# Just Energy? Designing for Ethical Acceptability in Smart Grids

Milchram, C.

**DOI**
10.4233/uuid:26655b53-2aab-4fa2-943d-943ebd037c5e

**Publication date**
2020

**Document Version**
Final published version

**Citation (APA)**
Milchram, C. (2020). *Just Energy? Designing for Ethical Acceptability in Smart Grids*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:26655b53-2aab-4fa2-943d-943ebd037c5e

# JUST ENERGY?

## DESIGNING FOR ETHICAL ACCEPTABILITY IN SMART GRIDS

CHRISTINE MILCHRAM

# Just Energy?

Designing for Ethical Acceptability in Smart Grids

Christine Milchram

**Just Energy?**

Designing for Ethical Acceptability in Smart Grids

**Dissertation**

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus, Prof.dr.ir. T.H.J.J. van der Hagen
chair of the Board of Doctorates
to be defended publicly on
Monday 5th of October 2020 at 15:00

by

**Christine MILCHRAM**

Master of Science in International Business Administration
University of Vienna, Austria
born in Vienna, Austria

This dissertation has been approved by the promotors.

Composition of the doctoral committee:

| | |
|---|---|
| Rector Magnificus | Chairperson |
| Prof.dr. R. Künneke | Delft University of Technology, promotor |
| Prof.dr.dr. R. Hillerbrand | Karlsruhe Institute of Technology, promotor |
| Dr. G. van de Kaa | Delft University of Technology, promotor |
| Prof.dr.mr.ir. N. Doorn | Delft University of Technology, promotor |

Independent members:

| | |
|---|---|
| Prof.dr. P. Palensky | Delft University of Technology |
| Prof.dr. F. Alkemade | Eindhoven University of Technology |
| Prof.dr. D. McCauley | Erasmus University Rotterdam |
| Dr. M. Arentsen | University of Twente |
| Prof.dr. I. van de Poel | Delft University of Technology, reserve member |

**Dissertation**
Just Energy? Designing for Ethical Acceptability in Smart Grids

Department for Values, Technology and Innovation
Faculty of Technology, Policy and Management
Delft University of Technology
The Netherlands

This work was funded by the Netherlands
Organization for Scientific Research (NWO).



Printed by Ipskamp Printing

ISBN 978-94-6384-163-4



An electronic version of this dissertation is available at http://repository.tudelft.nl/.

## Acknowledgements

When I started this PhD, my main motivation was to work in a content- and quality-driven manner on sustainability transitions in infrastructures such as the electricity or transport sector. In hindsight it is fair to say that I wasn't fully aware of what I was getting myself into. The joy of content-related, detailed work was definitely challenged by the reality of working for four years in the individualistic and persistent manner a PhD process demands. Yet I also gained so much more than expected; personal growth, and most importantly the profound relationships and friendships formed during these years. Lots of people accompanied and supported me throughout, and I am grateful to each and every one of them.

First of all I would like to thank my promotors. Some thought that having four promotors would be a couple too many, but I wouldn't be where I am had it been otherwise. Rolf, thank you for your trust. You were always available, making time for discussions and feedback. Rafaela, for your enthusiasm and thought-provoking comments that always made me learn, as well as for introducing me to the inspiring research environment at ITAS. Geerten, thank you for helping me navigate the depths of the academic publishing process and pushing me to write journal articles early on. Neelke, thank you for joining and staying in my supervisory committee. You are a role model in leadership, supervision, and research; thank you for convincing me that interdisciplinarity is not only okay, but much needed.

At TU Delft, I was fortunate to become part of the truly diverse group of people at the TPM faculty. Jan Anne, I was extremely lucky to have you as a mentor. Thank you for your pragmatic advice, support, and validation. Tristan, thank you for our collaboration in trying to understand our project and in forming our own lines of research, as well as on conference and workshop organizations. Daniel, thank you for your insights into the intricacies of TPM, and the warmth of the Tyrolean dialect. To all the members of the Friday Seminar and the PhD workshops on Elinor Ostrom's work, especially Aad, Marloes, Theo, Kas, Richard, John, Jaco, Martijn, Sander, Esther, Rutger, Robert, Thomas, and Amineh: I'm grateful for our productive discussions, your feedback, and happy to have shared many a treat!

A special thanks also to all colleagues in the ETI section. Cees, Roland, Robert, Laurens, Enno, Zenlin, and Claudia, thank you for your support, cups of coffee, and jokes. They were a relief whenever I started taking everything too seriously. Suzanne, your warmth and joy make a big difference in the section. Thank you for your thoughtfulness and commitment to overcome all administrative hurdles.

I am grateful to have met so many inspiring researchers and personalities across the entire faculty. To the members of the philosophy section and the 'Let's get ethical' peer group – Ibo, Sabine, Jeroen, Behnam, Udo, Peter, Nicole, Taylor, Georgy, Anna, Klara, Laura, Jonas, Scott, Thijs, Tom, and Shuhong – your feedback was incredibly helpful in dealing with the complexities of researching values. I also shared many research interests with members of the O&G section; Maria, Toyah, Elisabeth, and Shannon, thank you for being available to discuss research and experience on energy systems governance, and for your willingness to share strategies for overcoming mental challenges during a PhD process. Nina, thank you for your joyfulness and your clarity of thought; you always made me smile. To the EPA teaching staff, particularly Bert and Bertien, thank you for sharing the office space in The Hague, and for your valuable advice on academic life.

I had the privilege to work with several researchers outside of TU Delft. Carolin, Holger, Jens, Kirsten, and Johanna, thank you for showing me that research can be a collaborative effort! A special thank you to Carolin, Holger, and Sandra in Jülich and Jens, Michael, Giovanni, and Witold in Karlsruhe for your warm welcome.

To everyone who I met during my empirical work and the members of our project's valorization committee, thank you for sharing your experiences so openly, and for reminding me that my research is related to reality after all.

I would also like to express my gratitude towards my former colleagues. The professional attitude, people-oriented work ethic, and constructive feedback culture I learned while working with Accenture's sustainability team was an excellent basis to build a professional life on. Samanthi, I am very happy that we reconnected and am indebted to you for suggesting our joint virtual writing sessions. Our conversations during these times were always a source of motivation and joy.

My friends in the Netherlands, meeting you made a world of a difference for how much I felt at home here. Fabio, Vladimir, Rijk, and Ben, thank you for our numerous conversations, lunches, walks, coffee breaks, and joint working sessions. The time spent with you was always inspirational, full of intellectual and personal insights, joy and laughter. I will never forget your surprise. Indushree, thank you for your generosity, adventurousness, and for instilling in me a deep affinity for Indian culture and cuisine. Erin and Brian, thank you for the time spent cooking, eating, drinking, talking, and traveling; for your warmth and for always opening your house to us. Never having to explain what I do provided much needed breaks from academic life.

Finally, I would like to thank my family. I am fortunate to have grown up amongst you. My parents, Eva and Gerhard, thank you for devoting everything to your children and for teaching us to be honest, trusting, and open human beings who always see the best in others. I could not have become who I am without your safety net. Johannes, Maria, Markus, Caroline, in big families relationships always change; I am incredibly grateful that no matter what, we always find each other. Michael, you are my home. I deeply appreciate how you have supported and kept me grounded in these past years. Thank you so much.

*Christine Milchram,*
*August 2020*

## Contents

# Figures

## Tables

# Summary


### Smart grids within the transition to sustainable energy systems

Smart grid systems are widely considered as crucial in the energy transition, because they allow for greater flexibility in bridging temporal gaps between electricity supply and demand in renewable energy systems. To do so, the systems make use of information and communication technologies to measure and monitor supply and demand in real-time, on the basis of which the use of renewable electricity can be optimized. Despite this important role in future renewable energy systems, the introduction of smart grids comes with serious moral repercussions, for example for data privacy and security, autonomy and control, or distributive justice.

This dissertation *analyzes the moral implications of smart grid systems, and provides guidance for designers and policymakers on how to address these implications in smart grid technologies and institutions, with the ultimate motive to increase the systems' ethical acceptability.*

Interdisciplinary in nature, the research contributes to value-sensitive design, institutional analysis, and energy justice. It is in line with academic endeavors to enrich energy research with insights from the social sciences and humanities. It thereby adds to a literature that is dominated by technological approaches and presents smart grids as a technical 'fix' to make electricity systems more sustainable.

### Research design

The main body of this dissertation consists of four papers that, collectively, address the ethical acceptability of smart grids. It combines conceptual insights with empirical investigations. Conceptual investigations draw from ethics of technology, value-sensitive design and theories of justice used in the energy justice literature. Empirical methods involve qualitative content analysis and case study research to understand affected stakeholders' value conceptions and perceptions of a technology.

### The influence of value change on institutional change within the energy transition

Transition processes to low-carbon energy systems are shaped by changes in the institutions (i.e. the "rules of the game" such as legislation and regulation) that govern energy systems. Institutions are influenced by values, normative convictions that can be intersubjectively justified and are worth striving for to realize a good society. Analyses of institutional change should account for this influence, but have been

hindered by the absence of a structured framework that highlights the role of values in institutional development.

Chapter 2 of this dissertation therefore develops an interdisciplinary framework that explicates how values are embedded in existing infrastructure and institutions, how they shape communities and individual behavior, as well as how value controversies can trigger social learning processes that eventually can result in institutional change. The framework builds on a dynamic Institutional Analysis and Development (IAD) framework and expands it by conceptualizations of values in moral philosophy, institutional economics, and social psychology.

**Moral values as factors for social acceptance of smart grid systems**

Analyzing the moral implications of smart grid systems through the lens of moral values requires an identification and conceptualization of *relevant* vales. This includes insight into what values are embedded in different smart grid components (e.g. smart metering, storage, smart home), as well as how these values might influence the acceptance and adoption of smart grids.

Chapter 3 thus identifies a range of relevant values, and does so through a systematic literature review. Environmental sustainability, security of energy supply, and transparency are values underlying the motivations for smart grid development or values which are positively influenced by the technologies (i.e. 'drivers'). Values which reflect concerns or fear of being negatively impacted by smart grids (i.e. 'barriers') are data privacy, data security, (mis)trust, health, justice, and reliability. A range of values partly form drivers and partly barriers to smart grid implementation: these are control, inclusiveness, quality of life, and affordability. Findings indicate that whether smart grids affect these values positively or negatively depends on the detailed technological and regulatory context as well as the way in which users interpret and conceive values.

**Implications of smart grids for energy justice**

Among the range of relevant smart grid values, justice occupies a special place as an overarching value that is a powerful lens to put neglected social impacts of energy systems on the research and political agendas. Energy justice addresses the question what values and moral frameworks ought to guide the development of energy systems. Despite the aspiration to be a comprehensive framework that covers all aspects of energy systems, the energy justice literature has been limited in understanding the potential implications of digitalization in the electricity system that comes with the introduction of smart grids.

Chapter 4 conceptualizes justice in the context of smart grids, analyzing how pro and contra smart grid arguments in the Netherlands and the United Kingdom reveal potential impacts of these systems on justice. Findings show implications for distributive and procedural justice. Most of these are connected to the roll-out of smart metering, which is the dominant topic in the debates in both countries. Positive justice implications, generally speaking, are that smart grids are seen as part of a development towards more democratic and open energy systems, with higher citizen participation and empowerment. Negative justice implications, however, concern the distribution of benefits and harms between consumers and energy companies. Injustices might also arise in the distribution of benefits and costs between different consumer segments, as complex technologies requiring specific knowledge might discriminate towards groups with low IT literacy. Additionally, several aspects of smart grid pilot projects are criticized as unfair: the selection procedures for consumers who participate in these projects; the strong involvement of distribution system operators and experimentation using public money; and the increased reliance on specialized IT knowledge which might shift power from public bodies (e.g. municipalities) to private software companies.

**Designing for justice in smart grid pilot projects**

Having identified potential positive and negative justice implications, the question remains how to design for justice in real-life implementations of smart grids. Most smart grids are to-date realized in the form of local experiments, which combine for example photovoltaic systems, home or community batteries, and smart metering with software platforms to optimize local (renewable) electricity flows.

Chapter 5 thus analyzes how energy justice becomes embedded in the design of smart grid pilot projects. It compares four projects with respect to the extent to which their design contributes to justice in the distribution of benefits and harms, in the decision-making procedures, and in the equitable recognition of diverse types of end users. Based on the findings, the following recommendations are put forth for designing for justice in similar future systems:

For distributive justice,

- share profits individually or allocate them to the community as a whole depending on individuals having full control over profit achievement or not.
- emphasize knowledge sharing from and with other projects.
- collect and use as little personal data as needed.

For procedural justice,

- set up participatory decision-making processes.

- give users control to set their own preferences for batteries, smart appliances, and peer-to-peer trading in the app or in-home display.
- make sure that user interfaces are transparent regarding electricity flows and consequences for household electricity costs.

For justice as recognition,
- use a structured selection process for community and participants.
- experiment more with people who are not owner-occupiers.
- do not require all participants to own solar panels and batteries.
- make sure that user interfaces are as easy to use as possible.

**Contributions**

This dissertation highlights often neglected social and moral aspects of energy systems.

From a theoretical perspective, the research contributes to several fields:
- It expands value-sensitive design from technical artefacts to socio-technical systems.
- It adds a values-perspective to institutional analysis.
- It argues for moral values to be incorporated more explicitly in technology acceptance studies as potential variables that impact user acceptance.
- It broadens existing conceptualizations of energy justice from aspects pertaining to energy supply and use to include implications that are caused by an increased convergence of the energy and ICT sector.
- It increases the practical relevance of energy justice by presenting concrete and actionable design and policy recommendations.

The dissertation has also made a practical contribution, giving recommendations to designers and policymakers on how to address moral implications in smart grid technologies and institutions:
- For smart grid designers, the research provides an inventory of values that should form design goals. It ties relatively abstract values to concrete design features, thus providing the basis for value-sensitive design in practice.
- The inventory of values provides goals for policymaking regarding smart grids, too. The concluding chapter moreover puts forth more specific recommendations for the smart metering roll-out, for funding smart grid pilot projects, and for adjusting electricity regulation such that smart grids are more equitable and inclusive.

# Samenvatting

## Intelligente netten en de transitie naar duurzame energiesystemen

In de transitie naar hernieuwbare energiebronnen worden slimme netwerken (zogenaamde ‘smart grids’) algemeen als cruciaal beschouwd. Smart grids bieden de flexibiliteit die noodzakelijk is om tijdelijke verschillen tussen vraag en aanbod van elektriciteit te overbruggen. De systemen maken hiervoor gebruik van informatie- en communicatietechnologieën om vraag en aanbod real-time te meten en te volgen, op basis waarvan het gebruik van duurzame elektriciteit kan worden geoptimaliseerd. Ondanks deze belangrijke rol in toekomstige duurzame energiesystemen, heeft de introductie van smart grids serieuze morele gevolgen, bijvoorbeeld voor de privacy en veiligheid van gegevens, voor de autonomie en controle door gebruikers en distributieve gerechtigheid.

Dit proefschrift *analyseert de morele implicaties van smart grid-systemen.* Het onderzoek biedt richtlijnen voor ontwerpers en beleidsmakers om met deze implicaties in smart grid-technologieën en –instituties rekening te houden. Het uiteindelijk doel is de ethische aanvaardbaarheid van de systemen te vergroten.

Het onderzoek is interdisciplinair van aard. Het bouwt voort op en draagt bij aan *value-sensitive design*, *institutional analysis* en *energy justice*. Daarbij sluit het aan bij academische inspanningen om energieonderzoek te verrijken met inzichten uit de sociale en geesteswetenschappen. Het draagt daarmee bij aan een literatuur die gedomineerd wordt door technologische benaderingen en die slimme netten als een technische 'fix' presenteert om elektriciteitssystemen duurzamer te maken.

## Onderzoeksopzet

De kern van dit proefschrift bestaat uit vier artikelen die gezamenlijk de ethische aanvaardbaarheid van smart grids behandelen. Het combineert conceptuele inzichten met empirisch onderzoek. Conceptuele onderzoeken putten uit ethics of technology, value-sensitive design en rechtvaardigheidstheorieën die worden gebruikt in de literatuur over energy justice. Empirische methoden omvatten zowel kwalitatieve inhoudsanalyses en casusonderzoek. Beide methoden hebben het doel te begrijpen welke standpunten betrokken stakeholders hebben rondom smart grids en relevante waarden zoals milieuduurzaamheid, privacy, autonomie en rechtvaardigheid.

**De invloed van waardeverandering op institutionele verandering binnen de energietransitie**

De transitie naar koolstofarme energiesystemen wordt gevormd door veranderingen in de instituties (d.w.z. de "spelregels" zoals wet- en regelgeving) die de energiesystemen besturen. Instituties worden beïnvloed door waarden. Waarden zijn normatieve overtuigingen die intersubjectief worden gerechtvaardigd en die het waard zijn om na te streven teneinde een goede samenleving te realiseren. Analyses van institutionele verandering zouden de invloed van waarden moeten verklaren, maar er ontbreekt een gestructureerd kader dat hun rol in institutionele ontwikkeling benadrukt.

Hoofdstuk 2 van dit proefschrift ontwikkelt daarom een interdisciplinair raamwerk dat uitlegt hoe waarden zijn ingebed in de bestaande infrastructuur en instituties, hoe ze gemeenschappen en individueel gedrag vormen, en hoe waarde conflicten sociale leerprocessen kunnen prikkelen die uiteindelijk kunnen resulteren in institutionele verandering. Het raamwerk bouwt voort op het dynamische *Institutional Analysis and Development* raamwerk en breidt het uit met conceptualisaties van waarden in moraalfilosofie, institutionele economie en sociale psychologie.

**Morele waarden als factoren voor sociale acceptatie van smart grids**

Het analyseren van de morele implicaties van smart grid-systemen door de lens van morele waarden vereist een identificatie en conceptualisering van relevante waarden. Dit omvat het verkrijgen van inzicht in welke waarden zijn ingebed in verschillende smart grid-componenten (bijvoorbeeld slimme meter, opslag, smart home), evenals inzicht in hoe deze waarden de acceptatie en adoptie van smart grids kunnen beïnvloeden.

Hoofdstuk 3 identificeert dus een reeks relevante waarden, en doet dit door middel van een systematisch literatuuronderzoek. De waarden milieuduurzaamheid, continuïteit van de energievoorziening en transparantie motiveren de ontwikkeling van smart grids of worden positief beïnvloed door de technologieën (d.w.z. ‘drijfveren’). De waarden privacy, gegevensbeveiliging, wantrouwen, gezondheid, gerechtigheid en betrouwbaarheid reflecteren zorgen en angsten rondom smart grids (d.w.z. ‘barrières’). Andere waarden vormen deels drijfveren en deels barrières voor de implementatie van de systemen: controle, inclusiviteit, levenskwaliteit en betaalbaarheid. De vraag of smart grids deze waarden positief of negatief beïnvloeden hangt af van de precieze technologische en regelgevende context en van de manier waarop gebruikers waarden interpreteren en bedenken.

