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Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom

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HIGHLIGHTS

- This paper broadens current conceptualizations of energy justice for smart grids.
- The study explores values in the public debates on smart grids in two countries.
- Value conflicts show the importance of distributive and procedural justice.
- It is debated if the systems lead to more equity or reinforce injustices.
- Energy justice needs to be broadened to include data privacy and security issues.

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ABSTRACT

Smart grid systems are considered as key enablers in the transition to more sustainable energy systems. However, debates reflect concerns that they affect social and moral values such as privacy and justice. The energy justice framework has been proposed as a lens to evaluate social and moral aspects of changes in energy systems. This paper seeks to investigate this proposition for smart grid systems by exploring the public debates in the Netherlands and the United Kingdom. Findings show that smart grids have the potential to effectively address justice issues, for example by facilitating small-scale electricity generation and transparent and reliable billing. It is a matter of debate, however, whether current smart grid designs contribute to cost and energy savings, advance a more equitable and democratic energy system, or reinforce distributive and procedural injustices. The increased use of information and communication technology raises value conflicts on privacy and cyber security, which are related to energy justice. This research contributes by conceptualizing energy justice in the context of smart grids for the first time. The energy justice framework is broadened by including values and value conflicts that pertain directly to the increased use of information and communication technology. For policy makers and designers of smart grids, the paper provides guidance for considering interconnected social and moral values in the design of policies and smart grid technologies.

1. Introduction

Driven by policy objectives on climate change mitigation and advancements in communication technologies, electricity distribution networks are changing to become ‘smarter’ [1,2]. The European Technology Platform Smart Grids defines a smart grid system as “an electricity network that can intelligently integrate the actions of all users connected to it -generators, consumers and those that do both- in order to efficiently deliver sustainable, economic and secure electricity supplies” [3]. The definition reflects the European energy policy triad of environmental sustainability, economic efficiency, and the security of power supply [4,5]. Smart grid systems (in the remainder of the paper referred to as smart grids) target all three core objectives by facilitating the integration of decentral and intermittent renewable energy sources like wind and solar into distribution networks. The intentions are to automatically balance supply and demand flows within networks, accounting for weather-induced intermittencies and reducing peak demand or supply. By reducing electricity peaks, smart grids should help to avoid expensive network expansions [6]. They also target demand reductions by visualizing energy use and connecting it with daily behavior like the use of household appliances [7]. Smart grids are thus framed as key enablers in the transition to more sustainable energy

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systems.

Despite their prominent role in the energy transition, the development of smart grids has spurred critical public debates. For example, perceptions that energy companies are not open about benefits or do not pass on financial savings to their customers indicate trust and justice issues [8–10]. Further concerns stem from the automatic, more frequent and more fine-grained transfer and storage of information on consumers' energy use to central databases. This raises fears that consumers' privacy might be violated and that these data could be threatened in cyberattacks [11,12]. Such concerns can form barriers for the acceptance and adoption of smart grids and have already proven challenging in smart grid pilot projects [13]. Importantly, however, these societal concerns do not represent mere opposition against smart energy systems. They contain legitimate arguments that the systems touch upon core values such as privacy, security, or justice.

The exemplified societal concerns show that smart grids are not only a matter of the energy policy triad, but that a broader evaluation of the social and moral values affected by smart grids is needed, including how these values may be in conflict. We define values here as "general convictions and beliefs that people should hold paramount if society is to be good" [14,p. 1343]. For socio-technical systems such as smart grids, social and moral values provide criteria for design that go beyond the core technological functionalities of a system. They are normative principles that guide the design of technological systems [15].[1]

The concept of 'energy justice' has been proposed as one of the most comprehensive approaches that considers social and moral aspects of energy systems beyond the energy policy triad [16,17]. In the words of Sovacool & Dworkin [18 p. 441], assessing energy justice means "asking what this energy is for, what values and moral frameworks ought to guide us, and who benefits". Up to now, energy justice research has focused on the supply and use of energy as well as the energy system as a whole [19], and has – to the best of our knowledge – not examined smart grids. These systems, however, entail a convergence between the energy and the information and communication technologies (ICT) sector, and hence the range of ethical challenges goes beyond those related to energy supply and use. They include aspects pertaining to digitally connected systems, automation, and the increased recording and sharing of real-time data.

In this paper, we investigate the proposition that energy justice can serve as an approach to address social and moral aspects beyond the energy policy triad for the case of smart grids. To do so, we pursue two related aims. Firstly, we take a broad starting point to gain a deeper understanding of the moral and social values that underlie arguments used in public debates on smart grids in general. By relying on empirical material, we provided a descriptive account of how values are framed in the public debate. Secondly, we aim to set these values in context with energy justice. Thereby, we broaden evaluations of justice issues pertaining to energy supply and use by analyzing justice aspects in systems that operate at the intersection of the energy and ICT sectors. For policy makers and designers of smart grids, our research provides a basis for understanding values as design requirements and thus allows accounting for a range of interconnected social and moral dimensions within system design and decision-making processes. Our descriptive/empirical account can be a basis for a future normative account to answer the questions how injustices *should* be solved, or who *should* be involved to what extent and how in decision-making processes.

We take the public debates in the Netherlands and the United Kingdom as cases. Both countries have a density of smart grid pilot projects which is above EU average [12,20,21]. In addition, the political process and implementation of smart metering systems – sometimes called the backbone of smart grids – started relatively early, and with it a controversial public debate. While the Dutch and British debates may not be representative for other countries, underlying core values and conflicts can provide ample learning material beyond the two cases. To understand values in the public debate on smart grids, we conduct a qualitative content analysis of newspaper articles and analyzed extracted arguments with respect to underlying values, their interpretations in the smart grid context, and perspectives of stakeholder groups.

This paper is structured as follows. Section 2 provides a theoretical background on smart grids, the role of values in the design of socio-technical systems, and energy justice. Section 3 describes the methodology and smart grid developments in the Netherlands and the United Kingdom. Section 4 presents and discusses the results of the qualitative content analysis.

2. Background

2.1. Smart grid systems

The concept "smart grid" is used as an umbrella term to capture the digitalization of power systems (focusing on the distribution networks) with the aim to facilitate the transition to more sustainable energy systems. Sub-systems include smart metering, which is generally considered as the cornerstone of smart grids, smart home energy management systems (HEMS), demand-side response (DSR), household storage, and the integration of electric vehicles (EVs) through vehicle-to-grid and grid-to-vehicle solutions [22,23]. Smart grids are emerging systems and currently mostly implemented in pilot projects. The technologies are thus constantly changing. However, the use of ICT to achieve a more sustainable energy system is the combining factor.

Despite a strong focus on technological development, the changes smart grids imply for the energy system are not purely technological. Smart grids are socio-technical systems and their performance depends on the interaction between technologies, institutions, and social actors [24,25]. The technological advancements in communication technologies, through which distribution networks change from physical grids of copper to networks enforced by an advanced ICT infrastructure, also pose institutional questions on data property and market access rights [6]. Institutions are the legislation and regulations around smart grids; they form the (human-made) rules that govern their development and introduction [26]. Other differences between smart grids and 'conventional' networks include changes in roles and an increased diversity of actors. Probably the most prominent is the role change of the consumer, who can evolve from a largely passive energy consumer to an 'energy citizen', who becomes an active 'prosumer' and is an engaged actor in the energy transition [8].

2.2. Considering values in the design of smart grid systems

This paper aims at understanding how moral and social values that underlie the public debate on smart grids can be conceptualized under the comprehensive framework of energy justice. Studying how values are affected by smart grids is important for several reasons. Firstly, given the socio-technical nature of smart grids and the fact that energy systems deeply affect every-day life and well-being in modern societies, a focus on techno-economic aspects is too narrow to understand the intertwined nature of technological, institutional, and social developments. Despite this, the majority of literature on energy systems and policy has focused on techno-economic aspects [27]. In an extensive review of energy research, for example, Sovacool [28] found a prevalence of economics, mathematics, physics, and engineering and an underrepresentation of the social sciences and humanities. Only 20% of the authors of 4444 analyzed academic research papers were affiliated to a social sciences discipline.

[1] This conceptualization of 'values' from philosophy needs differentiation from how the concept is used in social psychology and sociology. In the latter disciplines, value orientations or values are individuals' personality characteristics [94]. 'Values' in philosophy and particularly ethics of technology are normative principles for system design [15].

Secondly, the introduction of smart grids is part of an inherently normative energy transition, as these systems are often presented as necessary solutions towards a more sustainable energy future [1]. The strive for sustainability in the energy system, however, gives rise to conflicts. Although very few people would disagree with the ambition to achieve a more sustainable energy system, the detailed opinions on what to change, how, and how fast to change vary considerably with, for example, actor perspectives, geographical contexts and time scales [29]. It is thus vital to understand the normative reasons and conflicts behind the introduction of smart grids. Values allow this understanding, because they are normative guiding principles for changes in a society. They relate to what people think is good, permissible, obligatory and what *ought* to be rather than perceptions of how things *are* [15,30].

Thirdly, smart grids are emergent technologies within an energy transition that is characterized by a high degree of uncertainty with respect to future technologies, regulations, and their consequences for system stakeholders. It is thus unlikely that stakeholders have fully-formed views about these changes [31]. In such a context, an approach that investigates the basic and relatively stable underlying principles for system design – i.e. the core values at stake for smart grids – is needed.

