essence of the conflict.

The analysis of the actors' perspectives involves several steps. These serve to disentangle aspects that are closely intertwined in the actors' argumentations, thereby breaking down their individual views into elements that can then be contrasted within and across cases.

4.4.1 Extraction: Identifying positions and interests

The analysis is begun by identifying the conflict parties' perspectives on the lighting in question in terms wherein they do (not) see problems and why. To this end, the various arguments made by the actors on each side are combined into a statement that summarizes the respective *lighting-related positions and interests* of the complainants and the defendants.

The positions relate to *what* the actors say they want in terms of the lighting situation [40, 41]. This may be more explicit on the side of the complainants than on that of the defendants. The complainants generally vocalize very concrete points of criticism and/or demands – such as in Märkisches Viertel, where they want the illumination to be either substantially dimmed and/or switched off at an earlier hour. In many cases, the defendants' positions are similarly concrete and essentially amount to the direct inversion or rejection of those of the complainants, to which they are reacting. In others, however, the defendants don't explicitly express a specific counter-position, but nonetheless affirm their positive view on the lighting and/or their positive intentions behind it by arguing their reasoning with the benefits they see the light to have. This especially occurred in cases in which the lighting had already been put in place, such as in Märkisches Viertel[15], and in which it appeared evident that the defendants had an interest in ultimately reaching a consensual solution, and/or themselves had doubts regarding the suitability of the lighting once it had gone from paper into practice.

The interests relate to *why* the actors say they want what they want in terms of the lighting situation, i.e. the reasons that underpin their positions [40, 41]. In the examined cases, this information was equally present and clearly recognizable in the argumentations of both sides. For example, in Märkisches Viertel the complainants argue amongst others that the brightness of the illumination needs to be dealt with because it disturbs their sleep, and the defendants argue amongst others that the illumination is beneficial because it perfectly highlights the buildings' unique architectural features.

[14] For example, in one case, a municipal administration may well defend its practice of not illuminating park pathways against demands to do so from residents [36]. In another, the situation is contrary, as residents protest against their local government's plans to illuminate their so-far unlit street [39].

[15] In the words of a representative of the housing company: "This decorative lighting is an important part of the design concept of the housing estate. It accentuates the individual characteristics of each architectural style and literally brings to light their formal aspects." (own translation) [34].

4.4.2 Abstraction: Interpreting and comparing positions and interests

On the basis of the thus identified positions and interests, three aspects are examined and abstracted into variables that played a key role in all studied conflict cases.

The first aspect is the *basic type of change to the lighting* that is debated in the conflict. This becomes evident from the demands that the complainants bring to the table, which are – at least initially – directly (in so many words) or indirectly (by not taking action and defending the current or planned situation) turned down by the defendants. As the analyzed cases showed, the basic types of lighting-change a conflict revolves around can go in one of three directions:

- demands for *more light*, as e.g. in Bad Lausick, Germany, where residents demand the reversal of part-night switch-offs of street lighting [42];
- demands for *less light*, as e.g. in Märkisches Viertel or Jona, Switzerland, where residents object to planned new sports field lighting [43];
- demands for *different light*, as typical in conflicts over the introduction of LED street lighting, such as in Aachen, Germany, Rome, Italy, or Davis, CA [35, 44, 45].

The second aspect concerns what the studied cases revolved around, namely the *characteristics of the lighting*, i.e. what concretely about the lighting is suitable or unsuitable, and should or should not be changed. The characteristics under debate include aspects that reach from the basic existence of the lighting installation to qualities of the emitted light, such as its color temperature, to questions of its operation, such as its timing (fig. 3). The characteristics are closely linked to the types of debated change: It is in these characteristics that the complainants see the problem – and in their change that they see the key to reaching the desired solution. These debated characteristics are again defined by the complainants, who bring them into the conflict as points of criticism (e.g. 'the light is too bright') or as demands (e.g. 'the light should be less bright') within their positions, which the defendants directly or indirectly reject. The analytical framework simplifies the two fractions' perspectives down to being 'in favor' or 'against' change to these characteristics. In cases in which several characteristics play a role, as in Märkisches Viertel with 'timing' and 'brightness', the framework thus flattens actors' possible prioritizations amongst the addressed aspects.