## Implicaties van smart grids voor rechtvaardigheid

Binnen het bereik van relevante smart grid-waarden neemt rechtvaardigheid een speciale plaats in als een overkoepelende waarde die een krachtige lens is om ondervertegenwoordigde sociale effecten van energiesystemen op de onderzoeks- en politieke agenda's te zetten. Daarom is het raamwerk van energy justice voorgesteld als een alomvattend raamwerk om morele en sociale implicaties van energiesystemen te analyseren, met nadruk op de vraag welke waarden en morele kaders de ontwikkeling van energiesystemen zouden moeten sturen. De literatuur over energy justice bood echter een beperkt begrip van de mogelijke implicaties van digitalisering in het elektriciteitssysteem door smart grids.

Hoofdstuk 4 geeft een beeld van rechtvaardigheid in de context van smart grids, waarbij wordt geanalyseerd hoe voor- en tegenargumenten voor smart grids in Nederland en het Verenigd Koninkrijk mogelijke effecten van deze systemen op rechtvaardigheid identificeren. De bevindingen hebben implicaties voor distributieve en procedurele rechtvaardigheid. De meeste hiervan houden verband met de uitrol van slimme meters, wat het dominante onderwerp is in het debat in beide landen. Een bevinding met een potentieel positief effect op rechtvaardigheid is dat smart grids worden gezien als onderdeel van een ontwikkeling naar meer democratische en open energiesystemen, met een grotere burgerparticipatie en empowerment. Negatieve rechtvaardigheidsimplicaties hebben betrekking op de verdeling van voor- en nadelen tussen consumenten en energiebedrijven. Er kan ook onrechtvaardigheid ontstaan in de verdeling van kosten en baten over verschillende consumentensegmenten. Deze complexe technologieën vereisen specifieke kennis en kunnen daardoor discrimineren ten opzichte van groepen met weinig ICT kennis. Bovendien worden verschillende aspecten van proefprojecten voor slimme netten bekritiseerd als oneerlijk: de selectieprocedures voor consumenten die aan deze projecten deelnemen; de sterke betrokkenheid van distributienetbeheerders en experimenten met overheidsgeld; en de toegenomen afhankelijkheid van gespecialiseerde ICT-kennis die de macht zou kunnen verschuiven van overheidsinstanties (bijv. gemeenten) naar particuliere softwarebedrijven.

## Design for justice in proefprojecten voor smart grids

Nu we de potentiële positieve en negatieve implicaties voor rechtvaardigheid hebben geïdentificeerd, blijft de vraag staan hoe we de daadwerkelijke implementatie van smart grids rechtvaardig organiseren. De meeste smart grids worden tot op heden gerealiseerd in de vorm van lokale experimenten. In deze worden technologieën zoals fotovoltaïsche systemen, thuis- of gemeenschapsbatterijen en slimme meters gecombineerd met softwareplatforms om lokale (hernieuwbare) elektriciteitsstromen te optimaliseren.

Hoofdstuk 5 analyseert hoe energierechtvaardigheid ingebed wordt in het ontwerp van proefprojecten voor smart grids. Het vergelijkt vier projecten in de mate waarin hun ontwerp bijdraagt aan rechtvaardigheid op drie aspecten: de verdeling van voordelen en nadelen, in de besluitvormingsprocedures en in de billijke erkenning van diverse soorten eindgebruikers. Op basis van de bevindingen worden de volgende aanbevelingen gedaan voor het ontwerpen van gerechtigheid in vergelijkbare toekomstige systemen:

Voor distributieve rechtvaardigheid,

- verdeel de winst tussen de individuën of geef de winst aan de gemeenschap als geheel. Maak deze keuze afhankelijk van de vraag of individuen de volledige controle hebben over het behalen van winst of niet.
- benadruk het delen van kennis van en met andere projecten.
- verzamel en gebruik zo weinig mogelijk persoonlijke gegevens.

Voor procedurele rechtvaardigheid,

- Organiseer participatieve besluitvormingsprocessen.
- geef gebruikers controle over het instellen van hun eigen voorkeuren voor batterijen, slimme apparaten en peer-to-peer-handel in de app of met het in-home display.
- zorg ervoor dat de gebruikersomgeving transparant is voor elektriciteitsstromen en gevolgen voor de elektriciteitskosten van huishoudens.

Voor 'justice as recognition',

- gebruik een gestructureerd selectieproces voor gemeenschap en deelnemers.
- experimenteer meer met mensen die geen eigenaar van hun woning zijn.
- eis niet dat alle deelnemers zonnepanelen en batterijen bezitten.
- de gebruikersomgeving zo gebruiksvriendelijk mogelijk is.

**Wetenschappelijke en maatschappelijke bijdrage**

Dit proefschrift belicht de vaak ondergewaardeerde sociale en morele aspecten van energiesystemen.

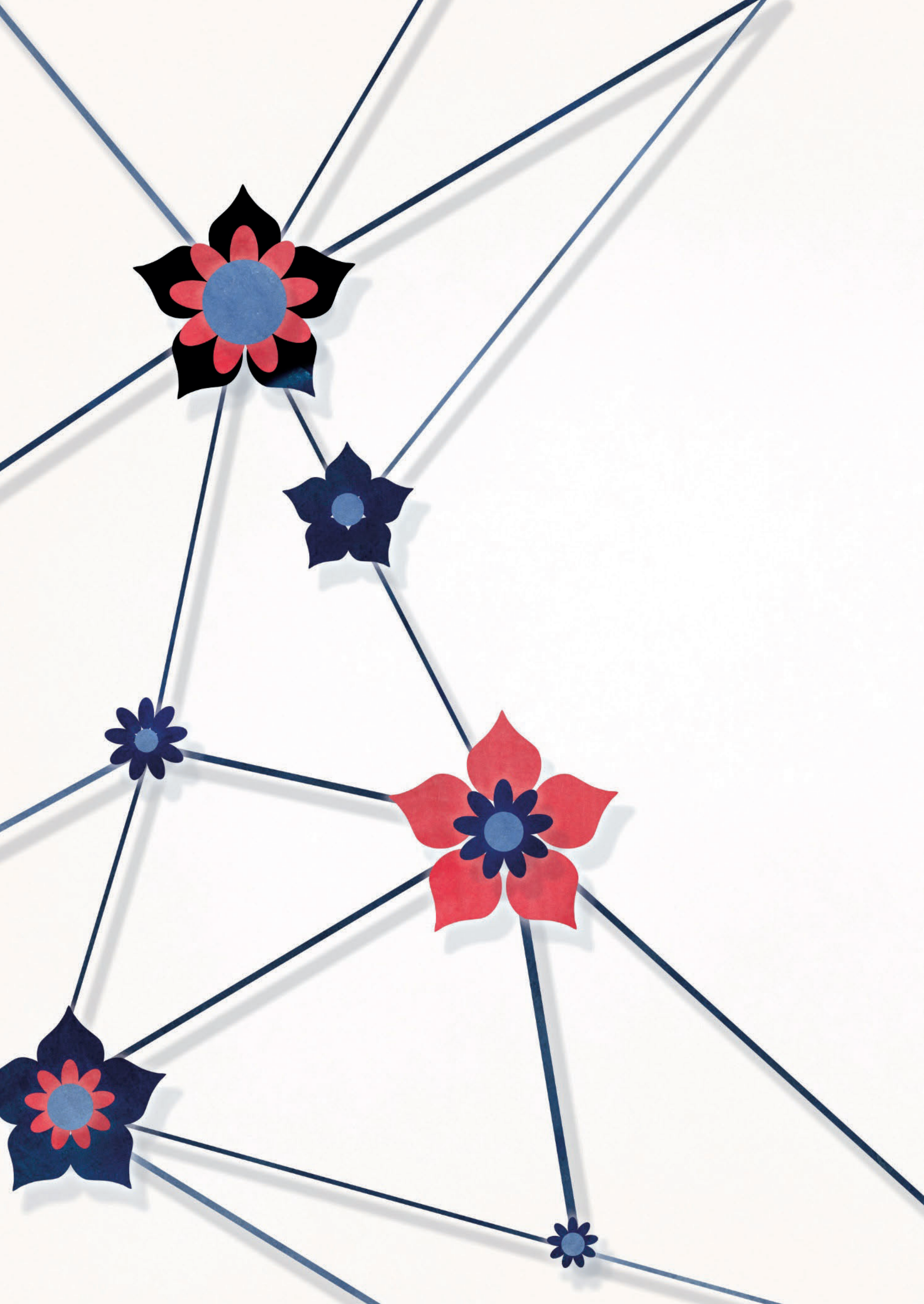
Vanuit academisch perspectief draagt het onderzoek bij op verschillende gebieden:

- Het breidt value-sensitive design uit van technische artefacten naar het domein van socio-technische systemen.
- Het voegt een waardenperspectief toe aan institutional analysis.

- Het pleit ervoor om morele waarden explicieter op te nemen in de literatuur over technology acceptance als mogelijke variabelen die van invloed zijn op gebruikersacceptatie.
- Het verruimt de bestaande opvattingen over energy justice door implicaties op te nemen van een samensmeltende energie- en ICT-sector.
- Het vergroot de praktische relevantie van energy justice door concrete en uitvoerbare ontwerp- en beleidsaanbevelingen te presenteren.

Het proefschrift levert ook een maatschappelijke bijdrage door aanbevelingen te doen aan ontwerpers en beleidsmakers over de aanpak van morele implicaties in smart grid-technologieën en instituties:

- Voor ontwerpers van smart grids biedt het onderzoek een inventaris van waarden die als doel moeten worden meegenomen in technologieontwerp. Het koppelt relatief abstracte waarden aan concrete ontwerpkenmerken en vormt daarmee de basis voor waardengevoelig ontwerp in de praktijk.
- De inventarisatie van waarden dient ook als beleidsdoelstelling met betrekking tot smart grids. Het afsluitende hoofdstuk bevat bovendien specifieke aanbevelingen voor de uitrol van slimme meters, voor de financiering van pilootprojecten voor smart grids en voor het aanpassen van de elektriciteitsregulering zodat slimme netten rechtvaardiger en inclusiever zijn.



# CHAPTER 1:
# **INTRODUCTION**

*Future sustainable energy systems cannot seem to succeed without them: Smart grid systems. Making use of innovative information and communication technologies, these systems promise to deal effectively and efficiently with a growing amount of renewable electricity supply and increased electricity demand from the electrification of transport and heating systems. However, the added deployment of digital technologies that comes with the introduction of smart grids has serious social and moral repercussions. These are related to, for example, data privacy and security, household autonomy and the loss of control to information technology systems, or the distribution of benefits and harms in the energy transition.*

*This dissertation aims to analyze the moral implications of smart grid systems, and provide guidance for designers and policymakers on how to address these implications in smart grid technologies and institutions, with the ultimate motive to increase the systems' ethical acceptability. It addresses this aim in two parts. Firstly, and more generally, the dissertation strives to understand the role of values in the energy transition and for smart grid design. Secondly, and more specifically, it focuses on the value of energy justice, aiming to understand potential impacts of smart grid systems on justice and developing design and policy recommendations for just and smart grids.*

*The following introduction chapter provides details on the motivation and background of the dissertation and states research problem, aim, and objectives. It gives an overview of the theoretical perspectives and knowledge gaps addressed in the dissertation. The chapter also delineates the research questions and outlines how these questions are addressed in the subsequent chapters.*

# 1 Changing energy systems

The decarbonization of energy systems is a crucial part of efforts to mitigate climate change. The latest energy policy framework of the European Union (EU) – the 'Clean energy for all Europeans package' – thus includes a binding target to produce at least 32% of final energy consumption from renewable sources (European Commission, 2019a). In the Netherlands, achieving this target requires substantial growth in renewable energy, including electricity. In 2019, only 8.6% of final energy consumption and 18% of electricity use came from renewables. Out of the latter, 73% were generated from wind and solar power with solar seeing the biggest growth in the past few years (CBS, 2020a, 2020b).

But it is not only electricity supply that changes; electricity demand is changing substantially, too, particularly with the decarbonization of transport and heat systems. The widespread adoption of electric vehicles, supplied with electricity generated from renewable sources, is crucial in the transition to a low-carbon transport system (van der Kam et al., 2018). EU transport targets for 2030 include a 37.5% reduction of emissions from newly registered passenger vehicles relative to 2021 (European Commission, 2019b). In the Netherlands, all new cars sold by 2030 should be zero-emission vehicles (RVO, 2020). In the heating sector, electrification using air or ground-source heat pumps is also an important strategy in the transition to low-carbon solutions (Dodds et al., 2015). The Dutch heating transition is particularly challenging, as the country has been relying on natural gas for heating, yet recently adopted the strategy to 'switch away from natural gas' (Ministerie van Economische Zaken en Klimaat, 2019). As a consequence, newly built neighborhoods and houses are no longer connected to the gas network, with a large number expected to switch to electric heating (PBL, 2019).

The changes in electricity supply and demand pose challenges for electricity networks and their operators, particularly on the level of medium- and low-voltage networks. On the supply side, rising shares of wind and solar power generation lead to increased volatilities and require new methods to balance supply and demand (Lunde et al., 2016; Muench et al., 2014; Wissner, 2011). The integration of renewables also implies a larger number of small and dispersed generation sites, creating a shift from a centralized to a more decentralized electricity network, and causing the need for a bi-directional flow of information and electricity (Muench et al., 2014). On the demand side, the electrification of transport and heat will result in increased electricity use. Charging of electric vehicles will also cause additional demand peaks, as conventional charging starts instantly when the vehicle is connected to the grid (González and Mulder, 2018; Schmalfuß et al., 2015; Xenias et al., 2015). These changes in supply and demand are made even more complicated by daily and seasonal mismatches between electricity generation from renewables and demand. For example, most solar generation occurs mid-day and during summer, whereas residential electricity demand is the highest during evenings and winter (van der Kam et al., 2018).

## 2 Smart grids as enablers in the transition to low-carbon energy systems

Smart grid systems are implemented to deal with the challenges from changing electricity supply and demand outlined above. In these systems, innovative information and communication technologies (ICT) are used to measure and monitor electricity flows in real-time, bridge temporal gaps between the supply and demand of electricity, and optimize the use of renewable electricity. Thereby, smart grids offer an alternative to more traditional ways of dealing with supply and demand peaks, namely grid expansion or curtailment of renewable power generation (Blumsack and Fernandez, 2012; Clastres, 2011; Connor and Fitch-Roy, 2019; Geelen et al., 2013; Verbong et al., 2013).

While there is no single and unanimous definition of what constitutes a 'smart grid', the term is typically used as an umbrella notion to capture digitalization in the electricity system with the aim to facilitate its decarbonization (Blumsack and Fernandez, 2012; Connor and Fitch-Roy, 2019). In this work, smart grids are thus defined following the International Energy Agency (2011, p. 6) as electricity networks that use

> "digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability."

From the perspective of residential electricity users, the broad notion of a 'smart grid' as understood in this dissertation can include the following applications, which are also depicted in Figure 1-1 (cf. Eid, 2017; Geelen et al., 2013):

- Micro-generators: Photovoltaic systems or small wind turbines generate electricity on household or community level (Bellekom et al., 2016; Sauter and Watson, 2007).

- The smart metering infrastructure: This is generally considered as the backbone of smart grids as it enables (near) real-time information on electricity flows (Depuru et al., 2011; Leiva et al., 2016).
- Storage systems: Home and community batteries can be applied to store electricity generated from solar panels during the day for use during the evening; this includes optimization to avoid network feed-in of the biggest generation peaks (Barbour et al., 2018; Devine-Wright et al., 2017).
- Smart household appliances: Appliances such as washing machines, ventilation systems, refrigerators, etc. can be programmed such that their use is shifted to times of abundant renewable supply (Geelen et al., 2013; Zhou et al., 2016)
- Dynamic integration of electric vehicles: Charging times of electric vehicles can be shifted to off-peak hours and batteries of electric vehicles can be used as temporal storage during parking (Eising et al., 2014; Schmalfuß et al., 2015).
- Dynamic pricing: Time-variable electricity prices are intended to provide consumers with incentives for shifting their electricity use over time so as to reduce peak demand or increase the use of renewable electricity (Geelen et al., 2013; Warren, 2014).
- Monitoring and control systems: ICT systems automatically optimize the use of renewable electricity within a smart grid (Connor and Fitch-Roy, 2019). For end users, this includes apps, web portals, or in-home displays to visualize electricity flows, thus enabling users to monitor and steer electricity use (Wilson et al., 2015; Zipperer et al., 2013).

While smart metering systems are currently being rolled out at large scale all over Europe, the other applications mentioned above have been predominantly applied in small-scale local pilot or demonstration projects (Evers and Chappin, 2020; Gangale et al., 2017; Grimm et al., 2020).

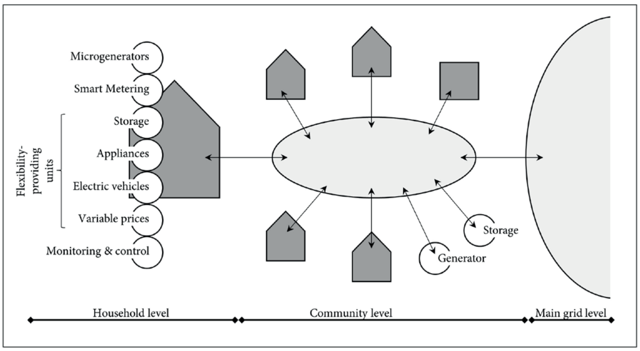



**Figure 1-1: Schematic overview of a smart grid system**

Source: adapted from Geelen et al. (2013)

## 3 Beyond technology: Smart grids have social and moral implications

Due to the opportunities smart grids provide to optimize electricity grid capacities vis-à-vis changing electricity supply and demand, these systems are considered essential in the transition to more sustainable energy systems (Connor and Fitch-Roy, 2019; Muench et al., 2014; Verbong et al., 2013). Yet, the development and implementation of smart grids comes with serious moral repercussions. Most of them are connected to concerns about the increased digitalization of electricity networks.