In the context of socio-technical systems such as smart grids, values provide criteria for system design, including technological design and decisions on regulation [15,31]. When considering values in systems, designers often face instrumental and conflicting relationships between two or more values. The Association of German Engineers (VDI), which is one of the biggest associations to set standards for German engineers, defines these relationships in their standard on concepts and foundations for technology assessment [32]. Instrumental relationships occur when one value positively contributes to another. An instrumental value is embodied in a system for the sake of achieving another value [33]. Distinctions between means and ends can only be made in their respective position in means-end-relations. Identifying instrumental relationships between values is therefore a precondition for evaluating the underlying reasons why a technology embodies certain values and how it contributes to the final objective of technologies as seen by the VDI: to secure and further a good human life [32].

The VDI refers to conflicting relationships between values if the objective to embody one value in a system is impaired by striving for another value [32]. Conflicts arise when choices have to be made between two design options that imply a trade-off between values, and when these values cannot be weighed against each other (e.g. a little more sustainability might not justify less privacy) [34]. Conflicts *between* two or more values occur when a specific attribute of a system positively contributes to one value but negatively impacts or harms another [35]. Identifying value conflicts is important for providing nuanced recommendations about the trade-offs design choices might imply and about the social cost or burden that might be connected to them.

Conflicts can arise *within* one value if it is interpreted differently by stakeholder groups [36]. This is rooted in the understanding that values have two levels of meaning: the concept (the value itself) and its conception (the value's interpretation or meaning). This distinction was coined by John Rawls [37], referring to earlier work by Herbert Hart [38]. Contestation occurs when there is broad consensus on the importance of the concept, but there are differences in the interpretations of the concept. As mentioned, almost everybody would agree that the concept of *sustainability* is important for the energy system. However, *conceptions* might differ as to what sustainability exactly entails and whether certain attributes contribute to a more sustainable system. To fully reveal value conflicts, it is thus important to understand values at the level of conception [36].

2.3. Energy justice

The concept of 'energy justice' has been proposed in the field of energy studies and social science as one of the most comprehensive approaches to understand and address conflicting social and moral values arising from changes in energy systems [16,17]. Energy justice addresses the "equitable access to energy, the fair distribution of costs and benefits, and the right to participate in choosing whether and how energy systems will change" [16, p. 143]. In this section, we first review existing applications and the three-dimensional energy justice framework and then discuss why the concept and framework might need to be broadened for smart grids.

2.3.1. A brief review on the development and applications of energy justice

Recent energy justice literature builds on a longstanding history of discussions on justice issues. Theoretical debates on justice have been going on since Aristotle. Philosophers (and economists) such as Adam Smith, Karl Marx, and John Rawls pursued questions what justice is and should be. A more contemporary debate on environmental justice emerged in the USA in the 1970s, centered around the unequal distribution of environmental burdens (e.g. pollution) between different locations and socio-economic groups (e.g. richer white and poorer colored neighborhoods) [39,40]. The scope has grown over time to include both local and global issues, with increased interest in climate change induced injustices [41]. In the 2000s, the World and the Global Energy Assessment recognized the importance of equity in context with energy provision and sustainable development [42–44]. Both assessments focused on distribution inequalities in income, resource access, and energy use globally between developing and developed countries and locally (within countries or regions) between rural and urban areas. Renewable and other small-scale decentralized electricity generation as well as smart energy systems were suggested to alleviate poverty and increase equity [43,44].

Justice theories and principles, explicitly using the concept of energy justice, have recently been applied to energy policy [5,41], climate change and the transition to low-carbon energy systems [45], energy supply [46–48], energy communities [19,49], energy use [50], pollution from fossil fuel combustion and nuclear waste [14,17], and energy poverty [51,52]. Details are briefly reviewed in the next paragraph.[2]

Targeting energy policy, Heffron et al. [5] developed a decision-making tool that relies on energy justice and expands the energy policy triad. Healy and Barry [45] argued that a focus on energy justice as guiding principle in the energy transition requires greater attention to fossil fuel divestment. With respect to energy supply, Heffron and McCauley [46] used the example of the wind energy sector in Denmark to demonstrate how the promotion of energy justice can enable growth along an entire supply chain. Investigating justice implications from energy communities, Johnson & Hall [49] argued for institutional changes to support equitable participation of civil society (e.g. new community business models and organizational structures). In context with energy use, Hall [50] analyzed how the energy justice field could benefit from literature on ethical consumption. Taebi and Kadak [14] considered intergenerational equity in the assessment of alternative fuel cycles for nuclear power. Finally, Bouzarovski and Simcock [51] synthesized the related fields of energy justice and energy poverty and highlighted the importance of spatial inequalities to understanding vulnerabilities.

2.3.2. Three dimensions of energy justice

Energy justice studies typically examine three intertwined dimensions of distributive justice, procedural justice, and justice as recognition [39–41,46]. These three dimensions are drawn from environmental justice, and are largely based on (a) theoretical work, for example, by Rawls [37], Young [53], and Fraser [54], and (b) empirical insights on how justice is conceptualized within environmentalist movements in the USA (cf. [39]).

[2] More detailed reviews of this emerging field can be found in Jenkins et al. [55] and in Sovacool and Dworkin [18].

Distributive justice is concerned with the distribution of benefits, burdens or costs, and responsibilities among stakeholders of an energy system [41]. Research has mostly focused on identifying and evaluating injustices, for example, in siting decisions of wind parks or unequal access to energy services [55]. Energy poverty has been defined as a form of injustice that is particularly faced by economically vulnerable consumer groups such as low-income families, the elderly, or the disabled [52]. Community energy systems are generally viewed as positive in sustainability and justice discourses. However, they face distribution issues because benefits are mainly attributed to a well-resourced and energy-engaged middle class in areas with healthy municipal finances [49].

Procedural justice is concerned with equitable access to and participation in decision-making processes that govern the distribution of benefits and costs in energy systems [40]. A large part of research on procedural injustices outlines the role of citizens and consumers in decision-making processes (e.g. around infrastructure siting for transmission power lines or nuclear waste disposal sites). Conflicts are portrayed in the dichotomy of consumers/citizens on the one side and policy makers and industry on the other [16,55].

Justice as recognition is concerned with the equitable appreciation of stakeholder groups involved in energy systems [41]. Processes of disrespect that “devalue some people and place identities in comparison to others” [40, p. 615] are exemplified in the ‘Not-In-My-Backyard’ argument; the NIMBY-explanation has been used by project developers and energy companies to dismiss local protests against, for example, wind parks as rooted in selfishness and misinformation [41]. Such an explanation and attitude towards local resistance against energy projects fails to recognize legitimate concerns rooted, for example, in place attachment or aesthetic values [56]. Social science studies on siting issues and local opposition has shown that NIMBY is empirically false. Local resistance raises legitimate concerns, which might reveal underlying values [57,58]. The NIMBY label has thus been criticized in academic literature as overly simplistic, outdated, and as disrespecting concerns voiced by local stakeholders [57–60].

2.3.3. Application to smart grid systems

Energy justice has up to now focused on energy supply and use, as outlined in Section 2.3.1. We advance this understanding of energy justice for smart grids, which signify an increased convergence of the energy and ICT sectors. As such, ethical challenges including repercussions for energy justice, which are connected to digital systems, become relevant for the energy system. It is worth noting that distributive justice is mentioned in some studies on the benefits and drawbacks of smart metering, smart home, and DSR. Tensions arise between consumers and energy companies, with consumers fearing to bear a disproportional share of the costs for smart metering [61] while also being burdened with the responsibility to save energy [62]. Injustices between different socio-demographic or socio-economic consumers are related to an increased reliance on ICT systems, which can discriminate against the elderly, disabled, or less IT savvy [9,62]. Yet, there is a lack of theorizing about energy justice. Concerns about potentially unfair distribution of costs and benefits emerged from qualitative research, voiced by industry experts and consumers in focus groups or workshops, among a broad range of advantages and drawbacks of smart grid technologies. We aim to contribute by adding the theoretical lens of energy justice and by positioning justice aspects within a broad range of values, revealing instrumental and conflicting relationships.

3. Methodology

We conducted a qualitative content analysis to explore the values and value conflicts underlying the public debate on smart grids in the Netherlands and in the UK and to set these values in context with energy justice. Public debates reflect societal discourses on technological developments in the energy sector and are a rich source of relevant values and value conflicts [29,31]. Qualitative content analysis, where text data is interpreted through a systematic process of coding to identify themes or patterns [63], was chosen to gain an in-depth understanding of the debate by extracting value-laden statements from national newspaper articles. While the method is suitable for the aim of our study, we acknowledge that it is limited by its qualitative and descriptive nature such that our results cannot be generalized to wider contexts and that we rely on the reporting and availability of content in print media [63]. However, we do not strive to give a representative overview of public perceptions of smart grids. Our aim is to gain insight in the meaning and framing of values. Newspapers contain written representations of public debates and are thus useful for extracting value-laden statements [29]. In addition, the choice of using print media was motivated by the need to read all articles and by their relatively high accessibility.

The Netherlands and the United Kingdom were chosen because they share similarities in smart grid development but differ in certain aspects. This led us to expect differences in the values underlying the debates. The number of smart grid pilot projects and investment in these projects are above average in both countries. The majority of all projects from 1994 to 2016 started after 2007 (93% in both countries), with a peak of project starts in 2012 (26% in NL, 21% in the UK) [21]. The legislative development for smart metering started at similar times and relatively early, in 2006 (NL) and 2007 (UK) [64]. Consequently, there was enough time for a public debate to evolve, and at least smart metering systems are already in the implementation stage. However, there are differences in the technology and regulation, which are likely to impact the salience of different values. In the UK, smart meters are complemented with an in-home display, in the Netherlands they are not. In the UK, the metering market is competitive, energy suppliers are responsible for the implementation, own the devices, and also finance the rollout. In the Netherlands, the metering market is regulated, distribution system operators (DSOs) are responsible for the implementation and own the devices, and the rollout is financed via network tariffs.