It is relevant to note that the expressions actors in lighting conflicts use in order to describe characteristics of lighting may not necessarily correspond to established technical terminology. Rather, they are closely connected to their personal perception of the situation. As the framework looks through the eyes of the actors, it stays as close as possible to the terms they are using. For example, while one complainant may describe a light as 'too bright', another might say it is 'too glaring': Both aspects are adopted as variables, irrespective of whether the two actors may or may not be referring to what in technical terms would be the same phenomenon. Further interpretation is applied when it is clear what actors are referring to, e.g. complaints about light being 'too cold' or 'too white' are grasped as 'color temperature'.

The third aspect takes into view what the examined cases showed the conflict parties' differing perspectives – and thus ultimately the conflict – to be rooted in, namely: their differing perceptions of the *effects of the lighting*, i.e. why it is that they appreciate or disappreciate the lighting in question. These are reflected in the interests the actors express and cover a broad range of topics including economic effects, effects on safety and security, on human health and on the living environment (fig. 3).

The framework is built to separate not only the actors' views on the effects from each other, but also the perceived effects from their valuation: first, the effects with which the defendants and complainants respectively argue are identified and grasped in purely descriptive (unvalued) variables; to these, then, the defendants' and complainants' valuations are attached in terms of 'positive', i.e. wanted, or 'negative', i.e. unwanted. This double-separation is rooted in the finding that the complainants' and defendants' views on the effects of the given lighting can differ in two ways: firstly, which range of effects they relate to, and secondly, how they judge these effects. This reflects the high degree of selectivity and ambivalence typical for perceptions of lighting, which also becomes apparent in that the same type of effect can be judged positively as well as negatively: An effect that the defendants see as a benefit in one case, may be seen as problematic by the complainants in another. This can equally occur within one conflict, when complainants and defendants have different views of the same effect – as in Freiburg, Germany, where some perceived the new cathedral illumination aesthetically befitting, while others found it unsuitable [46].

In going through these steps of analysis, it is essential that effects are reflected as the actors perceive them, irrespective of whether or not there is scientific evidence to support them or their linkage to the debated characteristics, as it is exactly in the differing interpretations of reality that the conflict lies [41]. Furthermore, the process of translating the actors' interests into (un-)wanted effects demands a certain amount of interpretation, which may be greater or smaller depending on the information at hand. In some cases, the (un-)wanted effects emerge fairly directly, as they are explicitly named (e.g. negative effect on sleep, i.e. human health and well-being). In others, more inference is called for: for example in Märkisches Viertel, the housing

company does not directly state that it wants to achieve indirect economic effects with the lighting – however, given that it is a for-profit company, it can safely be interpreted that the stated interest in increasing the attractivity of the housing estate is directed not only at current, but also at potential future residents, and at improving the company's overall image and visibility. Finally, as with the characteristics, the framework simplifies the actors' views on the effects by disregarding that they are, in reality, often weighted unequally.

Once the interpretive process is completed, it is possible to contrast the complainants' with the defendants' views on the effects that the lighting in question has – and thus on why it is they find it 'good' (suitable) or 'bad' (unsuitable) – and to see how these relate. In the visual template, it quickly becomes clear in which of two possible situations the conflict is rooted:

- The actors judge the lighting by different points of reference, effectively 'looking past each other'.
- The actors judge the lighting by partially or completely overlapping points of reference, on which they, however, have opposing views.

In combination with each other, the three regarded aspects provide a shorthand for assessing what the conflict revolves around at the surface – namely: what type of change and which concrete characteristics views are split about –, and what underpins the actors' opposing positions on these aspects at the underlying level – namely: which effects of the lighting they do or do not want.

5. Discussion

The proposed analytical framework allows for systematically comparing lighting conflicts amongst each other in terms of their key lighting-related parameters – the functional and technical type of lighting concerned, the conflict trigger and involved actors, the types of change and characteristics they debate, and the positive and negative effects they associate with the lighting. The following discussion revisits the empirics on which the framework is based, outlines its limitations and highlights its possibilities for being expanded, adapted and applied to a variety of purposes.