Perhaps the most prominent examples are repercussions regarding data privacy and security in the context of smart metering. Privacy concerns emerged based on the fear that the collection and sharing of near real-time data on energy use might reveal activities occurring within a household that are usually considered as private (McKenna et al. 2012). Data privacy issues have been the major cause for substantial delays in the Dutch smart meter rollout between 2008 and 2011 (Cuijpers and Koops, 2013). In addition, securing the network from (cyber-)attacks is essential when equipping energy networks with novel ICT solutions. Another example is the concern that the automated scheduling of appliances through complex algorithms might imply lower levels of autonomy regarding electricity use for households, and loss of control to ICT systems and to the software providers, aggregators, and energy suppliers that offer them (Buth et al., 2019; Kostyk and Herkert, 2012; Ligtvoet et al., 2015). Beyond those prominent concerns around digitalization, repercussions involve the extent to which costs and benefits of smart grid systems are distributed in a fair way and how the systems affect the aim of an affordable access to energy supply for all (Buchanan et al., 2016; Fell, 2020).

## 4 Research aim

This dissertation aims to *analyze the moral implications of smart grid systems, and provide guidance for designers and policymakers on how to address these implications in smart grid technologies and institutions, with the ultimate motive to increase the systems' ethical acceptability*.

Focusing on the ethical acceptability of technologies entails studying the reception of technologies in a society through the lens of moral values. Acceptability is thus a predominantly normative concept, referring to the extent to which "a new technology […] takes into account the moral issues that emerge from its introduction" (Taebi, 2016, p. 1818). This entails judgements to what degree moral values seen as important in a given technological context are embedded in technologies. Values are "lasting convictions or matters that people feel should be strived for in general and not just for themselves to be able to lead a good life or realize a good society" (Van de Poel and Royakkers, 2011, p. 72). When examining the societal concerns with smart grids exemplified earlier in this introduction more closely, it becomes visible that they are related to values: Privacy, security, autonomy, trust, distributive justice, and affordability. These themes are essentially values about technological development in a society (Davis and Nathan, 2015; Shrader-Frechette and Westra, 1997a; Van de Poel and Royakkers, 2011).

The dissertation contributes to academic endeavors to enrich energy research with insights from the social sciences and humanities. Research on energy systems and smart grids is dominated by technological approaches and has been criticized for paying too little attention to fundamental social and ethical issues (Buchanan et al., 2016; Wilson et al., 2015). For example, a review of 4,444 papers in energy research by Sovacool (2014) revealed a prevalence of engineering and an underrepresentation of the social sciences and humanities with particularly few philosophical studies. Only 20% of the authors of all analyzed papers were affiliated to a social sciences discipline.

The same pattern can be found for the context of smart grids. The primary focus how smart grids are presented – and how it was also done earlier in this introduction – is a technological one: A technical 'fix' support growing shares of intermittent renewable energy generation (Skjølsvold et al., 2015). The majority of the practical work in smart grid implementations, for example within smart meter roll-outs or smart grid experiments, mirrors this and is technology driven, led by distribution system operators (Gangale et al., 2013).

Such a technological focus neglects the fundamental social nature of energy systems: serving human well-being. Smart grids are implemented to enable a more renewable energy system, and hence essentially exist to allow humans producing and using energy in such a way that it is in line with planetary boundaries. They may often be presented in technical terms (i.e. the optimization of the capacity of electricity grids), but implementing the systems has at least as many social as technological aspects. What is more, the uncertainties whether smart grids will be successful are largely due to social factors, not technological ones (Connor and Fitch-Roy, 2019).

## 5 Theoretical perspectives and knowledge gaps

With its applied focus on the moral implications of smart grid systems, this dissertation is interdisciplinary in nature. It builds on and expands a number of theoretical perspectives, as outlined in the following paragraphs.

**1. Value-sensitive design and socio-technical systems.** The first theoretical perspective, which is applied throughout this dissertation, is value-sensitive design, "a theoretically grounded approach to the design of technology that accounts for human values in a principled and comprehensive manner throughout the design process" (Friedman et al., 2013, p. 56). It is often recognized as one of the most extensive approaches to actively embed values in technologies through design (Albrechtslund, 2007; Davis and Nathan, 2015; Friedman et al., 2002)[1]. Value-sensitive design aims to develop technologies that do not only meet functional requirements from clients and users (such as usability, efficiency, reliability) but also promote moral values like justice, privacy, trust, etc. (Flanagan et al., 2008). Originating from information studies and human-computer interaction literature, value-sensitive design has been extended to other domains of technological design such as energy supply facilities (Correljé et al., 2015a; Dignum et al., 2016; Mouter et al., 2018; Oosterlaken, 2014), automated vehicles (Flipse and Puylaert, 2017), healthcare robots (Van Wynsberghe, 2013), or nanopharmaceuticals (Timmermans and Zhao, 2011).

Most of value-sensitive design literature traditionally focuses on technical artefacts, for example the design of a web browser for informed consent (Friedman et al., 2013; Manders-Huits, 2011). In contrast to this, smart grids are socio-technical systems, in which technologies, institutions (the "rules of the game", e.g. legislation and regulation), and social actors are closely interrelated (Bale et al., 2015; Hughes, 1983; Künneke and Finger, 2009). Understanding what values become relevant for systems and why as well as designing for values is therefore not only a matter of technologies but also a matter of the institutions that govern the system. To give an example, in 2009 the initial legislative proposal for the Dutch smart metering system was amended to account for data privacy. This was not a technical but an institutional solution: consumers were allowed to choose the frequency of energy use data transmission from the smart meter to a central database as well as opt-out of sharing

[1] 'Value-sensitive design' is used here to encompass also literature labelled as 'design for values' (Van den Hoven et al., 2015) and 'values in design' (Flanagan et al., 2008), as these approaches share the common goal to embed values in technologies through design. Acknowledging the different denominations, I use value-sensitive design for clarity of reading.

data at all (Cuijpers and Koops, 2013). This goes to show that value-sensitive design can be extended to include both technologies and institutions; especially laws and regulations (formal institutions) can be (re-)designed to account for moral values (Correljé et al., 2015a). My dissertation thus represents an approach in which value-sensitive design is extended from technical artefacts to socio-technical systems.

**2. Values in institutional analysis.** Extending value-sensitive design from a pure focus on technical artefacts to institutions requires a theoretical perspective on institutions. The one chosen here is the literature on and around the Institutional Analysis and Development (IAD) framework (Ostrom, 2005). The framework has been developed as a tool to compare institutional development (i.e. how institutions are designed and how they change over time) in different empirical situations (McGinnis, 2011a; Ostrom et al., 1994). Institutions are understood as a set of political, social, and legal 'rules of the game' that enable and restrict actor behavior (North, 1991; Polski and Ostrom, 1999). For this dissertation, it is particularly relevant how values become embedded in formal institutions such as laws and regulations. The IAD framework has originally been developed in the context of common pool resources (e.g. forests, fisheries, or irrigation systems), but has also been used to describe socio-technical systems, since it provides generic guidance on important structural elements of systems and their interrelations (Ghorbani, 2013; Iychettira et al., 2017a; Lammers and Hoppe, 2019).

For the aim of this work to understand how values relate to socio-technical systems and institutional development, however, the framework is limited. Values are underrepresented; they are not analyzed in their influence on institutional development. Researchers working with and on the framework mention the concept 'values' sometimes, for example when McGinnis (2011a, p. 175) includes "the extent to which members of a community share the same core values" in his description of the IAD framework. Nevertheless, values are neither defined nor more closely analyzed, and therefore questions remain as to how they get embedded in institutions and how they influence institutional change. This dissertation will therefore extend the IAD framework with a values-perspective, and by doing so, will build a framework that allows explicating how values might influence institutional development.

**3. Energy justice and digitalization.** Next, this dissertation builds on a field that has been proposed as one of the most comprehensive frameworks to address moral and social implications of energy systems: Energy justice (Heffron and McCauley, 2014; Jenkins et al., 2016). Assessing energy justice means "asking what this energy is for, what values and moral frameworks ought to guide us, and who benefits" (Sovacool and Dworkin, 2015, p. 441). With this as guidance, energy justice researchers have explored the justice consequences of energy supply and demand, often focusing on the transition to renewable energy systems (Cowell et al., 2011; Forman, 2017; Gillard et al., 2017; Heffron and McCauley, 2014; Johnson and Hall, 2014). Thereby, a three-dimensional understanding of justice is dominant, which has been drawn from environmental justice studies (Schlosberg, 2007): Distributive justice refers to the distribution of benefits and harms; procedural justice addresses equitable decision-making processes; justice as recognition is concerned with inclusiveness and the respect of affected stakeholder groups (McCauley et al., 2013; Schlosberg, 2007).

As of now, however, there is little research discussing specifically the implications of digitalization for energy justice (Powells and Fell, 2019). Smart grids widen the range of ethical challenges from issues related to energy supply and demand to ones that pertain to digitally connected systems, automation, and the increased recording and sharing of real-time household energy data. As a consequence, this dissertation will explore such implications and will outline how a variety of smart grid design choices influence distributive, recognition, and procedural justice.

**4. Energy justice and its practical relevance.** Energy justice is also a relatively young research field, with most publications written since 2010. This may be why the majority of the literature so far has a conceptual focus, establishing for example the conceptualization of energy justice in the three dimensions of distributive, procedural, and recognition justice (Heffron and McCauley, 2014; Jenkins et al., 2016) and discussing relations and demarcations to related fields, such as environmental justice, climate justice, energy poverty, or the just transitions literature (Gillard et al., 2017; Heffron and McCauley, 2018; Jenkins, 2018; Walker and Day, 2012). Researchers have tried to establish energy justice as a lens through which social aspects of energy transitions can be made tangible, in response to dominant energy policy perspectives from engineering and economics (Miller et al., 2013; Sovacool et al., 2016). Thereby, the “focus is firmly on energy policy” (Heffron and McCauley, 2014, p. 437), with scholars stressing the importance of considering justice in energy transitions policymaking and aiming also to develop energy justice as a decision-making tool by providing criteria that energy policies should adhere to (Sovacool et al., 2017a; Sovacool and Dworkin, 2015).

Despite the ambition to be policy-relevant, only the minority of publications goes beyond criticism of existing technologies and policies to offering concrete action recommendations. The literature has therefore largely remained in an academic silo with little impact on technology developers and policymakers (Galvin, 2020; Jenkins, 2018). This dissertation will contribute with a concrete application of energy justice to a specific system (smart grids). Thereby, it will go beyond conceptualizations, and develop recommendations how technology developers and policymakers can consciously design for justice.

## 6 Methods

The interdisciplinary approach in this dissertation is also reflected in the methods chosen to conduct this research. Conceptual insights in value-sensitive design, institutional analysis, and energy justice are combined with with empirical investigations into the energy transition and smart grids.

This approach and the methods chosen in each of the chapters are in line with the tripartite approach in value-sensitive design, which applies conceptual, empirical, and technical investigations in an iterative and integrative way to embed values in technical artefacts (Davis and Nathan, 2015; Friedman et al., 2013, 2002). Conceptual investigations build on normative, philosophical theories of values. For this, I draw from ethics of technology and theories of justice used in the energy justice literature. Empirical investigations make use of various methods from the social sciences to understand affected stakeholders' value conceptions and perceptions of a technology. For the empirical methods, I apply qualitative content analysis and a case study design. Technical investigations aim at the physical design of a technical artefact. Here, I don't go as far as the actual design but rather develop design and policy recommendations based on the conceptual and empirical investigations.

This translates to the following approaches in Chapters 2 to 5:

- Chapter 2 is conceptual. It develops a framework to expand value-sensitive design from technical artefacts to socio-technical systems and, at the same time, adds a values perspective to institutional analysis. Although predominantly conceptual, the chapter uses illustrative examples from the energy transition to ground the framework in empirical reality.
- Chapter 3 combines conceptual insights on values with a systematic literature review of empirical smart grid studies. The literature review approach is based on Moher et al. (2009).
- Chapter 4 ties together conceptual work on values and energy justice with an empirical analysis of how values are reflected in public debates on smart grid technologies. It applies a qualitative content analysis based on Krippendorff (2004) and Friese (2012).
- Chapter 5 builds a conceptual framework for energy justice, which is applied in an empirical case study research of four smart grid projects. The qualitative case

study approach, which is based on Yin (2009) and Flyvbjerg (2006), makes use of semi-structured interviews and qualitative content analysis.

Details on the methods are described in each of the subsequent chapters (2-5).

## 7 Research questions and dissertation outline

Building on the theoretical perspectives introduced in Section 5, this dissertation addresses four research questions. This section outlines the research questions and how they are tackled in the subsequent chapters of the dissertation (see Figure 1-2). Thereby, I distinguish broadly two parts of the dissertation. Part A focuses on *moral values*, and more specifically on identifying and conceptualizing their role in the energy transition and for smart grid systems. Part B concentrates on *energy justice*, aiming to understand potential impacts of smart grid systems on justice and developing design and policy recommendations for just and smart grids.

The first question in Part A reflects the socio-technical nature of energy systems, acknowledging that the transition to low-carbon systems does not only involve technological changes but is shaped and incentivized by institutions on the national and supra-national level. Institutional change can in turn be affected by changes in values, an influence that is yet largely neglected in institutional analyses. Hence, the first question reads as follows:

***A/1. How do values and value changes influence institutional change, and how can this influence be illustrated in the energy transition?***

**Chapter 2** addresses this question. It develops an interdisciplinary framework that explicates the role of values in institutional change, i.e. how they are embedded in existing infrastructure and institutions, how they shape communities and individual behavior, as well as how value controversies can trigger social learning processes that eventually can result in institutional change. The chapter builds on the Institutional Analysis and Development (IAD) framework (Ostrom, 2005) as well as the understanding of values in moral philosophy, institutional economics, and social psychology.

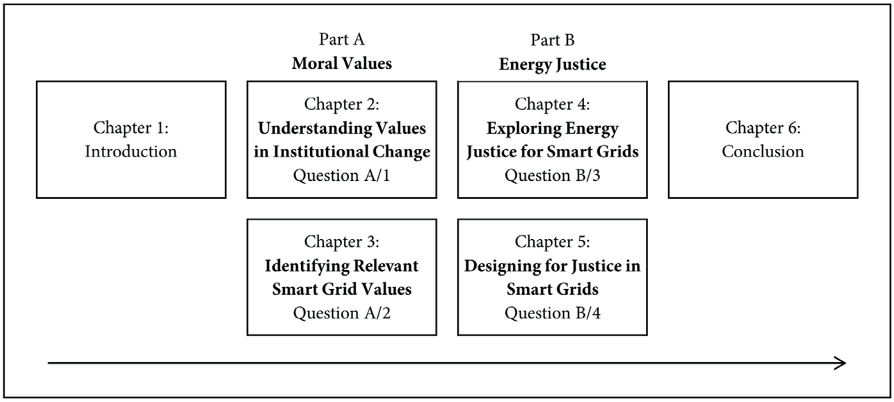



**Figure 1-2: Dissertation outline**

Question A/2. emphasizes that developing smart grids such that they are responsive to values requires an identification and conceptualization of *relevant* values. This includes insight into what values are embedded in different smart grid components (e.g. smart metering, storage, smart home), as well as into their influence on the realization of smart grids. Therefore, the second question is:

***A/2. Which moral values can be seen as drivers and barriers for the implementation of smart grid systems?***

**Chapter 3** answers this question. Using a systematic literature review, the chapter analyzes the implications that smart grid systems have for end users. The chapter draws from value-sensitive design literature for the relation between values and characteristics of a technology and for an initial list of values of ethical importance that are often mentioned in this literature. It also uses literature on technology acceptance and adoption and argues that moral values might be included more explicitly as potential factors in technology acceptance models.

Part B zooms in on *energy justice*. The third question picks up the energy justice framework as a lens to evaluate social and moral aspects of changing energy systems. It also builds on findings from the previous chapter, in which distributive and procedural justice are identified as important smart grid values. The question reads as follows:

***B/3. In what ways do smart grids potentially impact justice and what does this imply for current conceptualizations of energy justice?***

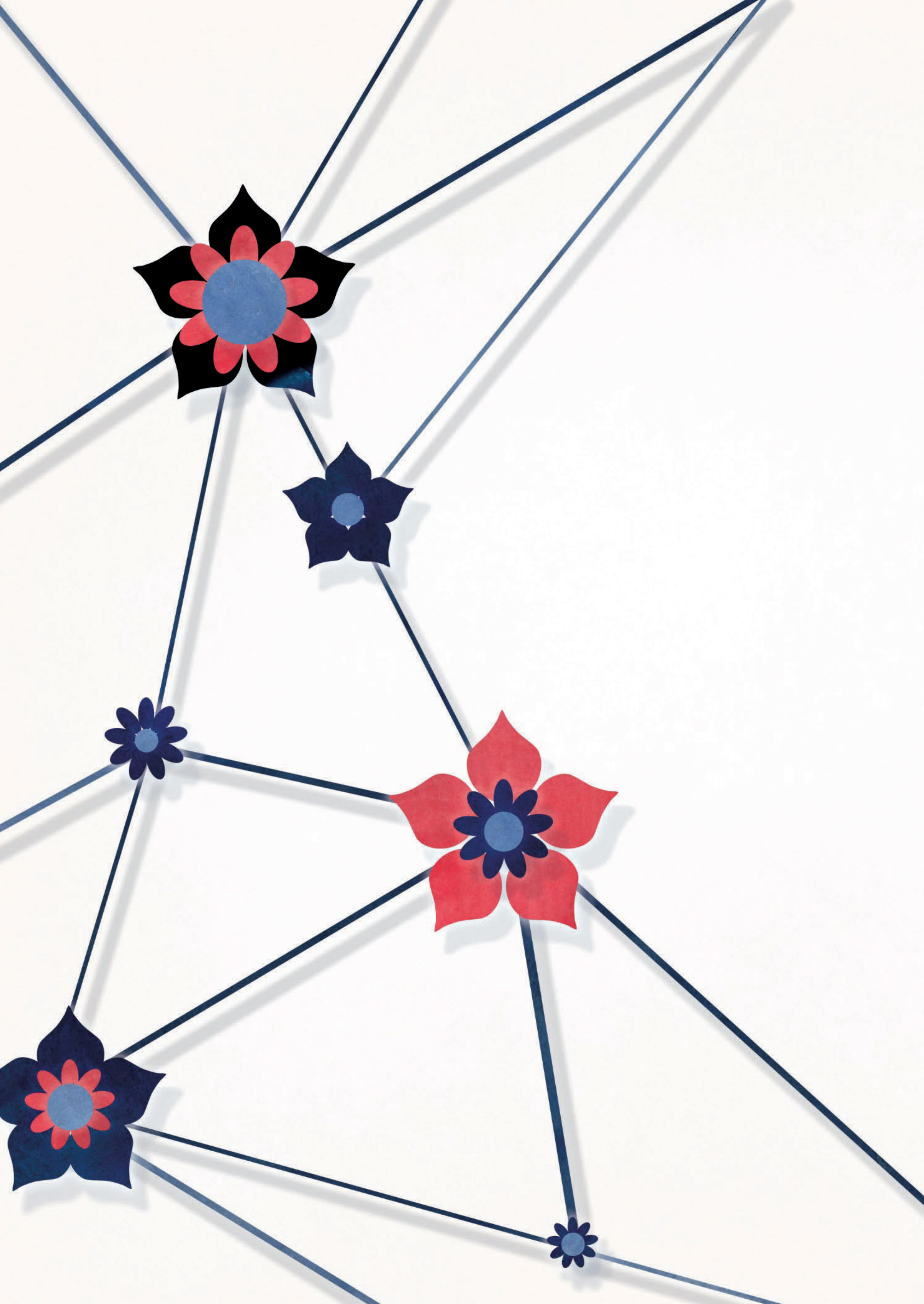
This question is answered in **Chapter 4**. The chapter analyses how pro and contra smart grid arguments in public debates of two European countries reveal potential impacts of smart grid technologies on justice. Based on this analysis, the chapter broadens the energy justice framework for the context of smart grid systems, highlighting that the convergence between the electricity and ICT sectors raises additional justice concerns which are not yet considered in the energy justice literature.