3.1. Data collection

Newspaper articles for our analysis were retrieved from the databases LexisNexis (NL) and Factiva (UK). Our English and Dutch search terms included smart grid sub-systems and synonyms: ‘smart grid’, ‘smart energy systems’, ‘microgrid’, ‘smart energy regulation/legislation’, ‘smart meter(ing)’, ‘smart home’, ‘home energy management systems’, ‘household storage’, ‘demand(-side) response’, ‘demand-side management’, and ‘smart charging’. The beginning of the main political debate and development of smart metering in 2006 (NL) and 2007 (UK) was taken as starting point for data collection, because smart metering is seen as a cornerstone of smart grids [2]. In both countries, search results were included up to 30 June 2017. Due to the large number of search results, we applied stratified sampling to include all newspapers in our sample and replicate the variating number of articles over time [63]. Articles were first screened for relevance and only included in the sample if they were indeed from a national newspaper, reported on smart grids, and contained content from the correct country.

3.2. Data analysis

The data analysis followed an iterative process of reading articles, extracting value-laden statements, and developing codes using the software ATLAS.ti [65]. The main coding was performed by the first author. The detailed coding and recording principles are provided in Appendix A. An initial code book of potentially relevant values and definitions was developed based on a literature review on smart grids and on values of ethical importance often mentioned in ethics of technology [66,67]. Values were mentioned both explicitly (e.g. “Many people fear a violation of their privacy”) and implicitly (e.g. “Cheaper?

Possibly for […] the energy companies. For tenants is it a setback.") [31]. Statements were reflected in front of the initial code book to identify implicit values. For example, the second statement was coded with distributive justice, because it pertains to the distribution of costs among stakeholder groups. Value-laden statements were coded with sentiments: positive (if in favor of, or reporting an advantage of smart grids), negative (if against smart grids, or reporting a disadvantage or a challenge), or neutral (neither pro nor contra position). Technological and institutional attributes were coded to demarcate why a value is relevant. We also assigned stakeholder groups, distinguishing between stakeholders that put forward a statement and stakeholders that were affected by the statement. Finally, we recorded information from the document context. This included the source publication, the publication date, and the main topic of the article. The initial code book was open for additions, changes in definitions, and changes in coding categories. The iterative coding procedure was performed until the code book was saturated, i.e. no new insights on values and value conceptualizations would be found by analyzing further articles [68]. To address the limitation that qualitative content analysis relies on interpretative work by researchers, an inter-coder agreement check was performed [63]. A second coder checked all the coding to enhance the validity of the results. Disagreements between coders were solved through discussion.

In addition to the coding procedure, we analyzed how values were intertwined through instrumental and conflicting relationships (see Section 2.2). This analysis allowed identifying relationships between energy justice and other values. Instrumental relationships were analyzed through co-occurrences (or overlaps) of positive conceptions. In this context, we did not discuss whether the values were instrumental per se (i.e. pursued as a means to contribute to another value) or intrinsic (i.e. pursued because it is valuable for its own sake). We acknowledge this difference, but were interested in the relation between values. Conflicting relationships were identified through an analysis of contradictory value conceptions.

3.3. Smart grid systems in the Netherlands

The Dutch development of smart grids in the past decade (Fig. 1) is dominated by the rollout of smart metering. In anticipation of the EU Directive 2006/32/EC on energy efficiency, the Netherlands started to prepare for the smart metering rollout in 2006 [69,70]. The legislative development from 2006 to 2011 was characterized by controversies between parliament, the senate, and the consumer representation body about the mandatory rollout and data privacy issues. The final design was a voluntary rollout and allows consumers to choose from several design options regarding data transfer to DSOs. A pilot rollout from 2012 to 2013 was positively reviewed [71]. The national rollout to private and small corporate consumers started in January 2015 [72,73]. In parallel, smart grids have been implemented in the form of pilot projects. Until the end of 2015, the database for smart grid projects at the Joint Research Center of the European Commission registered 58 demonstration projects with a total investment of €166 million (EU average 32 projects with an investment of €108 million) [21].

Table 1
Dutch newspapers.

Newspaper type	Newspaper
Quality	NRC Handelsblad, NRC.Next, Trouw, Volkskrant, Het Financieele Dagblad
Popular	Algemeen Dagblad, De Telegraaf, Metro/Spits[1]
Religious background	Reformatorisch Dagblad, Nederlands Dagblad

[1] These two newspapers merged in 2013 and are both free, low-quality newspapers. They were thus combined in our analysis.

Our data collection resulted in a sample of 75 newspaper articles from January 2006 to June 2017 in ten national newspapers (Table 1). The complete list of analyzed articles is included in Appendix B. There is no prevailing negative or positive sentiment towards smart grids in media articles: 48% of value-laden statements reflect a positive sentiment, 46% show a negative sentiment and 6% a neutral sentiment. More popular newspapers (such as De Telegraaf and Algemeen Dagblad) tend to take a more critical stance, stressing the disadvantages of smart grids.

The smart metering rollout is the focus topic of 36% of all analyzed newspaper articles. However, the variety of topics increases over time. While there is a clear focus on smart metering from 2007 to 2009, from 2010 onwards topics such as digitalization, energy transition, smart grid pilot projects, the role of EVs, and smart home applications received more media attention. Consistent with the dominance of the smart meter rollout, smart metering as a sub-system occurs in 68% of the articles. This is followed by discussions of smart grids in general (28%), DSR (12%), HEMS (8%), the integration of EVs in smart grids (8%), and household storage (1%).

3.4. Smart grid systems in the UK

In the UK, the Smart Grid Forum is the platform for industry and government to facilitate the deployment of smart grids. Fig. 2 presents an overview of the development in the past decade. The Smart Grid Forum's vision of the British Smart Grid outlines a road map consisting of the 'development phase', including the smart metering rollout, followed by the 'rollout phase' from 2030 to 2050 and the 'developed phase' after 2050 [74]. The development of smart grids between 2007 and 2017 focused on smart metering. Initial policy discussions started with the White Paper on Energy in 2007 [75], driven by the EU Directive 2006/32/EC on energy efficiency and the Directive 2009/72/EC on common rules for the internal electricity market [70,76,77]. From 2007 to 2010, a large-scale trial found that smart metering with in-home displays could lead to average energy savings of 3% [78]. In 2008, the British government announced the 100% rollout of smart metering to all private and small corporate consumers until 2020

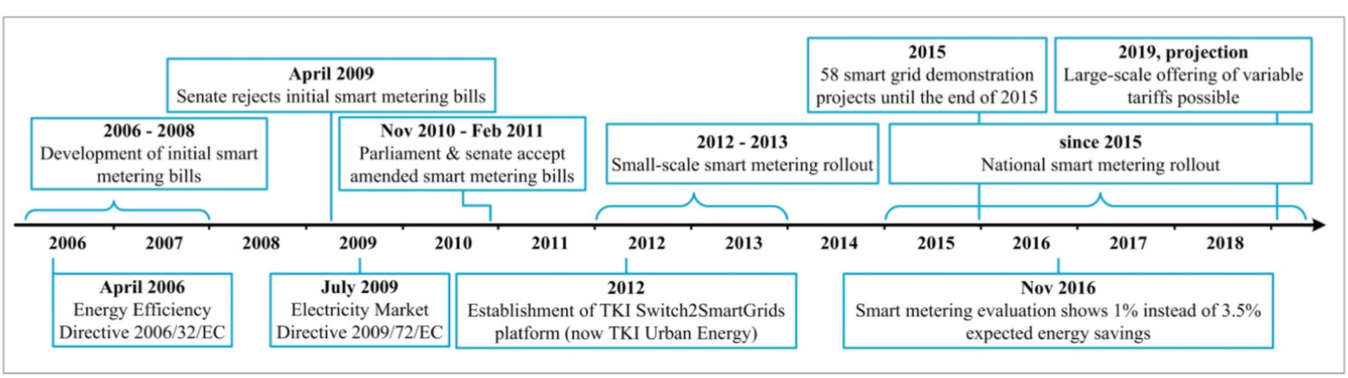

Fig. 1. Smart grid development timeline in the Netherlands.

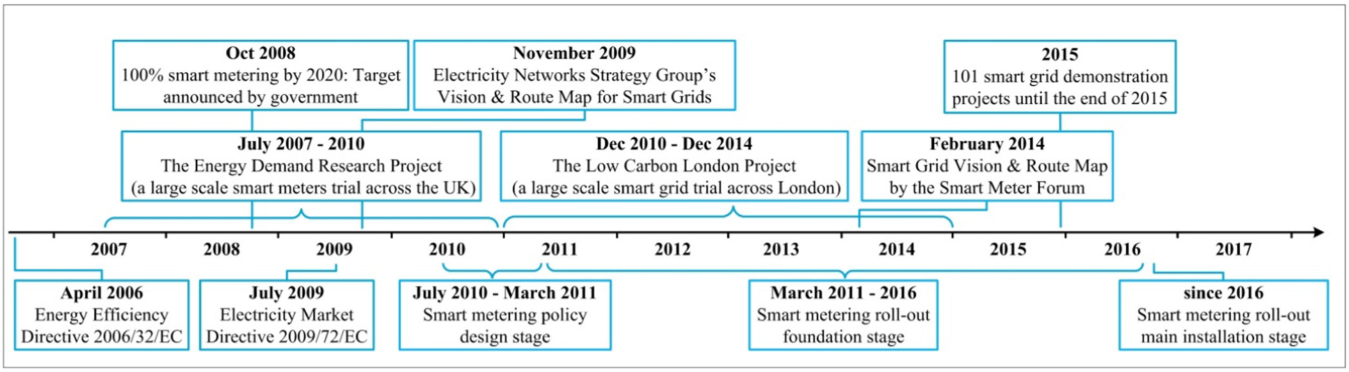

Fig. 2. Smart grid development timeline in the UK.