5.1 Limitations and expandability of the analytical framework

Media reports were chosen as an empirical basis for this study for several reasons: they provide the possibility of obtaining a wide sample of cases (far wider than the small portion of conflicts that is taken to courts), are easily accessible and a fairly reliable and detailed source of information that is regularly used in studies of large numbers of conflicts or protests [15, 21]. It is important to acknowledge, however, that media reports present a selective and interpreted picture of reality – analyzing them thus means interpreting interpretations. The hidden biases this brings could not be eliminated, but were countered by searching for and, wherever possible, including articles from different authors and media sources on one conflict.

The sampling of the conflict cases for the analysis was geared toward maximizing variety within a limited – and manageable – amount of data, to allow for developing a framework capable of reflecting the plurality of lighting conflicts. To this end, cases were researched in two different languages and via several different channels. Nonetheless, there are unquestionably conflict constellations that are not represented in the sample. In particular, by choosing media reports as an informational basis, only such lighting conflicts could be found that 'made the news'. As such, it is likely that especially 'smaller' lighting conflicts remained hidden. Furthermore, as a result of the study's focus on the global North, lighting conflicts in the South, where lighting is far more scarce and issues thus likely substantially different, were outside the field of vision. These blind spots were kept in mind during the development of the framework with the aim of making its structure robust and adaptable enough to accommodate such 'unknowns'. Whether this could be accomplished, and where adaptations may be necessary, should be verified with further testing.

The framework was kept lean by focusing only on those aspects of lighting conflicts that were considered essential for the purpose of grasping and comparing the lighting-related causes of contention. The framework is, however, conceived such as to allow for expansion: further descriptive aspects can easily be added, such as the type of built area in which the lighting is placed, the conflicts' level of escalation [22], or types of arenas in which conflicts are played out. Similarly, the conflict outcome could be captured in a fourth, yet to be developed, dimension of analysis.

The provided sets of variables, which were largely developed based on the studied cases, cover a broad range of aspects but are not exhaustive lists. Rather, they provide a basic structure and starting point which can be expanded to reflect the findings in studied cases. This adaptability is integral to the framework, and allows for adapting it to conflict cases in other geographic or temporal (historic, future) contexts, in which lighting technologies and issues will be different from those in the selected cases. Also, for more fine-grained analyses, the level of differentiation of the variables can be increased, e.g. by adding measurements of brightness as attributes to the types of lighting technology, or by distinguishing types of effects in more detail.

A way in which the framework reduces the complexity of conflicts to make them comparable in lager numbers is by disregarding nuances – in terms of the range of actors and perspectives included, more subtle differences between actors' positions, as well as priorities amongst their interests. While including more perspectives beyond those of the defendants and complainants, and/or differentiating amongst sub-groups' perspectives, would likely considerably compromise the framework's agility, developing a way of weighting the (un)wanted effects appears feasible and could add further depth to analyses.

As it is devised, the framework can cope with a single conflict at a time that revolves around a concrete lighting installation. It is not capable of adequately depicting lighting conflicts whose object does not have a certain degree of concreteness, or more complex systems of conflicts. This especially concerns conflicts that revolve around more general lighting policies, such as the adoption of dark-sky guidelines in a community, or framework decisions that target multiple different types of lighting installations around which various issues may arise, such as urban lighting concepts. Applying the framework to such conflicts may be possible by segmenting them into sub-conflicts that are then analyzed individually. Similarly, the framework is not capable of capturing dynamics such as shifting actor constellations and positions. However, such changes may be grasped and documented by applying the framework at various stages of a conflict's evolution.