Question B/4. continues the focus on energy justice with a more detailed investigation of real-life implementations of smart grids in local experiments. It analyzes how the three dimensions of energy justice are embedded in the design of smart grids in order to develop recommendations for design for justice in similar future systems. Hence, the question reads:

***B/4. How does the design of smart grid projects impact energy justice?***

**Chapter 5** concentrates on this question. Through case study research, the chapter compares four local smart grid experiments. They are evaluated for the extent to which their design contributes to justice in the distribution of benefits and harms, in the decision-making procedures, and in the equitable recognition of diverse types of end users.

The final **Chapter 6** synthesizes the findings from previous chapters, discussing theoretical implications and recommending avenues for future research. The concluding chapter also considers the societal implications of the work and contains recommendations on how to design smart grid technologies and institutions such that they are responsive to social values and energy justice.



CHAPTER 2:

# UNDERSTANDING THE ROLE OF VALUES IN INSTITUTIONAL CHANGE: THE CASE OF THE ENERGY TRANSITION

This chapter has been published as:

Milchram, C., Märker, C., Schlör, H., Künneke, R., van de Kaa, G., 2019. Understanding the role of values in institutional change: the case of the energy transition. Energy. Sustain. Soc. 9, 1–14. https://doi.org/10.1186/s13705-019-0235-y

*When starting to work on smart grids from the perspective of moral values that are embedded in socio-technical systems I made two observations that eventually led to the writing of this chapter. I observed, firstly, that there is no agreed upon conceptualization of 'values' in academic literature. What is more, the different understanding in disciplines – especially between philosophers and psychologists – was not explicit and frequently stood in the way of a successful interdisciplinary communication at conferences and research events. Secondly, my perspective on energy technologies as socio-technical systems acknowledges that their development is strongly influenced by the institutional setting. Yet, the literature in value-sensitive design is limited to the design of technical artefacts and needs expansion towards the design of institutions.*

*Chapter 2 addresses these observations and aims to develop an interdisciplinary framework that makes explicit the influence of values and value change on institutional development, taking the transition to low-carbon energy systems as a case to illustrate different paths of influence. In doing so, the chapter builds on the Institutional Analysis and Development (IAD) framework. It distinguishes conceptions of values in moral philosophy, institutional economics, and social psychology and investigates how the disciplines can complement each other in explaining different ways in which values might influence institutional change. From the perspective of institutional theory, the chapter contributes to the IAD literature, in which the importance of values is acknowledged but structured approaches to conceptualize and analyze them are still missing.*

*The first section of the chapter gives a background on the IAD framework and explains the aim to extend the framework by an account of values. Section 2 details the dynamic IAD framework, which is used as the basic analytical framework for institutional change. Following that, Section 3 expands on the value gap in IAD literature, and Section 4 reviews multiple conceptualizations of values in moral philosophy, institutional economics, and social psychology. Section 5 synthesizes these theoretical perspectives by analyzing step-by-step the roles of values for the single elements of the dynamic IAD framework. Examples from the energy transition are chosen to illustrate the analysis. The chapter concludes with a reflection on the complementarity of the three perspectives on values, and how the framework might be used by researchers and policymakers in the future.*

# 1 Background

Energy systems are currently undergoing profound transition processes towards low-carbon systems. This transition does not only include changes to energy technologies or infrastructures. It is also shaped by changes in the institutions (the "rules of the game", e.g. legislation and regulation) that govern energy systems. Most aspects of generation, distribution, and consumption of energy are subject to regulation (Hoppe et al., 2016; Lammers and Heldeweg, 2016). The Institutional Analysis and Development (IAD) framework developed by Elinor Ostrom and her colleagues (Ostrom, 2005; Polski and Ostrom, 1999) is widely used by social scientists and policy analysts to understand institutions in various sectors, including energy systems (Iychettira et al., 2017b; Koster and Anderies, 2013; Lammers and Heldeweg, 2016; Shah and Niles, 2016). A dynamic version of the original IAD framework is used in this chapter to capture institutional change (Pahl-Wostl, 2009). However, this framework is limited in recognizing important drivers of institutional change: values and value changes.

Changes in core values can induce institutional change and changes in (energy) policies (Correljé et al., 2015b; Pesch et al., 2017). For example, the value change from focusing on market efficiency towards affordability, security of supply, and sustainability in the European Union's energy policy led to legislation regarding renewable energy (Correljé et al., 2015a; EUR-Lex, 2018). Analyses of institutional change should account for this influence, but so far a structured framework that highlights the role of values in institutional development is absent. This gap is all the more striking as the term "values" is mentioned by the core scholars who have developed and are working with the IAD framework. For example, scholars stress the importance that institutions "fit the values of those involved" (Ostrom, 2011, p. 16) and that shared values in a community will influence institutional development (McGinnis, 2011a). However, these accounts of values are limited to mentioning values in context with institutional change. Questions remain as to how 'values' are defined, how to evaluate to what extent institutions are in line with values, how to elicit values of 'those involved', or why and how shared values influence institutional development. Hence, structured approaches that go beyond mentioning and acknowledging that values might influence institutional change are still missing in IAD literature.

It is the aim of this chapter to extend the dynamic IAD framework such that it can be used to analyze the role of values in institutional change. The resulting framework makes explicit how values are embedded in the material environment such as infrastructures, how they are embedded in existing institutions, how to elicit values shared by a community, how values influence behavior, and finally how they influence institutional change. To illustrate each of these potential ways how values can influence the elements of institutional change, we draw from the current transition to low-carbon energy systems as a case which we deem especially useful to highlight how changes in core values can induce policy changes. As already mentioned above, the value changes in EU energy policy from market efficiency to affordability, security of supply, and ecological sustainability during the first two decades of the 21st century led to changes in legislation, such as a greater interconnection of Europe's electricity networks, promotion of the use of energy from renewable sources, and many more (Correljé et al., 2015a; EUR-Lex, 2018).

In order to extend the dynamic IAD framework by a value perspective, we take an interdisciplinary approach and review insights on values from moral philosophy, institutional economics, and social psychology. Since there is no unanimously agreed upon conceptualization of 'values' in academic literature (Kroes and Van de Poel, 2015), we consciously take a broad approach and investigate how conceptions of values from different disciplines can complement the dynamic IAD framework. Thereby, the aim is not to develop a unified conceptualization of values. Rather, we will show how the disciplines with their different epistemological foundations can complement each other and each provide their own specific contribution to our framework. To the best of our knowledge, our paper is the first to analytically distinguish the different conceptions of 'values' in these three disciplines and also combine those perspectives to highlight ways how values might influence institutional change.

In the next section, we start by introducing the basic analytical framework for institutional change: the dynamic IAD framework in which the original framework is expanded by social learning. Subsequently, Section 3 presents the current value gap in IAD research in further detail and explains how this chapter can contribute to fill this gap. In Section 4, we outline conceptualizations of values from the perspective of different academic fields. Section 5 synthesizes these theoretical perspectives and presents an analysis of the different roles of values for the single elements of the dynamic IAD framework. In order to illustrate the new framework, examples from the realm of the energy transition are chosen suitable for each element of the dynamic IAD framework.

# 2 A dynamic framework for institutional change

## 2.1 The Institutional Analysis and Development (IAD) framework

The IAD framework, developed by Elinor Ostrom and her colleagues, is a framework that allows analyzing policy interventions and understanding how institutions develop (Ostrom, 2011, p. 9) (Figure 2-1). The framework identifies and describes important elements in decision-making situations within the policy process (so-called action situations), and how these are influenced by exogenous variables, such as the physical environment or laws and regulations (Ostrom, 2011).



The benefit of the IAD framework that makes it of special interest for this chapter is its flexible applicability independent from the context of a specific sector. Rather than providing solutions, the framework raises important questions that help understanding the study problem and what potential solutions could be (Heikkila and Andersson, 2018). Therefore, it has been used in a variety of sectors, such as forestry, water management, fisheries, transportation systems, and others (Polski and Ostrom, 1999).

At the beginning of the framework development in the 1970s and 1980s, it has been applied to public administration and metropolitan organization, for example through empirical studies on police service in metropolitan areas (Ostrom, 1972; Ostrom and Ostrom, 1971; Polski and Ostrom, 1999). More recently the framework has increasingly been used in energy systems research. For example, Koster and Anderies

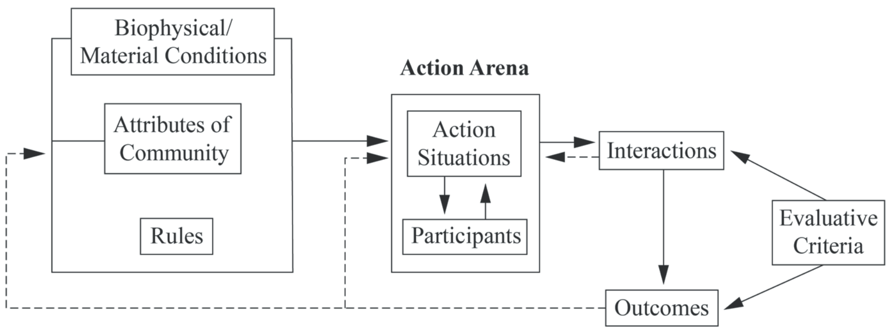



**Figure 2-1: Institutional Analysis and Development (IAD) Framework**

Source: Ostrom (2005)

(2013) apply the IAD framework to compare the transition to renewable energy systems in four countries which were part of the top renewable energy users in 2012: Brazil, Spain, China, and the United States. They identify eight institutional drivers that contribute to the implementation of renewable energy, out of which the commitment of governments to set standards and provide financial incentives is found as the most important.

Lammers and Heldeweg (2016) use the IAD framework in an exploratory case study of local smart grid development. They enrich the IAD framework with institutional legal theory and show how the resulting framework can be used both for analytic description and prescriptive design of local smart grid systems.

Another application of the IAD framework in context with the transition to renewable energy systems is the work by Shah and Niles (2016) on Caribbean energy policy. The authors use the framework to analyze strengths and weaknesses of existing institutions and identify critical intervention points to reinforce or build institutions that promote a 'clean energy transition'.

Additionally, Iychettira et al. (2017a) apply the IAD framework to understand the design and impact of governmental support schemes for renewable energy sources for electricity (RES-E). By distinguishing action situations at the level of government and energy producers, they use the IAD framework as basis for a simulation how support schemes for RES-E (developed by governments) impact investment in RES-E (by energy producers). This allows an understanding how specific support schemes (e.g. the German Premium Tariff or the British Contract for Differences schemes) contribute to renewable electricity targets (Iychettira et al., 2017a).

The application of the IAD framework to a variety of topics as described above stems from the recognition that the framework offers a generic approach in analyzing public policies by diagnosing key elements of policy processes. It helps investigating important actors and their characteristics, rules that apply as well as the biophysical and socio-economic setting of a policy process (Heikkila and Andersson, 2018). As Heikkila and Andersson (2018, p. 318) state: "…the IAD framework can provide a set of diagnostic questions for parsing out the key features of an institutional context that may affect policy outcomes". This structured way of analysis is very useful in tackling problems in highly complex systems, such as energy systems. Therefore, the IAD framework serves as the basic conceptual framework in this chapter.

Within the IAD framework, institutions are defined as political, social, and legal 'rules of the game' that incentivize (enable or restrict) actor behavior in situations which require coordination among two or more individuals or groups (Polski and Ostrom, 1999). With this focus on institutions as rules, Elinor Ostrom's view on institutions is based on Douglass North, who defined them as the "humanly devised constraints that structure political, economic and social interaction" (North, 1991). The definition differs from the common notion to understand the term institutions as a synonym for organizations. Institutions can be formal or informal: Formal institutions are laws and regulations, such as prescriptions how and how much tax is added to energy prices; informal institutions, for example, in communication prescribe in many cultures that a speaker is listened to and not interrupted. For our case of the energy transition, we will focus on the formal rules that govern the energy system. Formal rules are of special relevance because the energy system is one of the critical infrastructures which constitute an important issue of national governance, sovereignty, and security.

The following paragraphs give an overview of the single elements of the IAD framework[2]. Broadly, the framework distinguishes exogenous variables, the action arena, interactions, evaluative criteria and the outcome (Figure 2-1). The element of action situations captures important or decisive events within a policy field (e.g. energy policy). Action situations are thus used in order to analyze human behavior within the institutional context (Ostrom, 2011). "Action situations are the social spaces where individuals interact, exchange goods and services, solve problems, dominate one another, or fight […]" (Ostrom, 2011, p. 11). Thus, any analysis using the IAD framework starts by the identification of an action situation. The decision on what can be described as an action situation and what level of aggregation is best suited depends on the specific case study (Pahl-Wostl et al., 2013). Using the IAD framework for an analysis of energy systems in this chapter, the decarbonization of national energy systems constitutes the main problem that is addressed in various action situations, such as policy and innovation processes across vertical scales.

Participants of an action situation are human actors, who can be both individuals and organizations, such as governmental and non-governmental bodies or firms (Ostrom, 2011). This means that actors become participants when they take part in an action situation. They are influenced by biophysical/material conditions, attributes of the community, as well as rules. The biophysical/material conditions are the physical environment in which an action situation is located. Attributes of the community describe the socio-economic characteristics of the community that forms the social environment of the action situation. Rules denote the institutional environment of an action situation, i.e. the formal laws and regulations that enable

[2] Section 5 provides more detailed information about the IAD elements in order to combine them with different conceptualizations of values. Furthermore, readers might refer to (McGinnis, 2011a; Ostrom, 2011, 2005; Ostrom et al., 1994; Polski and Ostrom, 1999) for detailed descriptions of the framework.

or constrain behavior of participants (Ostrom, 2005). The outcome of an action situation as well as the process of interaction are assessed by various evaluative criteria, determined by the participants in action situations and those observing these situations. These criteria, for example, can be questions about sustainability, distributional equity, or conformance to other values (Ostrom, 2011).

## 2.2 The IAD framework combined with social learning

The main idea behind the IAD framework is breaking institutional development down to subsets consisting of various action situations (McGinnis, 2011a). Nevertheless, in terms of institutional change processes, the IAD framework reaches its limits. By focusing on separate action situations, institutional change cannot sufficiently be captured (Heikkila and Andersson, 2018). Even if the framework already includes feedback loops (see dotted lines in Figure 2-1), thereby hinting that the evaluation of outcomes can have an influence on following action situations or the prevailing exogenous variables, it does not offer further explanation of this process. For this reason, this chapter uses the dynamic version of the IAD framework as proposed by Pahl-Wostl et al. (2010) including the concept of social learning. Like this, the IAD framework becomes process-oriented (Pahl-Wostl et al., 2013).

Social learning is a prominent concept in environmental and sustainability science that states that individuals learn and thereby increase the adaptive capacity of the system through their participation in decision-making (Berkes, 2009; Reed et al., 2010). Therefore, it can also serve as a valuable concept with regard to the transition towards low-carbon energy systems. However, many definitions of social learning exist so far (Armitage et al., 2008; Blackmore, 2007; Cundill and Fabricius, 2009; Rodela, 2011). Here, the definition of Reed et al. (2010) is applied who state that "social learning may be defined as a change in understanding that goes beyond the individual to become situated within wider social units […] through social interactions between actors within social networks". Hence, the concept of social learning is characterized by three qualities. Firstly, it comes with an alteration in understanding of those involved in the management of socio-technical systems. This can relate to attitudes, norms, or beliefs, i.e. mental models (Armitage et al., 2008; Scholz et al., 2014). Thereby, ideas, experiences, and knowledge are shared among participants (Berkes, 2009). This transforms into a higher awareness for related issues and can eventually lead to appropriate action (Cundill and Fabricius, 2009). An outcome, for example, could be more sustainable patterns of behavior (Reed et al., 2010). Secondly, this change of understanding needs to exceed the individual level and influence a wider social context. It is assumed that the complexities and uncertainties that come with regard to the management of natural resources require learning processes that go beyond the individual (Blackmore, 2007). Like this, also social units, such as organizations, are able to learn as well, even if, in principle, only individuals possess the ability to learn, not do organizations per se (Reed et al., 2010). Thirdly, social learning takes place through interaction within social networks (Berkes, 2009). These networks are embedded in and constraint by the technical, social, and institutional setting (Armitage et al., 2008). One way of interaction that can stimulate social learning are participatory processes (Cundill and Rodela, 2012; Reed et al., 2010; Scholz et al., 2014).

Generally, social learning can have three levels of impact. It can occur in the form of single-, double-, or triple-loop learning (Flood and Romm, 1996; Keen et al., 2005). Whereas single-loop learning is defined by an incremental adjustment of existing processes or goals, double-loop learning occurs when important principles underlying these processes are changed (Diduck et al., 2005). Double-loop learning causes changes in actor constellations and power structures (Armitage et al., 2008). Triple-loop learning requires changes in fundamental structures and norms (Armitage et al., 2008). The different levels of social learning are of special importance to the case of the energy transition since they describe if changes are rather superficial or have deeper impacts, such as structural changes.

Originally, the concept of double-loop learning stems from management theory and was mainly developed by Argyris and Schön (1978). Keen et al. (2005) extended this concept by triple-loop learning which additionally alters the existing exogenous environment such as rules-in-use and biophysical/material conditions. Since the transaction costs resulting from institutional change can be very high, institutions and processes tend to be path-dependent. Therefore, political systems often only slowly adapt to altering environmental, political and economic contexts (Pahl-Wostl, 2009; Villamayor-Tomas, 2017). Against this background the three levels of single-, double- and triple-loop learning often occur iteratively (Pahl-Wostl, 2009). However, in order to profoundly change the way we generate, distribute, and consume energy triple-loop learning seems to be necessary. Only by changing the exogenous variables, such as infrastructures, patterns of behavior, and institutions, current energy systems can adapt to the challenges of a low-carbon future.