[76,79]. Smart meters were combined with an in-home display and the energy suppliers were made responsible for providing and paying for smart metering [74]. In 2012, the rollout was changed to be voluntary [76]. Smart Energy GB was founded in 2013 as the main campaign body to increase consumer awareness and engagement [80]. The Data and Communications Company (DCC) was granted the license for the control of the communication system [81]. In parallel, smart grids have been mainly implemented in pilot projects. Until the end of 2015, the Joint Research Center of the European Commission registered 101 demonstration projects with a total investment of €628 million (EU average 32 projects with an investment of €108 million) [21].

In the UK, we analyzed 71 articles from January 2007 to June 2017 in 17 national newspapers (Table 2). The complete list of analyzed articles is included in Appendix B. On average, there is a slightly stronger representation of advantages as 58% of all value-laden statements reflect a positive sentiment, 38% show a negative sentiment, and 4% a neutral sentiment. Popular newspapers (such as The Sun and Daily Mirror) are predominantly positive about smart grids. Quality newspapers (such as The Times, The Telegraph, i, and Financial Times) tend to take a more critical stance, with exception of The Guardian.

The smart metering rollout is the focus of 46% of all newspaper articles and is the dominant topic in all analyzed years. Since 2010, 18% of all articles focused on energy savings. Other topics include national infrastructure investments, energy price increases and the risk of energy poverty, the energy transition, the increased dissemination of EVs, and complaints about problems with energy billing and energy providers' customer service. Smart metering, as a smart grid subsystem, occurs in 83% of all articles. This is followed by discussions about smart grids in general (7%), household storage (6%), HEMS (4%), and the integration of EVs in smart grids (4%).

4. Results and discussion

4.1. Values reflected in Dutch and British newspapers

The analysis of newspaper articles discussing smart grids in the Netherlands (75 articles) and the UK (71 articles) revealed that a broad range of values was reflected in statements that describe advantages and drawbacks of smart grids. Table 3 gives a detailed summary of the results, stating positive and negative conceptions of each value with example statements from newspaper articles as well as attributions to the sources of these statements. In the Netherlands, 18 values were mentioned in the debate, compared to 13 values in the UK (Table 3). There is a substantial overlap between the countries with respect to which values were mentioned and which were most salient. In both countries, smart grids were perceived as positive due to their contribution to the energy policy triad, i.e. the values of economic development, environmental sustainability, and security of supply. Additionally, transparency and comfort were mentioned as advantages. Arguments that reflect challenges of smart grids revealed the importance of distributive and procedural justice. In addition, smart grids were considered controversial because of privacy and security risks, concerns that innovative ICT lacks reliability, and trust issues.

Despite a generally similar salience of values, a few differences became apparent between the two countries. Firstly, economic development dominated the British debate more than the Dutch debate, with almost 70% of all statements referring to monetary advantages or disadvantages of smart grids. On the positive side, energy savings for consumers, and more accurate billing were important drivers for smart metering in the UK. On the negative side, energy poverty and rising energy prices for consumers, as well as high infrastructure investments were more salient in the UK than in the Netherlands. Secondly, environmental sustainability was less salient in the UK than in the Netherlands. In Dutch newspaper articles, statements that focused on energy savings also mentioned sustainability benefits such as reduced greenhouse gas emissions. These benefits were presented to arise for consumers and the society in general. In the UK, statements on energy savings were mostly presented in connection with cost and benefits for consumers. When sustainability benefits were mentioned, they were related to the government's and industry's climate change goals. Thirdly, consumers' data privacy dominated the debate more in the Netherlands than in the UK. In fact, privacy issues related to the more frequent sharing of fine-grained consumer energy use data with external entities was the smart grid challenge mentioned most in the Netherlands. The special salience of privacy issues around smart metering occurred most probably because the legislative procedure was mainly delayed for reasons of privacy law violations. This is debated extensively in media articles.

In addition, the results reveal that the majority of the values salient in newspaper articles are used both in statements with a positive and a negative sentiment. This shows that values are contested concepts; there is general agreement on the importance of a value, but controversies are salient about different potential interpretations of a value. Such controversies can reveal value conflicts between different stakeholder groups. An example is the contribution of smart grids to economic development. In general, energy savings to decrease costs and emissions are considered as important, and smart grids are seen as contributing to both aspects by governmental organizations and energy

Table 2
British newspapers.

Newspaper type[1]	Newspaper
Quality	Financial Times, The Guardian, i, The Observer, The Daily Telegraph, The Sunday Telegraph, The Times, The Independent, Independent on Sunday
Mid-Market	Daily Express, Sunday Express, Daily Mail, The Mail on Sunday
Popular	Daily Mirror, Daily Star, Metro, The Sun

[1] Source: The Audit Bureau of Circulations (ABC) at www.abc.org.uk.

Table 3
Overview of results: smart grid values reflected in Dutch and British newspapers.

Values Frequencies*	**Sentiment**	**Conceptions** (<u>NL</u>, **UK**, **<u>both countries</u>**)	**Example Statements**	**Source Attributions**
Economic Development NL: 35% UK: 69%	Positive	**<u>Energy savings</u>**, **<u>cost savings (consumer & operational / supply side)</u>**, <u>improved business models</u>, **accurate billing**	*"Households are equipped with smart meters to realize 3.5% energy savings (Algemeen Dagblad (AD), 2 Dec 2016)."*	Media
			"Smart meters that show energy use will lead to less usage of energy and give accurate billing information for the first time (The Mail (M), 20 May 2007)."	Consumer Representation
	Negative	**<u>Energy savings too low</u>**, **<u>unequal profits</u>**, **<u>expedient spending of public money</u>**, <u>waste of resources</u>, <u>energy intensive ICT</u>, <u>dependence on ICT</u>, **high investment costs & market mechanism**	*"Smart meters may be more efficient at communicating accurate information to energy suppliers, but trials have shown them not to alter consumers' behaviour at all (The Sunday Telegraph (ST), 7 April 2013)."*	Consumer
			"There could be serious implications for energy prices if utility companies pass on the cost to consumers (Daily Mail (DM), 23 May 2007)."	Government
Environmental Sustainability NL: 29% UK: 16%	Positive	**<u>Energy savings</u>**, **<u>integrating renewables</u>**	*"Smart grids contribute to two worldwide trends: sustainable energy and decentral power generation (Het Financieele Dagblad (FD), 24 Oct 2011)."*	Media
			"As promoting energy efficiency and fighting climate change have become mainstream political aims, the government and energy companies are making more aggressive noises about installing them (Financial Times (FT), 4 August 2007)."	Media
	Negative	**<u>Energy savings too low</u>**, <u>waste of resources</u>, <u>energy intensive ICT</u>, <u>designing long-lasting systems</u>	*"But where energy savings of 3.5% were expected, we are stuck at 1% (De Telegraaf (DT), 20 Nov 2016)."*	Environmental Assessment Agency
Security of Supply NL: 10% UK: 5%	Positive	**<u>Balancing supply & demand</u>**	*"Managing the flows of high volumes of intermittent power on new routes will require a more flexible and responsive network that can maintain steady supplies (FT, 24 Nov 2009)."*	Transmission System Operator
	Negative	<u>Role of DSO</u>, <u>dependence on ICT</u>	*"[…] commercial side activities of network operators […] can endanger their core task – security of energy supply (FD, 28 May 2016)."*	Regulator (ACM)
Transparency/Accuracy NL: 15% UK: 17%	Positive	**<u>Information on energy use</u>**, **<u>Information on price</u>**, **<u>billing accuracy</u>**	*"See exactly how much energy you are using in pounds and pence in virtually real-time. Turn on the kettle and watch the display increase […] (The Sun (S), 24 June 2017)."*	Media
	Negative	<u>Insufficient information on energy use</u>, <u>meter reading accuracy</u>, <u>data access issues</u>	*"Where did it go wrong? The smart meter registers the consumption and sends it to the energy supplier, who informs consumers bi-monthly how much […] was used. They did not choose for a display where consumers could read directly how much they use (DT, 20 Nov 2016)."*	Media
Comfort NL: 5% UK: 4%	Positive	**<u>Automation is convenient</u>**	*"[…] when we leave the house, we just have to push one button (Volkskrant (VK), 19 Jan 2011)."*	Consumer
	Negative	**Behavioral restrictions**	*"The smart meter doesn't stop it being expensive. […] You think, 'Oh dear, that's a lot', but you don't actually go and turn anything down, because you need to be warm (ST, 12 June 2016)."*	Consumer
Control/Autonomy NL: 11% UK: 7%	Positive	**<u>Power to consumers/the people</u>**, **<u>participation (voluntary)</u>**	*"Consumers become stage-managers of their energy consumption (VK, 6 March 2010)."*	Certification Body for Power Systems
	Negative	<u>Participation (forced)</u>, <u>knowledge is power</u>, **ICT takes over control**	*"Demand-side response can play its part […], but it is imperative that any agreements made with industry are on a voluntary basis (G, 1 March 2016)."*	Industry Representation
Democracy NL: 2% UK: –	Positive	<u>Power to consumers/the people</u>, <u>citizen representation in parliament</u>	*"The combination of decentral communication technology and decentral renewable energy, via freely accessible smart networks, means power to the people (VK, 17 Sept 2007)."*	Research
Cooperation NL: 2% UK: –	Positive	<u>Private-private & public–private</u>	*"Municipalities can profit from innovation in the energy sector, […] and also for smart grids an active role of the municipality is crucial. Network operators and others need the active role of municipalities (FD, 5 April 2014)."*	Consultancy
	Negative	<u>Knowledge is power</u>	*"[…] non-expert civil servants might let themselves be misled by technology companies (NRC.Next, 17 Oct 2015)."*	Research
Autarky NL: – UK: 2%	Positive	**Temporal self-sufficiency**	*"Energy self-sufficiency is becoming more achievable (Daily Telegraph (DaT), 1 Oct 2016)."*	Prosumer