5.2 Possible applications of the framework and further avenues of inquiry

The analytical framework is conceived primarily as a tool to generate data for multiple-case analyses, for which individual conflict cases serve as stepping-stones. This does not, however, exclude its application to individual cases in practical contexts. On the contrary, the framework can be used with data other than media reports, and applying it in planning processes or to evolving conflict cases may aid conflict prevention and resolution by making transparent the actors' underlying interests, which are what conflicts are essentially about [41]. These underlying interests are often not as diametrically opposed as the actors' positions, and can thus provide pointers toward solutions – which may also lie outside the realm of lighting. Additionally, the list of variables for perceived effects of lighting essentially provide an overview of the range of potential causes for conflict. Taking this broad range of effects into account in planning and policy-making for outdoor lighting would likely lead to a reduction of lighting conflicts.

While not indispensable, the visual template offers multiple advantages for practical as well as academic inquiry. As a means of illustration, it allows for quickly gaining an overview of the structure and nature of individual conflicts. As a working tool, it guides the researcher through the steps of analysis, and simultaneously provides a means of documenting the analytical process itself. Furthermore, by programming it as a mask that feeds the chosen variables into an underlying database, it can be directly used to assemble data for larger-scale studies.

Such analyses could allow for the development of typologies of lighting conflicts, by following up on potential interdependencies e.g. between types of debated change or characteristics and types of lighting, or between clusters of wanted/unwanted effects and other aspects. The framework also opens numerous possibilities for comparative studies of lighting conflicts, for example regarding different types of areas (e.g. urban/rural) or geographic regions as well as longitudinal studies of the development of lighting conflicts over time.

Additionally, multiple-case analyses could also help empirically found where an overarching line might be drawn between "intended" and "unintended" effects of lighting – two categories often referred to in recommendations for light pollution mitigation, that yet await to be operationalized beyond individual cases. While the effects judged positively by those who control the light are clearly intended, such effects that consistently do not appear in their argumentations, but are judged negatively by complainants, can provide indications of where a societal consensus might lie regarding what constitutes "unintended negative effects of lighting".

Finally, the case studies pointed towards aspects of lighting conflicts that are beyond the realm of the framework, but could provide interesting starting points for inquiries using other means of analysis. This particularly concerns factors that the analyzed cases showed may be highly influential in lighting conflicts, but lie beyond the lighting itself, such as communication issues and the design and execution of planning processes. A further point of interest would be to study "factual disputes" [47] – i.e. conflicts within the conflict, especially about the scientific reliability of arguments regarding the potential effects of lighting – and the role of experts in this context. This could provide valuable insights regarding communication about risks related to light pollution [48], and help to better understand which truths count in lighting conflicts and how the evolving body of knowledge regarding the effects of lighting is received and debated 'on the ground'.

6. Conclusions

The proposed analytical framework offers a means of dealing with the complexity and contingency of lighting conflicts by systematically reducing their complexity. With a focus on grasping the lighting-related causes of contention, it identifies constitutive aspects of the conflicts, and offers sets of variables that allow for describing their individuality in a standardized way. The framework thus facilitates comparative studies and the development of typologies of lighting conflicts, thereby opening up new avenues for interdisciplinary inquiry into the landscape of lighting conflicts.

The framework takes an impartial stance vis-à-vis the debated lighting situation to systematically look through the opposing conflict parties' eyes at the object of contention, thereby exposing differences in their perspectives. Differentiating these into positions and underlying interests shows that they relate to distinct categories: While lighting conflicts often revolve around specific characteristics of lighting at the surface, they are actually rooted in the conflict parties' differing perceptions of the effects of the given lighting. For the planning of artificial illumination, this finding underlines the importance of first assessing the full range of potential effects of a lighting intervention, and taking into account the perceptions of those affected by it, to only then take decisions about the appropriate solution in technical terms. Such an approach that is not technology- but effects-driven can likely aid in mitigating and reducing lighting conflicts.

Unconflictual lighting, however, is not automatically sustainable lighting – but from conflictual lighting lessons can be learned for making lighting more sustainable. The analytical framework itself provides a first overview of the broad range of types, characteristics and effects of lighting that play a role in lighting conflicts, which can be informative for the development of circumspect planning and policy approaches. Going further, it paves the ground for larger-scale studies that can make transparent where key issues lie and which interests compete and thus call for balancing at an overarching level.

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