Figure 2-2 illustrates how these levels of learning can be incorporated in the IAD framework. By using this definition of social learning, interrelations between subsequent action situations and impacts of prior action situations on changes in exogenous variables can be analyzed in greater detail than in the original IAD framework (Pahl-Wostl et al., 2013). Table 2-1 summarizes the definitions of the elements of the framework and the different levels of learning.

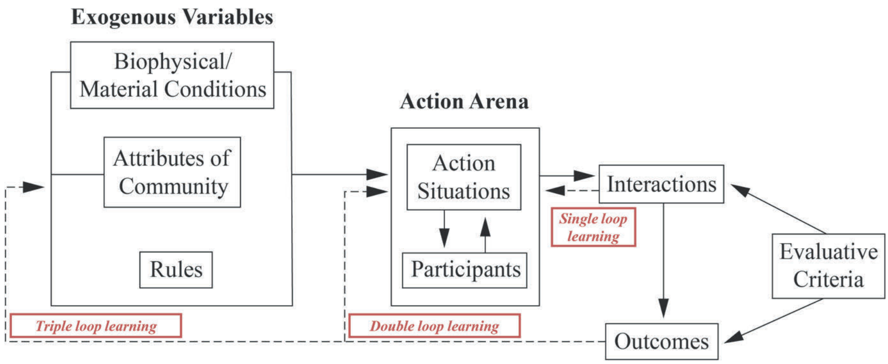



**Figure 2-2: IAD framework extended by social learning**
**(Original IAD elements in black font/lines, social learning processes in red font and italics)**

Source: Adapted by authors based on Ostrom (2005)

**Table 2-1: Definitions of the elements of the IAD framework extended by social learning**

| Framework element | Definition | Source |
|---|---|---|
| Biophysical/Material Conditions | Physical environment influencing possible actions taken in action situations, e.g. existing infrastructure | McGinnis (McGinnis, 2011a) |
| Attributes of Community | Socio-economic characteristics of the participants' community | Ostrom (Ostrom et al., 1994) |
| Rules | Institutions, e.g. formal laws and regulations that enable and constrain behavior of participants | Ostrom (Ostrom, 2005) |
| Action Situation | Social space of interaction, in which participants decide on their individual actions given the information they have about how those actions lead to outcomes and the costs and benefits associated with those actions and outcomes | McGinnis (McGinnis, 2011a) |
| Participants | Individual actors or actor groups, e.g. governmental and non-governmental bodies or firms | Ostrom (Ostrom, 2011) |
| Interactions | Procedural aspects, i.e. interaction among participants in an action situation | Ostrom et al. (Ostrom et al., 1994) |
| Outcomes | Results of interactions, which may be institutions, knowledge, or operational outcomes such as the implementation of new technologies | Pahl-Wostl et al. (Pahl-Wostl et al., 2010) |
| Evaluative Criteria | Criteria that are used to assess interactions and outcomes, e.g. sustainability, distributional equity, economic efficiency | Ostrom (Ostrom, 2011) |
| Feedback and learning processes | Impact of actors' evaluations of interaction patterns and outcomes on action situation and exogenous variables | McGinnis (McGinnis, 2011a) |
| Single loop learning | Process leading to an incremental adjustment of patterns of interactions within one policy process | Diduck et al. (Diduck et al., 2005) |
| Double loop learning | Process leading to change of principles that underlie future action situations, e.g. procedural aspects of decision-making | Diduck et al. (Diduck et al., 2005) |
| Triple loop learning | Process leading to changes in the existing exogenous variables | Armitage et al. (Armitage et al., 2008) |

## 3 A value gap in IAD literature

In its capacity to (a) analyze institutional change, and (b) provide generic guidance what structural variables are present in processes of institutional development, the dynamic IAD framework forms a suitable basis for our aim of explicating how values influence institutional change processes. Structured approaches to analyze this influence, however, are so far missing, even though the term 'values' is mentioned quite frequently by the scholars who have developed and are working with the IAD framework. Ostrom herself stressed the importance of an evaluation how institutions "fit the values of those involved" in their development (Ostrom, 2011, p. 16). McGinnis (2011a) mentions that the development of institutions will be influenced by the degree to which members of a community developing an institution share the same core values. Others acknowledge that human behavior cannot be fully understood when only focusing on material self-interest as a driver, but that values influence human behavior and thus also the development of institutions (Ramaswami et al., 2012; Schlüter and Theesfeld, 2010). A first effort to go beyond merely acknowledging and mentioning values has recently been undertaken by Prior (2016) in the context of the removal of pollutants from contaminated soil, sediment, and water. Using Schwartz' value framework (Schwartz, 1992; Schwartz and Bilsky, 1987), Prior (2016) finds that different stakeholders are motivated by different values to comply with existing institutions. For example, local governments are motivated by universalist values (concern for welfare and equity) while providers of services to remove the pollutants are motivated by achievement and power values (power and success). However, this is still limited in its focus on *individuals'* values, compliance with *existing institutions*, and conceptualization of values from *one* academic discipline, namely social psychology.

## 4 Multi-disciplinary conceptualizations of 'values'

In light of the value gap in the IAD literature identified in the previous section, there is a need to define and conceptualize 'values' before we can build our framework. In general, values can be defined as fundamental normative guiding principles to which changes in a society should adhere and which are considered to be intersubjectively shared (Van de Poel and Royakkers, 2011). Beyond such a general definition, however, the concept has been used differently across academic disciplines, and debates are often characterized by conceptual struggles and vagueness (Aligica and Tarko, 2013; Dietz et al., 2005; Kroes and Van de Poel, 2015).

Therefore, this section sets out to investigate possible literature perspectives that can be useful to integrate values into the dynamic IAD framework. Starting from first efforts of integrating values in the IAD framework by Prior (2016), we observed in the previous section that he makes use of an account of values used in social psychology. We also draw from institutional economics as the original discipline in which the IAD framework was developed and in which recent work addresses the relation between values and institutions. Additionally, we review the notion of values in moral philosophy, which has probably the longest tradition of reflecting on values. We will show that these conceptualizations of values can enhance the dynamic IAD framework in a complementary way and contribute to a more encompassing understanding how values might influence institutional change. The three perspectives are outlined below. Combined with the dynamic IAD framework they will be used in Section 5 to explicate the role of values for institutional change.

### 4.1 Values in moral philosophy

In moral philosophy, values are criteria to make statements about the ethical goodness of options for action. They are normative human principles worth striving for. Central questions include for example: "How should I live my life?" or "What is the right thing to do in this situation?" (Pojman, 1997, p. 12). Values are considered to be intersubjectively shared, that means different individuals can relate to a value and generally hold it important (Taebi and Kadak, 2010; Van de Poel, 2009). In ethics of technology, values are analogously used to make statements about ethical and social consequences of technologies. Typical values relevant for energy systems, just to state a few, are affordability of energy, security of supply, health, environmental sustainability, and justice (Milchram et al., 2018b). Central questions include "What types of values do technological artifacts have or contribute to? How are value considerations inherent to design choices?" (Van de Poel, 2009, p. 973). This highlights that values are seen as identifiable entities that are embedded in technologies.

Evaluating technologies in light of value embeddedness is grounded in the understanding that they are not mere neutral objects or instruments for humans in moral decision-making (Verbeek, 2008). Technologies are value-laden and thus capable of endorsing or harming specific values (Winner, 1980). In his seminal article on the politics of artefacts, Winner (1980) gives the much-cited example of very low overpasses over the only highway connecting New York with Long Island Beach, thereby hindering public busses (the main method of transportation for less well-off societal groups including racial minorities) to access the beach. Although the truth of this example has been debated, for example by Joerges (1999), it is often used to illustrate the moral importance of technological design in the sense that technologies tend to represent certain dominant values while failing to embed others (Albrechtslund, 2007; Shilton et al., 2013).



Assigning moral significance to technology does not mean that technology in itself has agency and humans have no responsibility. As Verbeek (2008) argues, technology *mediates* human perceptions on the basis of which moral decisions are made. To explain technological mediation, Verbeek (2008) points out how picturing an unborn baby through ultrasound enables to discover illnesses and constitutes parents as decision-makers over the life of the unborn.

Making technological mediation explicit and recognizing that moral decisions are based on a deep connection between humans and technologies, allows designing technologies consciously with specific values in mind. Furthermore, it allows recognizing the importance of the use context: Technologies are multistable, meaning that they can be interpreted and used in various ways, including for purposes that were not intended by designers (Ihde, 1990). The social context of the use or users of technologies may thus give rise to new behavior and lead to the emergence of new values and value changes (Kroes and Verbeek, 2014; van de Poel, 2018). This opens the door for understanding ethics of technology not as 'protecting humans against technology', but as careful experimentation with technological mediation in order to experience how values are embedded in different technological designs (Verbeek, 2008).

### 4.2 Values in institutional economics

In institutional economics (IE), values are seen as influencing the behavior of economic actors and as embedded in institutions, such as laws and regulations. Although values are usually not a central topic to institutional economists, recent literature does provide conceptualizations and addresses the relation between values and institutions (Aligica and Tarko, 2013; Correljé et al., 2015b; Correljé and Groenewegen, 2009). In general, IE emerged based on critiques of the pure focus on perfect markets and full rationality in neoclassical economics. It broadens economic analysis by looking at institutions and trying to understand how they influence human behavior and how they emerge (Knudsen, 1993). Decisions are not solely dependent on utility maximization and efficiency is not the ultimate objective to strive for. Actions also depend on positive or negative impacts of more divergent values which are seen as important in a society (Correljé et al., 2015b). As such, values are seen as normative guidelines and criteria for decision-making (Aligica and Tarko, 2013; Knudsen, 1993). Additionally, values influence the design of formal institutions (e. g. the formal 'rules of the game') (Williamson, 1998). In the distinction between formal and informal institutions (see Section 2.1), values are seen as informal institutions, which set the boundaries within which formal institutions are developed (Correljé and Groenewegen, 2009; Williamson, 1998). Formal institutions are therefore not value-free; they should endorse those specific values they have been designed for. For example, laws and regulations are designed to serve a certain purpose, e.g. the expansion of renewable energies. Usually, specific values underlie this purpose. In the case of renewable energies protection of nature would be one of these values. Additionally, other values might be embedded in institutions unconsciously by policymakers.

### 4.3 Values in social psychology

In social psychology, values are studied as personality characteristics that influence human decision-making and behavior (Rokeach, 1973). Values are "(a) concepts or beliefs, (b) about desirable end states or behaviors, (c) that transcend specific situations, (d) guide selection or evaluation of behavior and events, and (e) are ordered by relative importance" (Schwartz and Bilsky, 1987, p. 551).

Extensive theoretical and empirical work on conceptualizing and measuring values has been conducted based on the seminal contributions of researchers like Schwartz, Bilsky, and Rokeach (for reviews, see (Cheng and Fleischmann, 2010; Dietz et al., 2005)). Schwartz (Schwartz, 1992; Schwartz and Bilsky, 1987) is known for the development of the most commonly used measurement of values, the so-called 'Schwartz Value Survey'. The survey consists of 56 items to measure individuals' value priorities, grouped in ten value orientations. These include, for example, self-direction (e.g. freedom, independence, self-respect), achievement (e.g. success, ambition, intelligence), power (e.g. wealth, authority, public image) or universalism (e.g. equality, wisdom, social justice) (Schwartz, 1992). This approach to measuring individuals' values has recently been used within the IAD literature by Prior (2016) to study why individuals comply with existing institutions that regulate the remediation of contaminated environments. Prior (2016) found that local governments are influenced by universalist values while remediation providers are influenced by achievement values. Besides the Schwartz Value Survey, there are of course several other influential surveys measuring individuals' value priorities and value orientations. The details are out of scope for this text, but for further reading Cheng & Fleischmann (2010) give a good overview of different conceptualizations and lists of values in an attempt to create a meta-inventory of human values.

# 5 Discussion: Adding a value perspective to the dynamic IAD framework

A consideration of underlying values and their role for institutional change requires an expansion of the dynamic IAD framework. We use the conceptualization of values in different disciplines outlined above to illustrate the role of values in the framework elements. The following paragraphs describe what role values play for the single elements of the dynamic IAD framework and outline how they are related to different conceptualizations of values. Our analytical approach comprises of three steps (Figure 2-3). Firstly, we define the constituting elements of the dynamic IAD framework. Secondly, we highlight the relevant conceptualization of values applicable to the specific element, and thirdly, we combine the first two steps in examples from the energy transition. The results of our analysis are summarized in Figure 2-4 at the end of this section.

## 5.1 Participants

Since any transition process involves people taking action, our analysis starts at the element of participants. Participants can act as individuals or groups representing an entity. Ostrom defines participants as fallible learners that not only can, but actually make mistakes and have the ability to learn from these mistakes. If and how an actor learns is thus dependent on the incentives and possibilities provided by the institutional setting. Generally speaking, action choices are always influenced by the exogenous variables (Ostrom, 2011).

Assuming that human behavior is driven by personal or professional characteristics and attributes – depending on the role the participant is acting in – the psychological definition of values can deliver important implications for behavior regarding energy

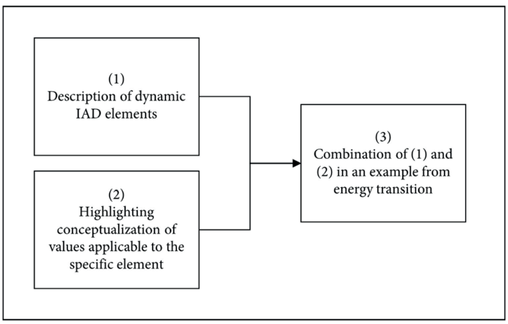



**Figure 2-3: Three-step analytical approach**

systems. Values work as principles influencing or driving human behavior and are thus specific characteristics of personality (Schwartz, 1992).

To exemplify that influence, we draw from a study by van der Werff and Steg (2016), who investigated the effects of biospheric values (e.g. valuing unity with nature and environmental protection), egoistic values (e.g. valuing wealth and social power), altruistic values (e.g. valuing social justice and helpfulness), and hedonic values (e.g. valuing comfort and pleasure) on interest and participation in smart energy systems. They found that people with strong biospheric values were more interested in smart energy systems and more likely to participate in a proposed pilot project because they were more aware of environmental problems of fossil fuels, had stronger feelings that they could contribute to solving those problems by participating in smart energy systems, and felt a stronger moral obligation to solve those problems. Interest was more strongly influenced by biospheric values than actual participation. Participation was also influenced by egoistic and hedonic values, suggesting that concerns about effort and money negatively influenced the likelihood of people participating in smart energy systems. Regarding the IAD framework and institutional change, this implies that, depending on the participants involved in an action situation, individuals' values – referring to social psychology – can influence what technologies are preferred by participants and how those technologies are discussed in an action situation.

### 5.2 Evaluative criteria for outcomes and patterns of interaction

The conceptualization of values in ethics of technology and IE allows us to outline the role of values as evaluative criteria for outcomes and patterns of interactions. Since Ostrom does not offer an explanation of what outcomes can look like, we apply the broader definition of Pahl-Wostl et al. (2010), who defined three types of possible outcomes of action situations: institutions, knowledge and operational outcomes. The latter, for example, also captures the innovation of new technologies, which is of special importance for energy systems.

In the context of new technologies, the definition of values from ethics of technology offers important implications. Values can be used to define and design essential characteristics of technologies. This is grounded in the understanding that technologies cannot be seen as neutral objects but are value-laden (Flanagan et al., 2008; Winner, 1980). In the same way, values can serve as design principles and characteristics of institutions. This implication, however, mostly derives from IE: Values are influential for institutional change and become embedded in institutions through value judgments (Bush, 2009).

To assess the performance of a system, outcomes as well as patterns of interactions are judged by specific evaluative criteria. Ostrom names different types of these criteria, e.g. economic efficiency, accountability or fiscal equivalence. In the case of the energy transition, sustainability, or distributional equity are critical (Ostrom, 2011). When giving those examples for evaluative criteria, Ostrom (2005) does not explicitly call them ‘values’, but the examples are in fact values as they are defined in moral philosophy: Goal-oriented assessment criteria and normative principles that are worth striving for and that institutional developments should adhere to (Shrader-Frechette and Westra, 1997b).

Two examples highlight how values can serve as evaluative criteria for outcomes and interaction patterns. Firstly, if the focus of an action situation is to incentivize investment in renewable energy technologies, the outcome (i.e. the actual investment in renewables) can be assessed using values as evaluative criteria. A hypothetical region A with a high degree of small-scale solar power might be compared with region B with a focus on hydropower. Region A is likely to incorporate the values ‘consumer empowerment’ and ‘participation’ in energy generation to a higher degree, while this might come at the expense of system reliability due to a higher degree of intermittent supply. Region B is likely to focus on values of emission-free, large-scale, relatively secure energy supply, while this might come at the expense of local ecosystems near hydropower dams.

Secondly, and with regard to interaction patterns, the degree to which a variety of stakeholder groups is integrated in decision-making processes on the siting of wind parks (i.e. the degree of procedural justice) might impact the acceptance of the wind park by local communities (Devine-Wright, 2005). This means that depending on where the action situation is located, the selection of participants will have an influence on the outcome. However, it will also influence an assessment to what extent core values were considered and, in the end, if certain technological or institutional changes are accepted or not.

## 5.3 Biophysical/material conditions

The biophysical/material conditions in the IAD framework describe the physical environment in which an action situation is located (Ostrom, 2005). It includes the physical and human resources needed to produce and provide goods and services, such as capital, labor, technology, sources of finance and distribution channels (Polski and Ostrom, 1999). The biophysical/material conditions include the humanly devised technologies to generate, distribute, and consume energy.

Research in ethics of technology allows identifying how values are linked to attributes of the biophysical world. Values are embedded in the technologies to generate, distribute, and consume energy through the design and use of these technologies. As values are seen as design goals, engineers create technologies with the aim to incorporate specific values, such as health and safety, or security of supply (Shilton et al., 2013). Ethicists analyze the moral repercussions of using certain technologies because technologies do not only fulfill the specific function they are designed for but can have unintended side-effects (Barry, 2001).