(*continued on next page*)

Table 3 (*continued*)

Values Frequencies*	**Sentiment**	**Conceptions** (NL, **UK**, **both countries**)	**Example Statements**	**Source Attributions**
Accountability NL: 1% UK: –	Positive	Concordance in billing	*"Disagreements because of (estimated) meter readings are a thing of the past (NRC.Next, 9 April 2009)."*	Media
Distributive Justice NL: 7% UK: 8%	Positive	Advantages for the economically vulnerable, free access network	*"A group, who […]benefits especially from a transparent view on the meter are consumers who have difficulties in paying (Trouw, 19 Nov 2007)."*	Energy Supplier
	Negative	**Unequal profits**, **expedient spending of public money**, **costs passed on to consumers**, **disadvantages for the economically vulnerable**	*"The audit office also warned that studies showed that vulnerable people, such as those on low incomes and pensioners, were less likely to take advantage of cheap tariffs[…]. However, they would still have to shoulder their share of the costs (The Times (T), 30 June 2011)."*	National Audit Office
Procedural Justice NL: 5% UK: 2%	Positive	Equitable market access, free access network, **participation (voluntary)**	*"Participants can buy and sell energy on a local market; thereby the system finds its optimum (FD, 24 Oct 2011)."* *"It is also fair that citizens can decide themselves if they want to participate or not (NRC.Next, 9 April 2009)."*	Certification Body for Power Systems Media
	Negative	**Selection bias** (algorithms & **pilot projects**), exclusive nature of new technology, unequal rights (prosumers & suppliers)	*"How do you guarantee that the algorithm stays neutral? (NRC.Next, 17 Oct 2015)"* *"It said that findings from the trial, which was a year late, were not representative of the population as the 50,000 households who took part were volunteers and so were more engaged about saving energy than most (T, 30 June 2011)."*	Municipal Government National Audit Office
Privacy NL: 12% UK: 1%	Negative	**Household privacy vis-à-vis external parties**	*"The fine-grained logging of energy consumption reveals living habits. […] the home becomes another link in the information chain on citizens (NRC.Next, 9 April 2009)."*	Media
Security NL: 5% UK: 2%	Negative	**Consumers' data security**, **operational cyber security**	*"The more sensors, infrastructure and management systems get an internet connection, the more vulnerable they get (NRC.Next, 17 Oct 2015)."* *"A risk assessment carried out by the energy watchdog, Ofgem, also identified 'a range of threats such as cyber, viruses and malicious software' (DaT, 7 July 2014)."*	Research Regulator (Ofgem)
Reliability NL: 5% UK: 6%	Positive	**Reliable billing**	*"Consumers might be prepared to pay a little extra to get the […] reliable bills they deserve (DM, 23 May 2007)."*	Consumer Representation
	Negative	**Instable performance of new (existing) technology**, **uncertainty of future technology**, uncertainty of future legislation	*"[…] disadvantage of new technologies […] being quickly outdated (FD, 2 May 2015)."* *"Difficulties in making the meters work in tall buildings and when customers switch supplier (DaT, 7 March 2015)."*	Research Parliament
Trust NL: 5% UK: 3%	Positive	**Trust among stakeholders**	*"Innovation and the mass arrival of the smartphone may do more to restore [consumer] trust in the industry than the constant stream of reviews since 2007 (DM, 27 June 2015)."*	Media
	Negative	Trust in operation of devices & networks, trust among stakeholders	*"People need to have the feeling that the network is trustworthy (Reformatorisch Dagblad (RD), 16 Oct 2013)."* *"Major reforms are needed to fix the Big Six [the big UK energy suppliers, authors' comment] and restore trust in this broken market (IND, 7 Oct 2014)."*	Research Consumer Representation
Health/Safety NL: 1% UK: –	Positive	Improved home ventilation	*"Heating and ventilation in a regular home is a large share of energy consumption. […] Comfort and health can be improved (DT, 4 Nov 2015)."*	Equipment Manufacturer
	Negative	Radiation	*"[…] disadvantages from radiation […], which are not revealed (AD, 19 Feb 2013)."*	Consumer

* Frequencies represent the share of a value in all value-laden statements.

companies. However, contestations occur for example on whether consumers' savings from smart metering would be big enough to outweigh that they have to cover the investment costs indirectly either through network tariffs (in NL) or because suppliers pass on the rollout costs (in the UK). Qualitative arguments on insufficient energy savings are typically brought forward by consumers and their representation bodies. In the Netherlands, the Environmental Assessment Agency (PBL) provided additional quantitative evaluations in their report on the smart metering rollout, which was conducted in 2016 after 25% of households had been equipped with smart meters. The evaluation showed that initially expected energy savings of 3.5% did not materialize, but that savings amounted to less than 1% of total energy use [82].

4.2. Instrumental and conflicting relationships reveal the role of energy justice

Values underlying both pro and contra smart grid statements in the Dutch and British public debate are closely intertwined through instrumental and conflicting relationships. Instrumental relationships occur when a value positively contributes to another one. Conflicting relationships within and between values arise when values are contested, or when one value negatively contributes to another one. The analysis of instrumental and conflicting relationship allowed setting all values in context with energy justice. This revealed three main themes, which are discussed in the subsequent sections.

4.2.1. Smart grid systems contribute to a more equitable and democratic energy system

Many of the positive smart grid arguments used in media articles in both countries convey a contribution of smart grids to the energy policy triad. These perceived positive contributions of smart grids – predominantly put forward by governmental organizations and energy companies – are consistent with EU policy objectives that smart metering should enable consumers to save energy costs and contribute to emission reduction [70].

Despite the centrality of the energy policy triad, our results show that perceived benefits of smart grids go beyond environmental, economic, and supply security aspects. These findings confirm that energy justice is an important and central concept for the development of smart grids. The debates highlight the enabling role of ICT for consumer and citizen participation and empowerment, which are perceived to enhance distributive and procedural justice.

Justice aspects are perceived as instrumentally (i.e. positively) influenced by the potential of smart grids to enhance control, transparency, and democracy. In both countries, control is positively related to procedural justice. The voluntary smart metering rollouts are viewed as enhancing self-control and codetermination by consumers. This is perceived as a more equitable access to smart metering than a system which prescribes a forced rollout to all consumers. Benefits from a voluntary rollout are more salient in the Netherlands, possibly because the initial institutional design prescribing a mandatory rollout was one of the major reasons for delays in the legislative procedure [12]. Changing the proposal to a voluntary rollout is reflected in positive media statements and perceived as fair.

In addition, both procedural and distributive justice are perceived as positively influenced by transparency. The combination of smart metering and DSR and variable tariffs allows consumers to have access to wholesale prices on the power exchange, as demonstrated by a Dutch pilot project. This is seen as a more equitable market access, where consumers have a greater role in determining the price they pay for their electricity than in the conventional electricity system where consumers play a passive role. Secondly, the timely visualization of energy use through smart metering is seen as advantageous particularly for less affluent consumers, because they are supported in planning their household budget instead of having to pay surprise catch-up bills at the end of the year. Transparency thus contributes to distributive justice.

In the Netherlands, smart grids are seen as symptomatic for a change to a more democratic energy system, because they facilitate small-scale electricity generation and the shift of consumer roles towards active 'energy citizens'. In the UK, the possibility of smart grids to facilitate the combination of small-scale generation and storage facilities is seen as a positive contribution to autarky, which is conceptualized in the debate as temporal self-sufficiency of energy prosumers. The change to an energy systems that gives 'power to the people' is portrayed as more democratic and more equitable than the conventional electricity system, because a larger share of stakeholders can influence market processes.

4.2.2. Contestation on economic and environmental aspects conveys issues around energy justice

Despite a dominance of positive conceptions of economic development and environmental sustainability, our analysis shows that both are contested values. The debate is not about their importance, but about how they are conceived by stakeholder groups and what would be needed to realize both aspects. Contestation around monetary and environmental consequences of smart grids is related to distributive and procedural justice.

The most prominent contestation pertains to discussions whether smart grids in general and smart metering in particular indeed contribute to the expected energy savings for consumers. The debate reflects conflicts between governmental organizations and energy companies on the one hand, and consumers and consumer representation organizations on the other hand. As mentioned before, consumers and consumer representation organizations are typically critical. Favorable smart metering arguments by governmental organizations and energy companies convey the assumption that increased visualization of energy use leads consumers to save energy. This relationship between transparency and economic/environmental benefits is often depicted as a causal relationship in pro-smart grid arguments. However, even if smart meters are installed and combined with in-home displays, consumers themselves still have to achieve energy savings by changing the way they use energy-related services. In criticizing this assumption as overly simplistic, the public debate is consistent with academic insights from behavioral economics on the relationship between energy use feedback and savings. Whereas the assumption that more feedback leads to more energy savings is based on traditional rational choice models, behavioral economists point out that factors influencing energy savings are more complex, depend on the framing of feedback, and highlight challenges in inducing energy savings that are persistent over time [13,83,84]. Recent research has shown for example that the effect of energy use feedback on savings might be stronger if the information is framed as loss aversion [13].