To exemplify the relation between values and technologies, we look at the value implications of hydropower dams: Large hydropower dams are considered a low carbon energy source that can provide access to energy for millions of people and are thus seen as affordable renewable energy. Targets to lower carbon emissions and increase energy access have therefore led to a renaissance of large hydropower developments particularly in Africa and Asia (World Bank, 2013). Despite their importance for energy access, important moral repercussions include protection of the river ecosystem and distributive justice, particularly with respect to the effects on downstream water supply and the fair distribution of water along the entire river basin. Studying three large hydropower dams in Cambodia, Malaysia, and Ghana, Siciliano and Urban (2017) investigate the dams' impacts on local communities with respect to procedural and distributive justice in the allocation of natural resources between competing users and land uses. From a distributive perspective, their findings reveal that beneficiaries of the dam are the dam builders, recipients of electricity in urban areas, and national governments because of improved energy access statistics on a national level. However, local communities were threatened in their livelihoods because of adverse effects on forestry resources, fisheries, and water supply. Procedurally, the limited consultation of local communities by dam builders and national government agencies illustrate the unequal power relations between those groups. The example highlights that energy technologies can implicate a range of values, which should be taken into account in their design and implementation.

### 5.4 Attributes of community

Attributes of the community are described in order to capture characteristics of the participants of the focal action situation (McGinnis, 2011b; Polski and Ostrom, 1999). Attributes that are important in affecting action situations include values or behavior generally accepted in the community, the level of common understanding about the structure of types of action situations, the degree of homo-/heterogeneity in preferences, the size and composition of the community, and the extent of inequality of distribution of basic assets among those affected.

Even though values are mentioned in literature on the IAD framework as part of the attributes of a community, a definition and explanation is lacking. Insights from moral philosophy are helpful to explain them in greater detail: Values are shared normative principles about what is a good and right development in a given community or society (Taebi and Kadak, 2010; Van de Poel, 2009). The degree to which different values are seen as important in a community will impact the potential outcomes in an action situation and the actual outcome that participants decide upon.

An example of such shared normative principles for energy policy that need to be considered in an institutional analysis can be seen in the three focus objectives of the European Union's energy strategy and policy: security of energy supply, affordability of energy for consumers, and environmental sustainability (European Commission, 2018). It strives to "secure energy supplies to ensure the reliable provision of energy whenever and wherever it is needed", ensure "affordable prices for homes, businesses, and industries", and achieve energy consumption that is "sustainable, through the lowering of greenhouse gas emissions, pollution, and fossil fuel dependence" (European Commission, 2018). This was not always the case: Until approximately halfway through the first decade of the 21st century, European energy policy was dominated by the goal to create *efficient* energy markets through increased competition. However, as policymakers were increasingly recognizing the threats associated with anthropogenic climate change and the need to decarbonize the energy system, the reduction of carbon emissions by moving away from the use of fossil fuels became an important goal for European policymaking (Correljé et al., 2015b). This shows how changing normative values can affect and broaden policy objectives considered in an action situation.

### 5.5 Rules

The most accepted and shared definition of institutions focuses on institutions as 'rules of the game' and systems of rules which enable and constrain actor behavior (Hodgson, 2015; Ostrom, 2005) (see Section 2). Rules in the IAD framework are prescriptions which define whether actions are required, prohibited, or permitted. Importantly, the focus lies on rules-in-use which are rules that are known to the participants in an action situation and thus have the capacity to influence their behavior. They are differentiated from rules-in-form, which are unknown to the participants in an action situation (Ostrom, 2011). In an open and democratic society, the origin of rules can be very diverse ranging from a group of individuals to decide on their own rules for an action situation, families, and workplaces, to firms, local and regional governments, national governments and supra-national organizations

(Ostrom, 2011). In short, rules in the IAD framework denote the exogenous institutional environment of an action situation.

Values are influential for institutional change and seen as entities that are embedded in institutions (Correljé et al., 2015b). Because of this, the exogenous rules-in-use shaping an action situation will embed the values they have been previously designed for. In a similar way as values are seen as embedded in technologies, rules are value-laden. Essentially, institutional economists view a change of rules as a change of value judgment by the community involved in creating rules (i.e. a change of the degree to which different values are seen as important and should be used as guiding principles for designing a rule) (Knudsen, 1993).

The example of European energy policy mentioned in Section 5.4 can be extended to illustrate how values become embedded in rules. Because of the shared understanding of the importance of security of energy supply, affordability of energy for consumers, and environmental sustainability, these three values have become the most important objectives that European energy policy is directed at. For example, as the value of environmental sustainability was operationalized by European energy policymakers in terms of the reduction of carbon dioxide emissions, it got embedded in the design of a range of policies, such as the European Emissions Trading Scheme, national support schemes for wind and solar power generation, or rules for the energy performance of buildings (Correljé et al., 2015b; EUR-Lex, 2018).

### 5.6 Social learning through value controversies

The concept of social learning explains how institutional change occurs (see Section 2.2). Social learning is “never value free” (Armitage et al., 2008) and can be induced by value controversies (Siebenhüner et al., 2016). Values can become apparent in controversies concerning the formal policy process, as institutional change may have different impacts on different groups of people and therefore raise questions of redistribution of responsibilities and risks. Defenders of the status quo may refer to different values than defenders of the proponents of change. In the language of the dynamic IAD framework, different evaluative criteria used by different participants can trigger social learning processes.

Value controversies may become expressed in the form of social interaction within governmental or non-governmental actor networks, such as public debates (Pesch et al., 2017). They are closely connected to double- and triple-loop learning, as they usually occur outside of the formal policy development process: Value controversies are expressed in public debates, which can put pressure on existing formal rules and thus trigger structural change. The types of learning in which non-governmental participants, e.g. NGOs, associations, and trade unions, get involved, are referred to as double- and triple-loop learning (Pahl-Wostl, 2009). Especially in cases of major societal transformation processes like the energy transition non-governmental participants play a vital role. They can provide governmental participants with additional knowledge useful for assessing problems and creating innovative solutions. Figure 2-4 summarizes all extensions made to the original IAD framework including the concept of value controversies.

Pesch et al. (2017) give examples for value controversies leading to double- and triple-loop learning in the Dutch Energy system. In case of a planned shale gas extraction in Boxtel, an already granted permit was revoked after local citizens and companies mobilized national NGOs and advocacy groups. A resulting national anti-shale-gas movement led not only to the withdrawal of the actual exploration permit but also to a prohibition of new exploration permits pending further research studies that explicitly include local concerns. Another example refers to a planned carbon capture and storage facility in the municipality of Barendrecht, where local resistance and high media attention, followed by a change in government led to the abandoning of the project. In both cases, value controversies were based on safety concerns, distrust between the local population and political and economic actors, as well as on an inadequate participation of the local population in formal permitting processes. These two cases, in combination with an increasing numbers of earthquakes near the country's major gas field in Groningen, eventually led to changes in the prevailing national institutional setting, namely the Dutch Mining Act. The controversies led to a decrease in public confidence towards political and economic actors, and to questioning the adequacy of the prevailing rules provided by the Dutch Mining Act, particularly rules regarding citizen participation. These reservations were acknowledged and articulated by various governmental actors and in the end led to a profound adjustment of the Mining Act regarding safety issues and the involvement of local authorities (Pesch et al., 2017). The examples demonstrate how social learning processes occur incrementally and can reinforce each other culminating in changes of the exogenous variables, which can be defined as triple-loop-learning.

2

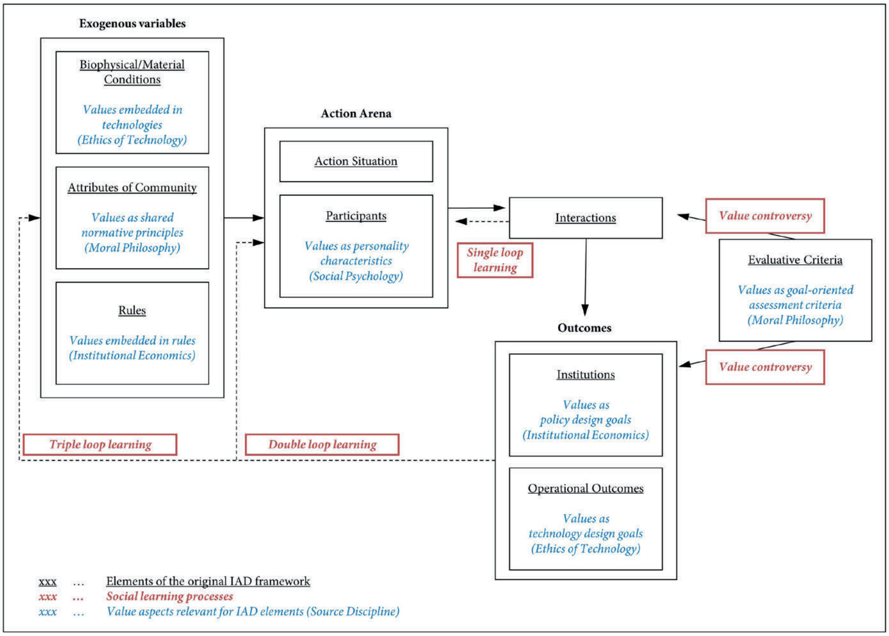



**Figure 2-4: IAD framework extended by social learning, highlighting the role of values**

Source: Adapted by authors based on Ostrom (2005)

## 6 Conclusion

In this chapter, we proposed a dynamic framework for analyzing the role of values in institutional change. The energy transition serves as a valid example showing that changes in (energy) policies can be induced by changes in core values. Thus, understanding how values become incorporated in (energy) policies is an important challenge for the analysis of institutional change. Up to now, such an analysis has been hindered by the absence of a framework that highlights the role of values. Therefore, we built on a dynamic IAD framework – a combination of the original IAD framework and social learning – and enhanced it by using conceptualizations and insights on values from different academic disciplines: moral philosophy, institutional economics, and social psychology. In the resulting framework, the roles of values for different IAD framework elements and feedback loops are explicitly highlighted.

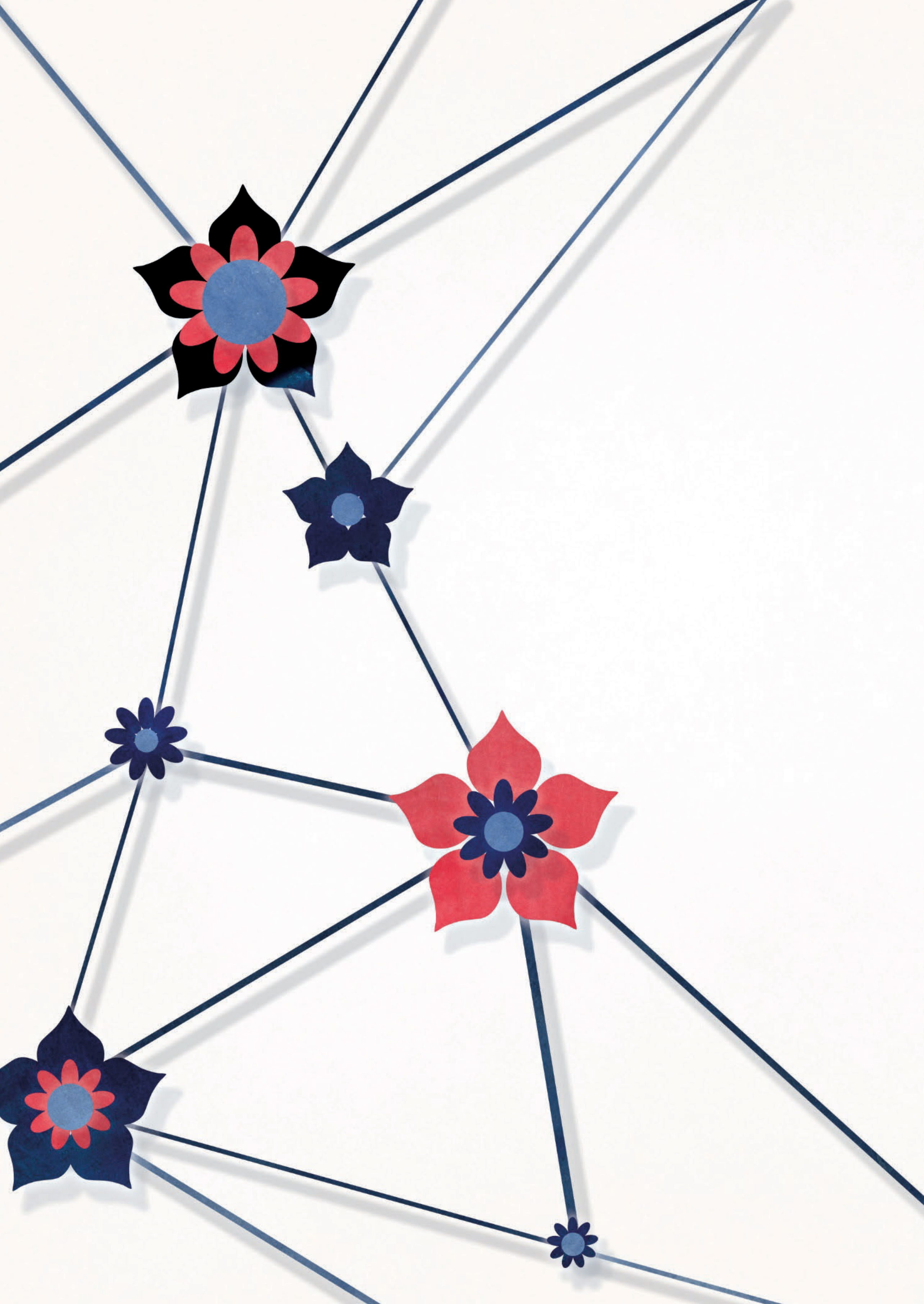
The framework makes explicit how values influence the behavior of participants in an action situation and how they are used as evaluative criteria for patterns of interaction and outcomes of an action situation. Values are embedded in the biophysical/material conditions such as infrastructures as well as in the rules creating the institutional environment of an action situation. In addition, they are shared principles of what is good and right in a given community. We also showed how value controversies can trigger institutional change by inducing social learning. These learning processes can have different levels of impact. In their most prominent form they can lead to changes in the exogenous variables with respect to the creation of value-laden technologies and institutions as well as community attributes. Since these exogenous variables are thereby related to previous action situations, the new framework helps connecting action situations and explains when and how institutional change occurs due to social learning (Cole, 2017).

While developing the framework, we showed that the three perspectives on values are complementary: Each of the disciplines offers their own distinctive conceptualization of values that can be used to explain different aspects of institutional change. The psychological perspective – previously used in IAD literature (Prior, 2016) – directs attention at individuals' motivations by investigating how values and value orientations influence human behavior. As such, this perspective on values would be suitable to understand why policymakers or other participants in an action situation prefer certain institutions over others, for example depending on their biospheric, altruistic, and/or egoistic value orientations. Philosophers of technology particularly direct attention to the embeddedness of values in technologies and to values as normative criteria for comparing the design and performance of energy systems, making this perspective useful to understand the relation between values and (technological) design. Recent literature in institutional economics is inspired by ethics of technology and the idea of value embeddedness, arguing that institutions can foster or harm certain values, and that they can be designed and analyzed with respect to those values. It therefore contributes to the understanding of relations between values and institutions.

Both researchers and policymakers can use our framework to analyze institutional change. It can help to explain how different values become relevant triggered by societal controversies and how this influences the change of shared values and institutions. Apart from this longitudinal perspective, our framework also allows cross-sectional, comparative analysis of different energy systems because values serve as evaluative criteria for different system designs. It allows comparison of change patterns across geographies and time spans such as speed of transitions, enablers and barriers, or the openness of formal learning processes. Both longitudinal and cross-sectional analyses can serve as input for changes in the design of energy systems in different temporal and spatial contexts.

Future research and practical applications of the framework could thus be done with respect to a specific case study of institutional change in energy systems. When doing so, we would advise to select a value perspective as depicted in Figure 2-4 that best fits the research focus. For example, if the purpose of a study is to compare national energy regulation (e.g. subsidies for energy generation) one might focus on the IAD framework element 'rules' and the values' perspective in institutional economics. If interested in ethical reflections of technological design (e.g. of wind turbines), the element 'evaluative criteria' together with value conceptions in philosophy are a suitable choice.

We acknowledge that a complete analysis of values in institutional change in the energy transition would necessitate additional tools and research. Most importantly, such an analysis needs to include an elicitation, conceptualization, and operationalization of the relevant values, which are specific to the technological, institutional, temporal, and spatial context. This might include the development of indicators to measure the embeddedness of values in different energy systems. In this chapter, we provided the basic framework for such research and concentrated on the conceptual foundation that enables a value-based analysis of institutional change in general and is open to include a variety of relevant values.



# CHAPTER 3:
# MORAL VALUES AS FACTORS FOR SOCIAL ACCEPTANCE OF SMART GRID TECHNOLOGIES

This chapter has been published as:

Milchram, C., van de Kaa, G., Doorn, N., Künneke, R., 2018. Moral Values as Factors for Social Acceptance of Smart Grid Technologies. Sustainability 10, 2703. https://doi.org/10.3390/su10082703

*The previous chapter has laid the conceptual foundation for defining values and understanding their role in the energy transition. However, the chapter has not yet focused specifically on smart grid systems and has also not systematically identified and conceptualized relevant values. Chapter 3 therefore focuses concretely on smart grids and analyzes what values are underlying reasons to develop and adopt smart grid systems (e.g. environmental sustainability) and also reasons to reject its adoption (e.g. privacy).*

*The findings are derived from a systematic literature review of empirical studies on smart grid systems. From a theoretical standpoint, the chapter links literature in ethics of technology with technology acceptance models.*



*Following an introduction, Section 2 outlines the two theoretical perspectives, ethics of technology and technology acceptance. The methodology of the systematic literature review is explained in Section 3. Subsequently, Section 4 reports the main results of the review, namely a list of values, their relevance for a number of smart grid sub-systems, and their influence on system acceptance. Section 5 discusses the contextual ambiguities for values constituting drivers and barriers to smart grid implementation, and argues that scientific understanding of the role of values in technology adoption could be enhanced by combining insights from ethics of technology and technology acceptance models.*

## 1 Introduction

Driven by climate change mitigation and transition to low carbon energy systems, governments worldwide have set targets to increase the use of renewable energy sources. The 2030 European energy targets include a minimum 27% share of renewable energy consumption (European Commission, 2016). Growing shares of renewables, particularly from wind and solar energy, lead to rising intermittencies of energy supply and to a larger number of small and decentralized generation sites. Growing intermittencies and decentralization, however, lead to challenges for balancing supply and demand in networks that were designed for relatively few large and controllable power plants (Muench et al., 2014; Römer et al., 2015).



Smart grid technologies are praised as one solution to support the integration of rising shares of renewable energy sources into power networks and are thus seen as essential in the transition to sustainable energy systems (Lund et al., 2014; Muench et al., 2014). They allow accounting for higher supply intermittencies and decentralization by using innovative information and communication technologies (ICT). For consumers, they contribute to increased information and awareness of energy use, potentially enabling energy savings (Fallah et al., 2018). As such, smart grids can be a promising solution to reducing greenhouse gas emissions in the electricity system while at the same time dealing with rising energy costs (Pooranian et al., 2018). Although the concept of smart grid technologies comprises many technological applications and lacks a single definition, widely accepted definitions include efficient management of intermittent supply, two-way communication between producers and consumers, and the use of innovative ICT solutions (Pooranian et al., 2016; Xenias et al., 2015).