Beyond such insights from literature, and important for the purpose of this study, are our findings how the discussion on the ability of smart grids to enable consumer energy savings is related to distributive and procedural injustices. Distributive justice concerns are reflected in arguments that criticize the distribution of monetary benefits between consumers and energy companies. As mentioned, the debates show that consumers might benefit less than energy companies and that consumers' potential monetary benefit through energy savings is not automatically achieved via the smart metering technology: energy savings have to be realized by consumer behavior. It is considered as unfair that consumers might benefit less than energy companies, particularly because communications by governmental organizations and energy companies highlight monetary benefits for consumers. In the Netherlands, additionally, it is seen as unfair that consumers are burdened with the responsibility to save energy and shift demand according to supply. Consumers see the energy companies as responsible for managing supply volatilities. The only way energy savings can be realized in this context without behavioral changes is via automated

DSR and smart appliances, which is seen as a positive future benefit of DSR in the debates.

The mechanisms to pass on costs for smart metering investments to consumers is also perceived as distributive injustice and increases the contested nature of arguments that consumers profit from smart metering with reduced energy costs. In the Netherlands, the smart metering rollout is financed via network tariffs. In the UK, investments are supposed to be covered by energy suppliers, who pass on these costs to consumers by raising energy prices. Perceptions of injustice are further increased in the UK because smart metering technology is seen as unreliable. On the one hand, the existing technology does not function reliably in all circumstances because of its use of wireless data transfer; for example, in high-rise buildings or buildings with a large distance between meter and in-home display. On the other hand, there are concerns that the devices will be out of date by the time the smart metering rollout is complete. As a result, reliability issues increase the negative relationship between economic development and distributive justice.

Distributive justice issues are not only perceived in the distribution of costs between consumers and energy companies, but also among groups of consumers. A potential risk of smart grids is their focus on novel technologies, which are perceived as complex and requiring specific knowledge. They rely on the internet and are thus often exclusive towards societal groups such as the elderly, disabled, or less well-off people – groups who are in general economically more vulnerable than others. Concerns about systematically excluding certain customer segments from smart grids are also related to DSR. Given that not all consumers have the same possibility to shift their demand, the risk that certain consumer segments are systematically excluded from DSR programs or would be left worse off financially by DSR programs causes concerns about distributive justice.

In addition to distributive aspects, procedural justice concerns are reflected in the debate about procedures for the selection of participants for smart grid pilot projects. These are criticized as biased both in the Netherlands and in the UK. Participation is usually voluntary and targeted at first-mover customers, who are generally interested in energy savings. Equitable access to projects is therefore not guaranteed and results with respect to energy saving potential are not representative of the entire population. Due to this selection bias, projections for country-wide energy savings from such projects would be invalid.

Besides the main contestation on energy savings for consumers, the public debate in the Netherlands reflects three additional concerns about energy justice. Firstly, contestation on monetary aspects and distributive justice in the Netherlands is centered around the role of DSOs in smart grid investments and reflects a conflict between regulatory authorities and DSOs. Although DSOs perceive themselves as the logical leaders in the smart grid development – after all the consequences of intermittent and decentral renewables are the strongest on distribution grid level – this lead position is criticized by the regulatory authority ACM, policy makers, and by energy suppliers. This is because smart grid investments other than smart metering are seen as commercial side-activities and beyond the core tasks of DSOs, and are therefore perceived to be inexpedient spending of public money. The ACM is also worried that such commercial side-activities could endanger the core task of DSOs, namely to guarantee a secure energy supply.

Secondly, the Dutch debate reflects concerns about procedural justice with respect to the market access under the current institutional design of the electricity market. Although the technological possibilities of smart grids and DSR to grant prosumers and consumers access to power markets are generally seen as positive, these market access possibilities are perceived as being restricted by outdated energy legislation and regulation. Prosumers are not granted the same rights as energy suppliers. This is perceived as unfair, as a growing importance of prosumers should go hand in hand with increased market access rights.

Thirdly, smart grids are argued to be challenging for municipalities' autonomy in the Netherlands, because they contribute to an unfair distribution of knowledge. This is related to the value of cooperation, which is defined as increased collaboration between stakeholders [67]. Cooperation becomes salient as a value, because smart grids cause actor roles in the energy industry to change and sectors to converge. Although increased public private collaboration is often seen as positive and necessary for the successful implementation of smart grids, challenges for knowledge distribution between private companies and municipalities are under debate. Particularly, the greater reliance on novel technologies in smart grids, which require more special knowledge, leads to perceptions that knowledge concentrated at private corporations is seen as source of power over municipalities.

4.2.3. Conflicts show a central role of trust, privacy and security

In addition, a range of conflicts are salient in the debate which would typically not be covered by the existing energy justice framework. These conflicts are clustered around trust, privacy, and security issues. Trust is seen as a central precondition for a successful smart grid implementation. Trust issues are mentioned mainly in two ways: trust among stakeholders and trust in the operation of devices and networks. In both countries, mistrust among stakeholders refers to consumers' mistrust in energy suppliers. In the UK, any attempts by energy suppliers to incentivize consumers to save or use variable tariffs are claimed to raise consumer suspicion of disguised price rises. In the Netherlands, consumer mistrust originates partly from perceptions that messages about energy savings by energy suppliers seem inconsistent with their business model of selling electricity. In addition, a perceived lack of transparency connected to the required bi-monthly energy consumption information in the Netherlands contributes to consumers' mistrust, as it has been reported that not a single supplier distributes the consumption information according to the rules set out by legislation and the regulator. This conception of mistrust is largely consistent with existing academic literature on the importance of trust for smart metering. Mistrust is often found to stem from consumer perceptions that energy companies are not open about their own financial benefits from smart metering and might not pass any savings on to their customers [8–10].

Our findings show a more complex role of (mis)trust between consumers and energy companies than acknowledged so far in this literature. In the UK, the use of ICT in smart grids is also seen as potentially contributing to increased consumer trust, as ICT applications allow for a greater transparency of monetary flows and more reliable billing. The importance of reliable energy bills is prominent in the UK, potentially because many UK meters date back to the nineteenth century, and consumers need to be present when meter readings are taken. This leads to a reliance on estimated bills, which are often inaccurate, and consumer dissatisfaction [85]. In addition, our analysis shows mistrust between industry players. This arises mostly from changing actor roles and an increased cross-sector cooperation, for example in pilot projects by the triple and quadruple helix (*"government, industry, research organizations, and citizens (Het Financieele Dagblad, 15 Dec 2015)"*, [86]) or between established energy suppliers and new service providers. Stakeholder relationships are new and cooperation still has to stand the test of time. The second aspect of trust is related to mistrust by consumers in the operations of devices and networks, including the protection of personal data. This is salient in the Netherlands and can be traced back to cyber security risks and concerns that smart meters do not show correct and reliable meter readings, which is related to the values of transparency and reliability. Potential risks on cyber security as well as incorrect and unreliable meter readings fuel mistrust in smart metering devices and networks.

Privacy and security issues result from an increased application of ICT and are the most prevalent challenges to smart grids covered in Dutch newspaper articles. The finding that both values are relevant is in line with existing research, which reports on these risks particularly in context with smart metering [87–91]. Privacy in the public debates is seen in the dichotomy between the household – the 'inner' – and the external world. Challenges to household privacy arise from smart metering, where a frequent transmission of fine-grained consumer data can reveal more information about household behavior than conventional electricity meters. Consumer privacy might be violated if this information allows insight into behavioral patterns such as identifying types and usage times of household appliances [90], and if such data is sold for commercial purposes [10]. Concerns about data privacy by the Dutch senate and the consumer representation body were one of the major reasons for the delay in the Dutch smart metering rollout [12]. Additionally, automated data transmission from smart meters is seen as critical due to data access challenges. Statements reflect a conflict between policy makers and consumers (who would be interested in an open access regime) and commercial entities (who would profit more from a closed data ownership by them). In the UK, data privacy issues are not particularly salient in the debate. When mentioned, statements show that consumers are not worried about sharing data, because they are in control of any data and trust energy suppliers with their information. Such statements are put forward by industry organizations (specifically Smart Energy GB), while the consumer representation body is not cited as stressing data privacy issues.

Cyber security problems are related to the risk of harmful use of data and networks, and conceived in two ways in both countries. Firstly, consumer data security is perceived to be at risk through smart metering, consistent with related academic publications. Cyber security concerns are often found to arise from the risk of cyberattacks and statements stress the importance of protecting and encrypting data adequately as well as collecting data proportionally to the purpose of the system (i.e. collecting only data that is required for the system to function) [1,89,92]. Secondly, the operational security of power networks is perceived to be endangered due to an increased dependence on ICT, with emphasis on the consequences for supply security and for the economy. Threats to power networks from hacking by terrorists are mentioned as well. Although both aspects of cyber security are salient in the UK, they are much less prominent than in the Netherlands.

While the insight that privacy and security are relevant values for smart grids is consistent with existing literature, our findings go beyond this and give indications how these values are related to energy justice. Especially the increased importance of sharing and storing more fine-grained data on energy use underlines that the distribution of property and access rights to these data among users, public, and private stakeholders is an important aspect of distributive justice. Distributive justice for smart grids is not only about the distribution of monetary benefits and costs, but also about the distribution of rights to access, withdraw, manage, alienate, and exclude others from using data and information about energy consumers.