In spite of their promising benefits for low-carbon energy systems, several challenges are associated with smart grid technologies. Next to concerns about high costs as well as uncertain investment and regulatory environments, moral values underlie many societal concerns (Sintov and Schultz, 2017). Concerns about data privacy and security have already delayed smart meter introductions in Europe and the US (Cuijpers and Koops, 2013; Raimi and Carrico, 2016). The possibility to share end-users' energy consumption data automatically and in (near) real time with grid operators and store these data in central databases raises concerns that energy companies could use this data to get insight into activities in a household that are considered as private (McKenna et al., 2012). Related to storing sensitive data in central databases are fears that these data could be threatened by cyberattacks and used in a harmful way. Additionally, consumer fears of reduced autonomy are reflected in concerns that smart meters or smart household appliances might give energy companies more control over a household's electricity use (Ligtvoet et al., 2015). Further concerns that energy suppliers will not be transparent about benefits and pass financial savings on to their customers relate to the values of trust and a fair distribution of costs and benefits (Buchanan et al., 2016).

Challenges in the smart grid development which are related to moral values need to be addressed to achieve sustainable energy systems and might hinder the wider acceptance and adoption of smart grid technologies. There is an extensive literature on factors influencing technology acceptance and adoption in the field of technology and innovation management (Schilling, 2002; Suarez, 2004), and social psychology (Stern, 2000; Venkatesh et al., 2012). Innovation management scholars emphasize market acceptance, which is determined largely by environmental and market-specific factors, the characteristics of the technology itself, and firm-level characteristics (Cusumano et al., 1992; Katz and Shapiro, 1985; Schilling, 1998). Theories in social psychology, on the other hand, concentrate on individual user acceptance, with models stressing the importance of technology specific beliefs, social influences, and personality beliefs as factors for acceptance (Ajzen, 1991; Stern, 2000; Venkatesh et al., 2012). Although these bodies of literature focus on a wide range of potential factors for acceptance, moral values—characteristics of a technology with ethical importance (Shrader-Frechette and Westra, 1997b)—are typically not included in these factors. Given that moral values underlie societal concerns uttered in public debates, there is a need for research that addresses how moral values impact the acceptance of smart grid technologies. This chapter therefore aims at exploring this relationship. It addresses the questions which moral values are relevant for the acceptance of smart grid technologies and how these values influence smart grid acceptance. The paper contributes to the development of sustainable smart grid technologies. To achieve sustainability, it is important not only to consider environmental impacts such as carbon emissions but also social and ethical impacts such as privacy and justice. We stress the importance of social and ethical aspects for sustainability by emphasizing the role of moral values for smart grid technologies.

The paper is structured as follows: The next section provides a theoretical background on moral values drawing from the field of ethics of technology, as well as factors for technology acceptance and adoption drawing from technology and innovation management, and social psychology. Sections 3 and 4 contain the methodology and results of a systematic literature review on values associated with the acceptance of smart grid technologies. The two final sections are devoted to discussions and conclusions.

## 2 Theoretical perspectives

### 2.1 Ethics of technology

Moral values are evident in societal concerns about smart grid technologies. Ethics of technology is the major field concerned with moral values and technologies. Moral values are used to make statements about ethical and social consequences of technologies. Although an unanimously agreed upon definition of the term 'moral values' is lacking, they often refer to abstract principles and "general convictions and beliefs that people should hold paramount if society is to be good" (Taebi and Kadak, 2010) (p. 1343). They are considered to be intersubjectively shared, which means they are principles that different individuals can relate to and generally hold important (Taebi and Kadak, 2010; Van de Poel, 2009). As such, moral values relate to convictions of what is perceived as good and bad that are shared by members of a society (Künneke et al., 2015). Typical examples of importance for technologies are health, well-being, safety, or justice (Friedman et al., 2013; Shrader-Frechette and Westra, 1997b).

Evaluations of technologies with respect to ethical and social consequences are grounded in the understanding that technologies are not neutral objects, but value-laden (Albrechtslund, 2007; Manders-Huits, 2011). That means that they are capable of endorsing or harming values (Winner, 1980). Winner (1980) gives the much-cited example of very low overpasses over the only highway connecting New York with Long Island Beach, thereby hindering public busses (the main method of transportation for less well-off societal groups including racial minorities) to access the beach. The example is often used to illustrate the moral importance of technological design (Albrechtslund, 2007; Shilton et al., 2013). Moral considerations of technological design are especially relevant as technologies do usually not only fulfill the specific function they are designed for, but also have positive and negative side effects (Barry, 2001).

For the design of technologies, moral values are (perceived) technology characteristics that go beyond functional requirements and address requirements of ethical importance such as justice, trust, privacy and more (Flanagan et al., 2008; Manders-Huits, 2011). They are seen as identifiable entities that should be considered in design or be embedded in technologies. To embed value in technologies through design choices, Value Sensitive Design (VSD) scholars follow a tripartite approach (Flanagan et al., 2008; Manders-Huits, 2011). The approach consists of iterative conceptual, empirical, and technical investigations (for a detailed description of the approach, see for example (Davis and Nathan, 2015; Friedman et al., 2013, 2002)). Conceptual investigations are applied to find out what values are relevant, and to identify indirect and direct stakeholders as well as reflections on how to deal with value conflicts. Empirical investigations focus on the stakeholders as unit of analysis in order to get insights into their interpretation and prioritization of different values. Technical investigations focus on the technology itself to identify which technological features support or harm which values. They refer to the "translation" of abstract values into concrete design requirements of the technology.

VSD scholars strive for an in-depth understanding of moral values and the design of technologies that are "better" from an ethical standpoint. Their research aim is focused on integrating convictions "that people should hold paramount if society is to be good" (Taebi and Kadak, 2010, p. 1343) into the design of technologies. Hence, their research aim does typically not include testing effects of their design on social acceptance of technologies.



## 2.2 Technology acceptance and adoption

Acceptance of novel energy technologies is typically defined in terms of perceptions of stakeholders involved in energy projects (Wüstenhagen et al., 2007). Acceptance can range from passive consent with novel technologies to more active approval such as taking action to promote a technology (Sauter and Watson, 2007). Adoption of technologies is defined as the behavior to purchase and use a technology (Broman Toft et al., 2014). Adoption can therefore be measured through e.g., market share. Some scholars include behavior towards energy technologies in their definition of "acceptance." When acceptance is defined as purchase/use, "acceptability" is sometimes used to refer to positive attitudes towards technologies (e.g., Huijts et al., 2012; Schuitema et al., 2010; Steg et al., 2005). For the purpose of this research, the definition of acceptance includes the purchase or use of a technology.

Various scholars have focused on factors that affect acceptance of technologies, particularly in the fields of technology and innovation management, and social psychology (Table 3-1).

### 2.2.1 Technology and innovation management

Scholars in the area of technology and innovation management take a market and firm perspective towards factors for technology acceptance and adoption (Cusumano et al., 1992; Gallagher and Park, 2002; Katz and Shapiro, 1985; Schilling, 2002, 1998; Suarez, 2004; Suarez and Utterback, 1995): Factors pertain to environmental and market-specific factors, the characteristics of the technology itself, and firm-level characteristics (Suarez, 2004; Van de Kaa et al., 2011).

**Table 3-1: Overview of factors for technology acceptance/adoption.**

| Type of Factors | Factors (Examples) | Technology & Innovation Management | Social Psychology |
|---|---|---|---|
| Environmental and market characteristics | Network effects, switching costs, installed base, regulators, suppliers | ✓ | |
| Technology-specific characteristics | Technological superiority, complementary goods, compatibility | ✓ | |
| Firm-level characteristics | Financial strength, brand reputation, pricing strategy, time of market entry | ✓ | |
| Perceived technology-specific characteristics | Performance and effort expectancy, cost-benefit perceptions, hedonic motivations | | ✓ |
| Perceived social influences | Subjective norm, image | | ✓ |
| Perceived personality characteristics | Personal norms, ecological worldviews, innovativeness | | ✓ |
| Others | Experience, habit | | ✓ |

3

Within environmental and market-specific factors, a strong emphasis is put on network effects. Network effects are positive consumption externalities that occur when the utility of a technology for one consumer increases with the number of other consumers that have adopted the technology (Cusumano et al., 1992; Katz and Shapiro, 1985; Schilling, 2002; Van de Kaa et al., 2011). In addition, a high diversity in the inter-organizational network, which is the extent to which stakeholders from different industries are involved in developing and marketing a technology, is beneficial for technology adoption (Suarez, 2004; Van de Kaa et al., 2014; Van de Kaa and De Vries, 2015).

Related to characteristics of the technology, the extent to which a given technology performs superior to competing technologies (i.e., its technological superiority) is generally regarded as beneficial for its adoption (Katz and Shapiro, 1985). In addition, a greater availability and variety of complementary goods has a positive effect on adoption (Cusumano et al., 1992; Schilling, 2002; Van de Kaa et al., 2015).

In addition, firm-level characteristics are found to impact technology adoption. The financial strength of the firm in terms of the availability of appropriate financial resources to develop and market the technology (Teece, 1986), the brand reputation and credibility (Suarez, 2004), and a strong learning orientation from past experiences (Schilling, 2002) are beneficial for the firm's specific technology to become adopted. Several factors are related to the firms' strategic choices connected to the introduction of the technology, such as the pricing strategy and timing of market entry (Schilling, 2002; Suarez, 2004).

### 2.2.2 Social psychology



Whereas technology management scholars focus on a firm or market perspective, social psychologists concentrate on individual user acceptance. Among the most prominent theories are the Theory of Planned Behavior (TPB) (Ajzen, 1991), the Technology Acceptance Model (TAM) (Davis et al., 1989), and its advancements to the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2012; Venkatesh and Davis, 2000), the Norm Activation Model (NAM) (Schwartz, 1977; Schwartz and Howard, 1981), or the Value-Belief-Norm theory[3] (VBN) (Stern, 2000).

Factors for technology acceptance can be categorized as technology-specific beliefs, social influences, and personality beliefs. Technology-specific beliefs include beliefs that a technology will be useful and enhance the achievement of a consumer's goal (performance expectancy) and perceptions of the ease of use associated with a technology (effort expectancy) (Davis et al., 1989; Venkatesh et al., 2012). Consumers are also more likely to adopt a technology if they perceive facilitating conditions, including the support available to use a technology (Ajzen, 1991; Venkatesh et al., 2012). Monetary aspects are considered in terms of the perceived trade-off between costs and gains. Finally, hedonic motivations (expected fun, enjoyment) are also found to positively impact acceptance (Ahn et al., 2016; Venkatesh et al., 2012).

Social influences—interchangeably used with subjective norm (Ajzen, 1991), and image (Venkatesh and Davis, 2000)—cover perceptions that important others such as family and friends believe they should use a technology and the belief that the use will enhance their social status (Venkatesh et al., 2012).

Personality-specific beliefs mostly refer to the role of personal norms as factors for pro-environmental behavior. They play a prominent role in the Norm Activation Model (NAM) (Schwartz, 1977; Schwartz and Howard, 1981) and the Value-Belief-Norm theory (VBN) (Stern, 2000). Personal norms are perceptions about one's moral obligation to take pro-environmental actions (Steg et al., 2005; Stern, 2000). They are

[3] The term "values" in this context needs differentiation from moral values in an ethics of technology context. Value orientations or values are referred to in social psychology as individuals' personality characteristics (Schwartz, 1994). Moral values in a technology context are perceived characteristics of the technology (Flanagan et al., 2008).

shaped by ecological worldviews, which are general beliefs about the relationship between humans and the environment (Steg et al., 2005).

Scholars also combine models focusing on technology-specific beliefs such as TPB and TAM with models focusing on personality-beliefs such as NAM. Broman Toft et al. (2014) for example combine TAM with NAM and show that if smart grid technologies are perceived as useful and easy to use, consumers are likely to show stronger personal norms to use the technology. Huijts et al. (2012) posit that perceived costs and benefits—elements from TBP—impact personal norms, which is a concept from NAM.



## 3 Method

To understand the role of moral values for the acceptance of smart grid technologies in greater details, we conducted a systematic literature review. We analyzed journal articles reporting the results of empirical studies to ensure capturing original research results. Articles were retrieved from the databases Scopus and Web of Science (see Table 3-2 for the full search queries). To capture a diverse range of smart grid technologies, search terms included smart grid, smart energy, smart metering, smart home, home energy management, energy and digitalization, and smart technology. Acceptance, acceptability, and adoption were used as search terms, because, as outlined in Section 2.2, these are common concepts which are often used interchangeably to study social acceptance of emerging technologies (e.g., Broman Toft et al., 2014; Huijts et al., 2012; Sauter and Watson, 2007; Schuitema et al., 2010; Steg et al., 2005; Wüstenhagen et al., 2007). An initial screening of relevant publications revealed that the term "values" is often not mentioned explicitly, even when moral values were included as factors for smart grid acceptance (Ehrenhard et al., 2014; Guerreiro et al., 2015; Hall et al., 2016; Muench et al., 2014; Paetz et al., 2011). To ensure capturing all relevant publications, the term "values" was therefore not included in our search terms.

The database search resulted in 706 articles, which were screened for inclusion in the detailed review (see Figure 3-1 for flow diagram of systematic literature review). After removing duplicates, the 532 unique search results were screened based on their abstracts. Articles that solely focused on technical issues or did not report results of empirical studies were excluded. As a result, for example, a study by Park et al. (2017) was eligible for further analysis because it investigated consumer acceptance of a home energy management system. In contrast, a study by Vagropoulos et al. (2017) was excluded because it presented an optimization model and did not empirically assess the acceptance of smart grid technologies. This abstract screening resulted in a total of 103 relevant articles, which were subsequently analyzed with respect to moral values as factors for smart grid acceptance. In the analysis, we searched for values of ethical importance often mentioned in the VSD literature. In addition, we aimed to find additional values that were reported in empirical smart grid studies but not included in prior literature. Apart from identifying values, we analyzed their conceptualizations, the relevant stakeholder group, the technical context, and applied methodologies. The analysis resulted in a group of 49 papers that reported moral values as factors for smart grid acceptance (see Appendix) and a group of 54 studies that did not include moral values as factors for smart grid acceptance (for example a study by Kobus et al. (2015) focusing on the role of smart appliances to bring about electricity demand shift by residential households).



**Table 3-2: Search queries used in the systematic literature review**

| Database | Search Query | # of Results | Date |
|---|---|---|---|
| Scopus | ((TITLE-ABS-KEY (smart AND grid) OR TITLE-ABS-KEY (smart AND meter*) OR TITLE-ABS-KEY (smart AND energy) OR TITLE-ABS-KEY (smart AND home*) OR TITLE-ABS-KEY (home AND energy AND management) OR TITLE-ABS-KEY (smart AND technology) OR TITLE-ABS-KEY (energy AND digital*)) AND (TITLE-ABS-KEY (acceptance) OR TITLE-ABS-KEY (acceptability) OR TITLE-ABS-KEY (adoption))) AND (LIMIT-TO (DOCTYPE, "ar ") OR LIMIT-TO (DOCTYPE, "ip")) AND (LIMIT-TO (SUBJAREA, "ENER ") OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "OCI") OR LIMIT-TO (SUBJAREA, "BUSI")) AND (LIMIT-TO (LANGUAGE, "English")) | 444 | 5 January 2018 |
| Web of Science | (TS = (smart grid OR smart energy OR smart meter* OR smart home* OR home energy management OR smart technology OR energy digital*) AND TS = (acceptance OR acceptability OR adoption)) AND LANGUAGE: (English) AND DOCUMENT TYPES: (Article) Refined by: WEB OF SCIENCE CATEGORIES: (ENVIRONMENTAL SCIENCES OR ECONOMICS OR ENVIRONMENTAL STUDIES OR PSYCHOLOGY APPLIED OR BUSINESS OR SOCIOLOGY OR GREEN SUSTAINABLE SCIENCE TECHNOLOGY OR URBAN STUDIES OR PSYCHOLOGY MULTIDISCIPLINARY OR PSYCHOLOGY EXPERIMENTAL OR SOCIAL SCIENCES INTERDISCIPLINARY) | 262 | 5 January 2018 |

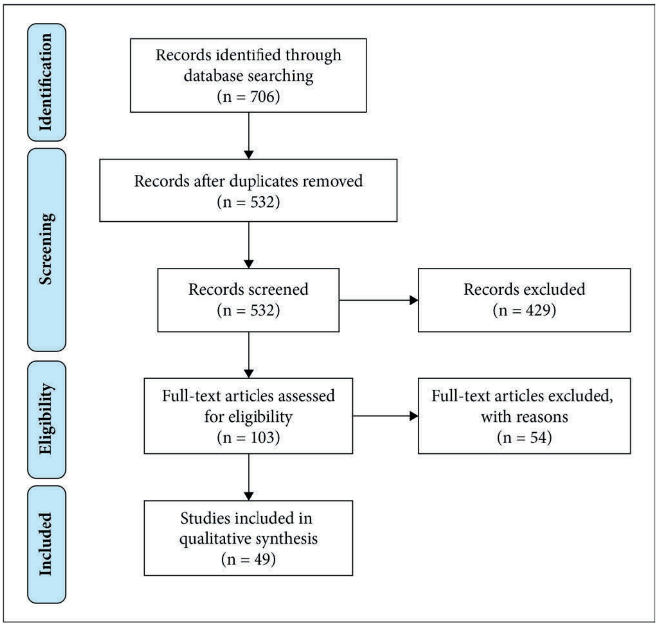



**Figure 3-1: Flow diagram for systematic literature review**

Source: Based on Moher et al. (2009)

## 4 Results

Our literature review reveals that moral values can act as factors for smart grid acceptance; moral values were found in 49 articles on smart grid acceptance (see Appendix). These articles were published in 23 different journals. However, more than 50% are concentrated in four journals: *Energy Research & Social Science* and *Energy Policy* were the most frequent journals, with 10 and nine publications respectively, followed by four publications in *Energy Efficiency* and three publications in *Renewable and Sustainable Energy Reviews*. The journals cover a large diversity of subject areas, including energy research, environmental science, engineering, business and management research, computer science, psychology, and philosophy. Journals have been mapped to subject areas based on their categorizations in Scopus and Web of Science.