5. Conclusion

In this paper, we broaden conceptualizations of energy justice for smart grids by developing a deeper understanding of the social and moral values underlying the Dutch and British public debate on these systems. Our results show that values are reflected in newspaper articles both as advantages and challenges of smart grids. Advantages include the systems' contribution to the energy policy triad, i.e. the values of economic development, environmental sustainability, and security of supply. Beyond these, smart grids are considered as advantageous for distributive and procedural justice, confirming the important role of energy justice for these systems. However, value conflicts also reveal distributive and procedural injustices, particularly when the potential of economic and environmental benefits is criticized. In addition, smart grids are considered as controversial because innovative information and communication technology increases privacy and security risks, and concerns of lacking reliability. Comparing the debate in the Netherlands and the United Kingdom, we find similar reflection and salience of values. One of the main differences is that privacy and environmental sustainability are more salient values in the Netherlands. In turn, economic development, particularly energy poverty and billing accuracy for consumers, is more salient in the United Kingdom.

By exploring the public debates on smart grids, we contribute to existing research on energy justice. Our analysis reveals that distributive and procedural justice aspects are perceived to be at the core of many benefits and drawbacks of smart grids. On the one hand, smart grids support a more equitable market access for consumers, by facilitating access to small-scale generation. On the other hand, contestations within the energy triad – i.e. concerns whether smart grids will indeed contribute to more sustainable, cost-efficient, and secure electricity supply – are related to energy justice issues from the perspective of consumers. Challenges evolve particularly around an inequitable distribution of benefits and costs. Smart grids have the potential to contribute to a more equitable access to electricity systems. However, this access might be restricted to more affluent parts of a population and reinforce monetary injustices faced by economically vulnerable citizens.

We also broaden the current focus of energy justice research on energy supply and use by concentrating on the convergence between the energy and the ICT sector. Our findings suggest that energy justice research should be extended by accounting for a broader range of (information technology related) values. Transparency, control, privacy, and security are the values which can be traced back solely to the collection, automatic transfer, and central storage of energy use data as well as the visualization of real-time information on energy use. The conceptualization of distributive justice should therefore include the property and access rights to these data and information. In addition, procedural justice aspects pertain to concerns that algorithms could imply selection biases. Reliability of existing and future technology is a concern due to the rapid technological development and relatively short product life cycles in the information technology sector. In fact, smart grids represent a clash between two fundamentally different industries: The electricity sector, which is focused on long-term thinking, stability, and little experimentation on a whole system level, and the information technology sector, where innovation and rapid technological change is key to success.

In addition, our analysis shows that values are related through instrumental and conflicting relationships. These occur because smart grids are complex socio-technical systems, where technologies, institutions, and social actors are closely intertwined. We provide a detailed overview of these relationships. For researchers interested in analyzing the complexity of energy systems at the intersection of technology, institutions, and actor behavior, our extended framework of energy justice can serve as input for complexity science models (cf. [25]).

The findings are also valuable for policy makers and smart grid designers. We provide them with a detailed list of value-laden aspects of smart grids that cause societal concerns and might reinforce injustices in the energy system. They can be a barrier to the wider adoption of smart grid systems. These values provide both policy makers and smart grid designers with criteria for design requirements of institutions and technologies in smart grids. On the one hand, our findings confirm that a focus on the three core energy policy objectives of environmental sustainability, economic development, and security of supply is insufficient to cover the broad range of value-laden benefits and drawbacks of smart grids. Since smart grids are part of energy systems that are deeply entrenched in the every-day normality of modern societies, changing energy systems is not just a matter of energy policy, but has wider social and moral implications for general well-being in a society. On the other hand, our insight that values are intertwined through instrumental and conflicting relationship clarifies the significance of considering a set of values as design requirements. Our findings show that the majority of values are contested, with different conceptions depending on the detailed technological and institutional context as well as societal groups. Relating values to technological and institutional attributes as well as to stakeholder groups is needed to understand the roots of value conflicts. This confirms the importance of considering differences in value conceptions in debates, decision-making processes, and system design.

Our findings provide a conceptualization of energy justice for the case of smart grids and indications what values should be considered in the development of institutional and technological design requirements. They are limited, however, in specifying in detail how relatively abstract value aspects such as a more equitable distribution of property rights on energy data should be translated into specific design requirements. Further research is needed to make this specification. Such research could build on the field of Value Sensitive Design (cf. [93]), where scholars have started to outline a dual approach of translating values first into more prescriptive statements (norms) and then into design requirements that can be directly implemented in (information) technologies.

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Appendix A. Coding principles

Coding and recording principles clarify the process of interpreting themes and patterns from the articles. They are made explicit to increase the reproducibility of results and listed below.

– An initial code book containing potentially relevant values and their definitions is established through a literature review on smart grids and values of ethical importance often mentioned in ethics of technology.
– The 'sensitizing concepts' principle is used during coding. This means that the initial code book is open for new additions, changes in definitions, and changes in coding categories (e.g. splitting one value into two).
– Statements in an article are reflected in front of the code book to identify which value is implied in the statement.
– A recorded statement needs to be at least one full sentence. Outside readers need to be able to understand the statement when reading it independently from the main article.
– Statements that reflect values are coded as positive, negative, or neutral depending whether they are used in favor of, against, or neutral to the smart grid development.
– Stakeholders are assigned in two ways: The group/organization to which the statement is attributed, or which puts forward an argument is the 'sender'. The group/organization which is affected by the statement is the 'receiver'. The two stakeholder classifications can be the same for one statement. If the statement does not cite a group/organization, the 'sender' stakeholder is left empty. If the article puts forward a value-laden statement or advice from the journalist/newspaper perspective without a clear source attribution, the newspaper is the 'sender' stakeholder.
– Statements have to be explicitly in context with smart energy systems or their components. Statements which contain values but refer to main tasks of market actors, general energy supply, or the energy transition in general, are excluded. Electricity generation from conventional sources and renewables is excluded if not mentioned explicitly in relation with smart energy systems.
– With each statement, the mentioned technological and/or institutional functionality is recorded to demarcate the reason why a value is relevant.
– Statements about smart homes need to be in relation with electricity use/savings/management/generation/etc. to be included. Smart home statements about health care, entertainment, and life style are excluded.
– Documents are coded according to the 'saturation principle': The coding procedure stops when statements become repetitive and accordingly the coding scheme is not adapted any longer. At a perceived saturation point, several further articles are coded with the (saturated) coding scheme to confirm saturation.
– To enhance the validity of the results, an inter-coder agreement check is performed. An additional person codes the statements. Discrepancies are solved through discussion and consensus.

Appendix B. List of analyzed newspaper articles

See Table B.1.

Table B.1
List of analyzed newspaper articles.

Publication	Headline	Date
Netherlands		
AD/Algemeen Dagblad	Energiebedrijven zien niets in splitsingsplan van Brinkhorst	11 February 2006
AD/Algemeen Dagblad	Consumentenbond wil keuze bij meters	14 April 2009
AD/Algemeen Dagblad	Rekening stroommeter niet te hoog	01 September 2011
AD/Algemeen Dagblad	WK-titels van Ard Schenk	19 February 2013
AD/Algemeen Dagblad	Een monteur plaatst een 'slimme' energiemeter.	12 March 2014
AD/Algemeen Dagblad	Stroomprijs laag? Vaatwasser aan!	10 November 2015
AD/Algemeen Dagblad	Je moet ook kunnen zien dat je veel geld bespaart	02 December 2016
AD/Algemeen Dagblad	Waakhond wil strenger controleren op nevenactiviteiten netbeheerders	09 March 2017
De Telegraaf	Slimme energiemeter bespaart 30%	09 April 2007
De Telegraaf	Slimme energiemeter tegen schulden; Den Haag laat 1500 prepaidkaarten installeren	02 May 2007
De Telegraaf	Kabinet grootste oorzaak van gebrek aan respect	21 June 2008
De Telegraaf	NS, is er wel goed nagedacht over zonnepanelen?	15 April 2009

(*continued on next page*)

Table B.1 (*continued*)

Publication	Headline	Date
De Telegraaf	Microgeneratie	10 April 2010
De Telegraaf	Logica met banken in slimme chips	28 July 2011
De Telegraaf	Tranen in mijn ogen: Job, ik zal je missen!	21 February 2012
De Telegraaf	Slimme energiemeter	21 February 2013
De Telegraaf	Elektriciteit terugleveren	13 July 2013
De Telegraaf	Rekening onder de loep	04 October 2014
De Telegraaf	Weinig nachtelijke wasjes	28 July 2015
De Telegraaf	Klimaat regelen; #DOORBREKER Niek de Jong	04 November 2015
De Telegraaf	Eneco zet in op internationale uitrol Toon	03 March 2016
De Telegraaf	Beetje dom	20 November 2016
De Telegraaf	Brieven	06 January 2017
de Volkskrant	Energie na internet	17 September 2007
de Volkskrant	'Chaos' bij invoering van slimme stroommeter; Nieuwe meters Netbeheerder vreest apparaten die slecht communiceren	15 April 2008
de Volkskrant	Energiemeter is handig voor dieven en terroristen	21 March 2009
de Volkskrant	Senaat moet privacy burger bewaken	06 July 2009
de Volkskrant	Hyves voor energie is het toekomstbeeld; Groene stroom Groningen begint Europese proef met huizen die energie opwekken en afnemen in wisselwerking met zonnepanelen en windmolens	06 March 2010
de Volkskrant	Met één druk op de knop alles regelen	19 January 2011
de Volkskrant	'Slimme meter moet slimmer'; privacy	12 June 2012
de Volkskrant	Design van een beter leven?	28 October 2013
de Volkskrant	Kom je aan de molen, kom je aan ons	04 April 2016
de Volkskrant	Slimme meter stelt bespaarders ernstig teleur	21 November 2016
Het Financieele Dagblad	Rijden op stroom	17 April 2010
Het Financieele Dagblad	De komst van stroom & saldo Energiebedrijf heeft veel met bank gemeen	04 September 2010
Het Financieele Dagblad	'Ik moet nu op veel meer borden schaken'; Kjartan Skaugvoll maakt overstap van Nuon naar kleine producent van energiemeters	25 January 2011
Het Financieele Dagblad	Slimme stroomslurpers	11 April 2011
Het Financieele Dagblad	Winst Alliander fors hoger; Netwerkbedrijf schroeft investeringen en winst op door invoering hogere tarieven	23 August 2011
Het Financieele Dagblad	Wereldprimeur Hoogkerk	24 October 2011
Het Financieele Dagblad	Consument maakt zelf wel elektriciteit; Het aantal burgerinitiatieven voor duurzame energie groeit in razend tempo. Dat zet Den Haag en de energiesector onder druk.	15 October 2012
Het Financieele Dagblad	Gemeenten moeten nu het voortouw nemen bij reductie van CO2-uitstoot	05 April 2014
Het Financieele Dagblad	Nederlands afvalbeleid moet veel slimmer worden; Als we het afval in Europa optimaal gebruiken, hebben we 20% minder Russisch gas nodig	20 September 2014
Het Financieele Dagblad	AMS zet in op slimme energie	20 February 2015
Het Financieele Dagblad	Het digitale huis	02 May 2015
Het Financieele Dagblad	Techniek helpt bij oplossen klimaatcrisis	15 December 2015
Het Financieele Dagblad	De spits mijden achter het stopcontact	28 May 2016
Het Financieele Dagblad	In de wet is nog helemaal niet nagedacht over mensen die zelf energie opwekken	20 September 2016
Het Financieele Dagblad	Kan de overheid het sleepnet aan?	04 March 2017
Het Financieele Dagblad	Ook energie wordt steeds slimmer Energiemarkt is bekend met transities	24 June 2017
Metro (NL)/Spits	Slimme energiemeter	01 October 2007
Metro (NL)/Spits	Slimme meter beter	26 May 2008
Metro (NL)/Spits	Politieke partijen schenden privacy	10 February 2010
Metro (NL)/Spits	Slimme meter, dit wil je ervan weten	04 May 2016
Nederlands Dagblad	Slimme energiemeter schendt privacy	11 November 2008
Nederlands Dagblad	Effect slimme meter valt tegen	21 November 2016
Nederlands Dagblad	Slimme energiemeter maakt fouten	04 March 2017
NRC Handelsblad	Liever wassen als het waait	13 March 2010
NRC Handelsblad	Graag één minister voor EZ en LNV	08 October 2010
NRC Handelsblad	Eerste Kamer doet steeds vaker waar parlementen voor zijn; Opklaringen	02 June 2012
NRC Handelsblad	Een burger in de goede richting duwen. Mag dat?	26 March 2014
NRC Handelsblad	Zuiniger met gas en stroom	09 January 2015
NRC Handelsblad	Netwerkbedrijf Alliander verwacht verdere toename 'zelfopwekkers'	31 July 2015
NRC Handelsblad	Elektrische auto moet het net balans brengen	10 February 2016
NRC.NEXT	Meten is te veel weten	09 April 2009
NRC.NEXT	't Lijkt zo makkelijk: opladen en karren maar; Maar de elektrische auto is niet populair. Het is namelijk nog niet mogelijk om de batterij in andere EU-landen op te laden	06 May 2010
NRC.NEXT	De slimme stad kan een dom idee worden	17 October 2015
Reformatorisch Dagblad	Keuzes in energieonderzoek noodzakelijk	21 July 2007
Reformatorisch Dagblad	Goede ingenieur weet ook iets van filosofie	16 October 2013
Reformatorisch Dagblad	Voor niets gaat de zon op	29 November 2014
Reformatorisch Dagblad	Revolutie achter het stopcontact	19 June 2015
Reformatorisch Dagblad	Het net in balans	24 June 2016
Trouw	Essents prepaid-energie stimuleert zuinigheid; Slimme meters een soort moderne muntjesautomaat	19 November 2007
Trouw	Energie besparen; denktank	26 March 2009
Trouw	Versnellen als stopwoord	01 April 2010
Trouw	Laadpaal kan gekraakt worden, en misbruikt	09 April 2014
United Kingdom		
Daily Mail	Families could be forced to install a £400 smart meter	23 May 2007
Daily Mail	Ask Tony; money mail's letter page tackles all your financial headaches	27 November 2013
Daily Mail	We need action, not more reviews	27 June 2015
Daily Mail	Put the elderly first	25 January 2017
Daily Star	4 m Brits in energy price cut	25 June 2016
Financial Times	Smart meters could save Pounds 40 m on energy	04 August 2007
Financial Times	Big six groups face challenge from residential gas supplier	12 January 2009

(*continued on next page*)

Table B.1 (*continued*)

Publication	Headline	Date
Financial Times	Three challenges for transmission networks	24 November 2009
Financial Times	Utilities hope vehicles will open electric avenues	04 October 2010
Financial Times	Higher costs wipe out Queen's smart meter gains	22 October 2011
Financial Times	Corporate governance is trumped by the gene pool	15 March 2014
i	Smart meters 'may lead to an increase in fuel poverty'	17 January 2012
i	Daily Money	07 October 2014
i	Benefits of smart meters 'not clear enough'	24 September 2016
Independent on Sunday	Consumers have had a narrow escape from smart-meter sales putsch	08 April 2012
Metro	Powering precious savings	12 August 2009
Metro	E.ON fined £7m for smart meter failure	10 November 2015
Metro	Power Trip	13 June 2017
Sunday Express	Is signing up for a smart meter such a bright idea?	02 August 2015
The Daily Express	Not such a smart policy	31 March 2011
The Daily Express	Want to save? It's Miller time	22 February 2013
The Daily Express	MPs: Energy smart meters are too costly	10 September 2014
The Daily Express	How your Sunday roast may be an hour overcooked	26 March 2016
The Daily Express	Smart meters are not for the benefit of consumers	08 March 2017
The Daily Mirror	25 ways to save £4000	18 May 2010
The Daily Telegraph	Tight budget? You can still switch to green in your home	17 May 2008
The Daily Telegraph	Vast potential rewards for a greener UK	17 July 2010
The Daily Telegraph	Time to connect with smart homes; Microgeneration benefits both the economy and the environment, says Stephen Hoare	09 May 2012
The Daily Telegraph	The Big Six are sitting on our cash	02 November 2013
The Daily Telegraph	Terror fears over 'smart meters'	07 July 2014
The Daily Telegraph	Smart meter will fail, say MPs	07 March 2015
The Daily Telegraph	Can I save energy in the kitchen?	30 April 2016
The Daily Telegraph	The £2,000 batteries that free us from the grid	01 October 2016
The Daily Telegraph	Workers' rights and curbs on pay at heart of push for centre ground	19 May 2017
The Guardian	Technology: Letters and blogs: Too hot to handle	21 June 2007
The Guardian	Energy firms in row with regulator over smart meters	11 February 2008
The Guardian	Weekend: Space: It's time to fight back: Horrified by your latest utility bills? Then it's time to take action. There's plenty we can all do, says energy expert Dave Hood, to save money and the planet. The key is knowing which changes really make the difference.	29 November 2008
The Guardian	Budget is last chance to switch to low-carbon economy, say Tories	17 April 2009
The Guardian	Wetherspoon toasts a record year	12 September 2009
The Guardian	Six months later… An update on the 10:10 campaign plus a look at sustainability at GNM: GUARDIAN PRINT CENTRES: Environmental performance, progress and plans	25 February 2010
The Guardian	Society: A galvanising force for infrastructure	11 June 2014
The Guardian	Batteries on wheels: 'vehicle-to-grid' technology allows electric cars to store energy	17 August 2015
The Guardian	The only way to beat the blackouts is smart, clean, affordable energy	06 November 2015
The Guardian	UK energy policy is in disarray - but blackouts are unlikely	01 March 2016
The Guardian	Top 10: tech tools for business efficiency and productivity	29 November 2016
The Guardian	Camden comedy as council doesn't let me read my meter	19 February 2017
The Independent	World's largest smart meter group set up	21 May 2008
The Independent	Letters	16 May 2009
The Independent	Our choices have caused the problem and they can solve it too, says Joanna Yarrow	04 September 2010
The Independent	Smart meters set to cost households £15 in return for minor savings	10 September 2014
The Mail on Sunday	Smart meters to cut fuel bills	20 May 2007
The Mail on Sunday	Hot tips to beat the winter chill	24 October 2010
The Mail on Sunday	Fed up with your energy provider? We give you the power to fight back	13 April 2014
The Mail on Sunday	Clean up as tech firms meters help reduce bills	14 August 2016
The Observer	'Smart meters' scheme for UK could cost up to pounds 20bn	16 March 2008
The Observer	Will smart meters bring an end to shocking utility bills?	07 March 2010
The Sun	Meters in £9bn bill	03 December 2009
The Sun	£1bn fuel plan axe	11 May 2013
The Sun	Weekend free leccy	15 May 2016
The Sun	The future is smart	24 June 2017
The Sunday Telegraph	Britain to get 'smart' grids	28 November 2010
The Sunday Telegraph	Britain's energy future	07 April 2013
The Sunday Telegraph	Will smart meters save or cost you money?	24 May 2015
The Sunday Telegraph	'Help – it costs £9000 to heat our mansion'	12 June 2016
The Times	Demise of Energywatch is a disaster waiting to happen	29 September 2007
The Times	The real cost of renewables	26 October 2010
The Times	Smart meter plan could prove a waste of energy	30 June 2011
The Times	Child benefit cuts looming large	22 September 2012
The Times	That's not very smart: E.ON fined for missing deadline	10 November 2015
The Times	British Gas smarting after £4.5 m fine	08 December 2016
The Times	Customers to pay £70 more after SSE raises electricity prices	14 March 2017

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