The most prevalent subject area was energy research: 32 out of 49 articles were published in this field. A smaller number of articles were published in the three subject areas that can provide the theoretical background to understand the role of values for social acceptance and were reviewed earlier. First, this concerns ethics of technology: two articles were published in journals within the subject area of philosophy (*Journal of Information, Communication and Ethics in Society*, and *Public Understanding of Science*). Second, three articles were published in journals that contribute to the field of technology and innovation management, such as *Technological Forecasting and Social Change*. Third, a total of 18 publications are from journals where theories on technology acceptance from social psychology are widely used, for example the *Journal of Consumer Policy* and *Psychology & Marketing,* but also *Energy Research & Social Science*.

Twenty-five studies with qualitative approaches exploring smart grid acceptance used predominantly expert interviews, focus groups, public workshops, and in-depth interviews, while 27 studies used quantitative methodologies to test the impact of various values on acceptance or adoption (three publications rely both on qualitative and quantitative methodologies). Twelve publications tested consumer acceptance of smart grid technologies based on technology acceptance models used in social psychology. The other 14 articles using quantitative methods derived their own antecedents of smart grid acceptance.

In the 49 publications, a range of moral values have emerged as factors for acceptance or adoption of various smart grid technologies (Table 3-3). These values were reported either as drivers or barriers of smart grid acceptance/adoption. A value is classified as a "driver" if it provides impulse, motivation, or reason for smart grid introduction or if smart grid technologies are perceived to have a positive influence on these values. A value is identified as a "barrier" if it is expressed as concerns or if there is a perceived fear that the technology might have adverse consequences for this specific value.

The drivers of smart grid acceptance were environmental sustainability, security of supply, and transparency. Data privacy, data security, (mis)trust, health, justice, and reliability were found as barriers to smart grid acceptance. Control, inclusiveness, quality of life, and affordability were partly identified as driver and partly as barrier. All of these values emerged in studies using inductive qualitative approaches. Most of them were also included in quantitative studies, with the exception of distributive justice, inclusiveness, quality of life, and transparency.

The majority of these values are relevant for citizen or consumer acceptance. Only seven articles report values relevant for office workers, manufacturing companies, energy companies, or the society at large. While values for office workers are similar to consumers' concerns (trust and quality of life or comfort), the values reported for companies and the societies in general are the main drivers for smart grid development: environmental sustainability and security of supply.

**Table 3-3: Values relevant for the acceptance of smart grid technologies**

| Values | # of Articles (*N* = 49) | Technological Context: Smart Grid | Smart Metering | Smart Home | DSM | Household Storage | Smart EV Charging | Sources* |
|---|---|---|---|---|---|---|---|---|
| Environmental Sustainability | 22 | + | + | + | + | | + | 3, 4, 5, 10, 12, 15, 19, 21, 22, 28, 31, 33, 36, 37, 38, 39, 42, 44, 45, 46, 47, 49 |
| Security of Supply | 7 | | + | + | + | + | + | 10, 12, 33, 37, 40, 42, 46 |
| Transparency and Accuracy | 6 | | + | + | + | | | 4, 5, 8, 21, 33, 36 |
| Privacy | 24 | – | – | – | – | | | 2, 3, 4, 5, 7, 9, 11, 12, 13, 14, 15, 16, 21, 24, 26, 27, 29, 30, 32, 34, 36, 39, 48, 49 |
| Security | 15 | – | – | – | | | | 2, 3, 4, 5, 12, 14, 16, 24, 29, 34, 35, 37, 39, 48, 49 |
| (Mis)Trust | 14 | – | – | – | – | | | 2, 3, 4, 9, 11, 15, 18, 20, 23, 25, 30, 32, 41, 48 |
| Health | 5 | | – | | | | | 21, 24, 32, 37, 39 |
| Distributive and Procedural Justice | 5 | | – | – | – | | | 2, 9, 21, 22, 25 |
| Control and Autonomy | 14 | – | – | +/– | +/– | | | 2, 6, 9, 12, 16, 17, 20, 21, 27, 31, 33, 35, 43, 47 |
| Inclusiveness | 7 | | – | +/– | | | | 2, 3, 4, 5, 9, 12, 35 |
| Quality of Life | 7 | | | + | – | | | 1, 3, 4, 5, 31, 36, 47 |
| Reliability | 5 | | | +/– | | | | 2, 3, 5, 8, 12 |
| Affordability of Energy | 4 | | +/– | +/– | – | | | 4, 6, 39, 45 |

* see ID in Appendix

+: Driver; –: Barrier; +/–: mentioned both as driver and barrier depending on study (refer to text for details)

DSM: Demand-side management; EV: Electric vehicle

3

3

## 4.1 Moral values that act as drivers of smart grid acceptance

The most often cited positive driving force (22 publications (Balta-Ozkan et al., 2014a, 2014b, 2013a; Buryk et al., 2015; Cherry et al., 2017; Dedrick et al., 2015; Ghazal et al., 2015; Guerreiro et al., 2015; Hall et al., 2016; Li et al., 2017; Mesarić et al., 2017; Moser, 2017; Paetz et al., 2011; Park et al., 2014, 2017; Raimi and Carrico, 2016; Schmalfuß et al., 2015; Shrouf and Miragliotta, 2015; Spence et al., 2015; Will and Schuller, 2016; Wilson et al., 2017; Zhou and Brown, 2017)) for the acceptance of various smart grid technologies was their contribution to the environmental sustainability of energy systems. Environmental sustainability refers to the reduction of emissions from the electricity sector, thereby contributing to climate change goals (Balta-Ozkan et al., 2013b; Buryk et al., 2015). Smart grid technologies contribute to environmental sustainability by facilitating the integration of renewable energy sources and electric vehicles (Dedrick et al., 2015; Schmalfuß et al., 2015; Will and Schuller, 2016).

Another key factor positively related to the acceptance of smart grid technologies was the security of electricity supply (seven publications (Buryk et al., 2015; Cherry et al., 2017; Moser, 2017; Park et al., 2014; Römer et al., 2015; Schmalfuß et al., 2015; Will and Schuller, 2016)). "Security of supply" in the context of electricity systems is defined as a low risk of interruptions in the supply (Römer et al., 2015). Given that the electricity system is vital for the functioning of modern societies, a high security of supply is one of the central values in any debate on changing energy systems. Smart meters were perceived to enhance the security of supply, because they allow detection and reduction of power outages faster than conventional meters (Park et al., 2014). Household electricity storage systems allow reducing the risk of supply interruptions because they can serve as a buffer for excess energy and allow decoupling electricity generation from consumption (Römer et al., 2015). Smart charging systems allow shifting the charging time of electric vehicles and thereby can help to avoid grid overload problems (Schmalfuß et al., 2015; Will and Schuller, 2016).

In the context of smart metering, smart home, and demand-side management, transparency and accuracy were found to be further values motivating the acceptance of such technologies (six publications (Balta-Ozkan et al., 2014a, 2014b; Berry et al., 2017; Guerreiro et al., 2015; Moser, 2017; Paetz et al., 2011)). Greater accuracy and a better overview of energy consumption data as well as transparency in the impact of consumption patterns on cost and the environment, which are enabled through smart meters and in-home displays, contributed positively to the acceptance these technologies (Guerreiro et al., 2015; Paetz et al., 2011).

### 4.2 Moral values that form barriers for smart grid acceptance

Privacy was by far the most prevalent moral value reported as a perceived barrier, mentioned in 24 publications (Balta-Ozkan et al., 2014b, 2014a, 2013a, 2013b; Begier, 2014; Buchanan et al., 2016; Chen et al., 2017; Cherry et al., 2017; Chou et al., 2015; Chou and Yutami, 2014; Dedrick et al., 2015; Ehrenhard et al., 2014; Guerreiro et al., 2015; Hess and Coley, 2014; King and Jessen, 2014; Krishnamurti et al., 2012; Luthra et al., 2014; Matschoss et al., 2015; Michaels and Parag, 2016; Muench et al., 2014; Paetz et al., 2011; Raimi and Carrico, 2016; Yang et al., 2017; Zhou and Brown, 2017). Concerns about privacy are related to the increased collection and transmission of information on energy consumption compared to traditional meters (Muench et al., 2014). Triggered by the possibility to share end-users' energy consumption data automatically and in real time with grid operators and store these data in central databases, consumers are concerned that energy companies could use these data to get insight into activities in a household that are considered as private (Ehrenhard et al., 2014; Guerreiro et al., 2015). Explicitly mentioned was the fear that smart grid technologies could allow identification of the type and time of use of household appliances (Hess and Coley, 2014). In addition, consumers were concerned that their personal data could be sold commercially (Michaels and Parag, 2016). One study also reported the perceived danger in the effect of combining different pieces of data to reveal more information or patterns about consumer behavior that could be extracted from single pieces (Balta-Ozkan et al., 2013b).

Concerns about data and cyber security were the second most often reported barrier to smart grid, smart metering, and smart home acceptance (15 publications (Balta-Ozkan et al., 2014a, 2014b, 2013b, 2013a; Cherry et al., 2017; Chou et al., 2015; Ehrenhard et al., 2014; Hess and Coley, 2014; Luthra et al., 2014; Muench et al., 2014; Ornetzeder et al., 2009; Park et al., 2014; Raimi and Carrico, 2016; Yang et al., 2017; Zhou and Brown, 2017)). Security refers to the existence of mechanisms that ensure that personal data is protected from outside, malicious attacks (Muench et al., 2014; Park et al., 2014). The increased collection and transmission of more energy consumption data than with "dumb" systems are at the core of security concerns. Consumers are concerned that their consumption data, which is transmitted to e.g., grid operators, might fall into the wrong hands due to cyberattacks. They stress the importance of ensuring that personal data is adequately protected and encrypted (Balta-Ozkan et al., 2013a; Chou et al., 2015; Luthra et al., 2014). In addition, and specifically connected to smart home platforms, consumers uttered the fear that outsiders could get more easy access to their private spaces/homes (Ehrenhard et al., 2014).

Trust, or rather the lack of trust by consumers in organizations charged with the implementation and management of smart grid technologies (e.g., electric utilities, governmental authorities), was reported as one of the key barrier values for smart grid acceptance (14 publications (Balta-Ozkan et al., 2014a, 2013a, 2013b; Buchanan et al., 2016; Chen et al., 2017; Dedrick et al., 2015; Gerpott and Paukert, 2013; Goulden et al., 2014; Hammer et al., 2015; Kahma and Matschoss, 2017; Matschoss et al., 2015; Michaels and Parag, 2016; Sandström and Keijer, 2010; Yang et al., 2017)). While trust was mainly relevant in consumer acceptance studies, one study from the perspective of US utilities revealed that utilities were aware of the problematic (mis)trust by consumers towards their companies (Dedrick et al., 2015). Consumers' lack of trust is reflected in concerns that the utilities industry and the government (a) are not open about their benefits and (b) will not pass any financial savings on to customers. Consumers also found it difficult to understand why utilities would promote energy-saving messages while they are perceived to increase profits with an increased energy consumption (Balta-Ozkan et al., 2014a; Goulden et al., 2014; Michaels and Parag, 2016). Additionally, concerns were related to the degree of trust that the personal data shared through smart meters with energy companies is protected (Gerpott and Paukert, 2013; Matschoss et al., 2015).

In the context of smart metering, consumers perceived health risks were found to be negatively connected to the acceptance and use of smart meters (five publications (Guerreiro et al., 2015; Hess and Coley, 2014; Michaels and Parag, 2016; Park et al., 2014; Raimi and Carrico, 2016)). Perceived health risks refer to the subjective evaluation of potential health threats resulting from an event or an activity (Guerreiro et al., 2015). Health risks were connected with exposure to electromagnetic radiation from smart meters (Hess and Coley, 2014; Michaels and Parag, 2016; Park et al., 2014). Whether or not radiation poses objective threats to consumers' health, the fact that smart meters are perceived as health risks in studies on consumer acceptance indicates that such concerns should be taken seriously by utilities and governmental authorities when introducing smart metering.

Concerns about the fairness of smart metering and demand-side management reflected the values of distributive and procedural justice as a barrier for smart grid acceptance from the perspective of energy consumers (five publications (Balta-Ozkan et al., 2013b; Buchanan et al., 2016; Guerreiro et al., 2015; Hall et al., 2016; Kahma and Matschoss, 2017)). Distributive justice refers to a fair distribution of costs and benefits among the key stakeholders involved in these technologies (Buchanan et al., 2016; Guerreiro et al., 2015; Hall et al., 2016). Consumers feared that they will have to bear the costs for the introduction of smart metering without receiving apparent benefits while energy providers would profit from financial savings (Hall et al., 2016).

In addition, there was a perception that the responsibility for saving energy would be pushed on consumers while supplier obligations to ensure low consumer prices would be neglected (Buchanan et al., 2016). Procedural justice refers to fairness in decision making processes, often based on the fact that all relevant stakeholders are able to participate in the process. Although this concern was less prevalent than distributive justice, it yielded interesting results in a study by Guerreiro et al. (2015). The authors were interested in the use of smart meters combined with an in-home display and found that increased perceptions of procedural justice let to decreased use in the devices. It might be that respondents who perceived the process of introduction as being fair felt a lower need to control the equipment.



### 4.3 Moral values with ambiguous effects on smart grid acceptance

Control or autonomy—defined in this context as the perception that one can direct events in life free of outside influence (Fell et al., 2015)—was related to consumers concerns about loss of control and autonomy with the introduction of smart metering and the installation of smart home platforms. They feared losing control to ICT systems and perceived the monitoring of daily behavior as too intrusive and restrictive (Balta-Ozkan et al., 2013a; Ehrenhard et al., 2014). Concerns were also directed to a fear of loss of control towards energy suppliers, who might manage their energy consumption for them (Buchanan et al., 2016; Guerreiro et al., 2015). While control was mostly perceived as a barrier (12 publications (Balta-Ozkan et al., 2013a; Barnicoat and Danson, 2015; Buchanan et al., 2016; Cherry et al., 2017; Ehrenhard et al., 2014; Goulden et al., 2014; Guerreiro et al., 2015; Krishnamurti et al., 2012; Moser, 2017; Ornetzeder et al., 2009; Schweitzer and Van den Ende, 2016; Wilson et al., 2017)), a later study reported a positive effect of control on the acceptance of an automated demand-side response tariff (Fell et al., 2015). This suggests that concerns about the loss of control play a more ambivalent role than previously assumed. The authors explain the effect with two reasons. Firstly, the tariff's impact was clearly defined (e.g., the room temperature was only allowed to shift by 1°C). Secondly, the option of overriding the automation was presented, which might have restored perceptions of self-control (Buchanan et al., 2016; Fell et al., 2015).

Inclusiveness was both seen as a barrier and a driver for smart grid acceptance. Inclusiveness refers to giving all different societal groups the possibility to be included in the technological development. On the one hand, six studies revealed that consumers were concerned that elderly people, disabled people, and people with less affinity to computers and IT systems would be systematically excluded from the smart grid development (Balta-Ozkan et al., 2014b, 2013b, 2013a; Buchanan et al., 2016; Cherry et al., 2017; Ornetzeder et al., 2009). In another study, however, consumers expressed positive views about the benefits, the support, and the additional services that smart homes could offer in assisted living for the elderly and people with disabilities (Balta-Ozkan et al., 2014a).

Increased quality of life was seen as a driver for smart home technologies in six publications (Balta-Ozkan et al., 2014a, 2014b, 2013b; Mesarić et al., 2017; Paetz et al., 2011; Wilson et al., 2017). Smart home services such as health monitoring or a remote control of security are perceived as practical and automation is seen as enhancing convenience and comfort (Balta-Ozkan et al., 2014a; Wilson et al., 2017). However, it was reported as a barrier in one study, in which building occupants were concerned with reductions in their living quality as a consequence of demand-side management (Aduda et al., 2016). When building equipment such as ventilation fans or cooling systems have communication and control capabilities to steer the energy demand of the building automatically, the effects on the perceived thermal comfort of building occupants was reported as a major concern and barrier for the implementation of such a DSM measure (Aduda et al., 2016).

The reliability of novel smart home technologies was questioned and reported as barrier by consumers in four publications (Balta-Ozkan et al., 2014b, 2013a, 2013b; Cherry et al., 2017). The adoption of non-mainstream technology was seen as risky with respect to the malfunctioning of the system, such as a break-down of communication systems or room sensors being triggered unintentionally (Balta-Ozkan et al., 2014b, 2013b). Consumers felt unease at becoming reliant on computer systems they might not fully understand. In addition, concerns were reported that innovations, once adopted, would not widely spread or become rapidly obsolete due to fast technological progress. This was especially seen problematic when smart home technologies were seen as a costly and long-term investment (Cherry et al., 2017). However, one publication found that in-home displays have the ability to enhance the reliability of an entire home energy management system because such displays support in discovering system failures or underperformance (Berry et al., 2017).

Future affordability of energy was found to be both a driver and a barrier for the acceptance of smart metering, smart home platforms, and demand-side management. Affordability is the availability of financial means to be able to pay for energy. In two studies (Barnicoat and Danson, 2015; Raimi and Carrico, 2016), the potential of smart meters and smart home platforms to save energy and prevent energy poverty were seen as reasons to accept these technologies. In two different studies (Balta-Ozkan et al., 2014a; Spence et al., 2015), however, consumers were concerned about hidden costs and were generally skeptical whether smart grid technologies will indeed reduce their energy bills.

## 5 Discussion

Our literature review on the role of moral values for the acceptance of smart grid technologies showed that values are indeed discussed in the literature on smart grid acceptance and adoption. However, their relationship with acceptance is not always clear. Whereas certain values are always seen as either drivers or barriers, others could be seen as having an ambiguous effect on acceptance. We turn to a more detailed discussion of our findings.

### 5.1 Values as factors for consumer and citizen acceptance



In general, our results show that moral values can act as important factors for consumer and citizen acceptance of smart grid technologies. The fact that all the values we found have emerged from inductive, qualitative studies indicates that consumers expressed values in an unprompted way as both drivers for smart grid development and concerns around these technologies. Thus, values were not a priori introduced into these studies by researchers but were expressed by consumers independently. In addition, quantitative studies confirmed for almost all reported values that they influence consumer or citizen acceptance. Distributive justice, inclusiveness, quality of life, and transparency were the exceptions which were only reported in qualitative studies.

However, our results also show that there are two aspects of values which pose additional complexities to their investigation as factors for acceptance. First, some values were found to have an ambiguous effect on acceptance. More specifically, whereas some values were clearly positive forces driving smart grid development (e.g., environmental sustainability) and some were clearly consumer concerns around the technology (e.g., privacy, justice), some were mentioned both as drivers and barriers. For example, studies mentioned the potential of smart grid technologies to save energy and thus save costs as perceived benefits with regards to energy affordability (Barnicoat and Danson, 2015; Raimi and Carrico, 2016). However, consumers were also concerned that they will have to bear the costs for the introduction of smart grid technologies through higher electricity bills. Another example is inclusiveness; whereas there are concerns that several societal groups (e.g., the elderly, disabled) would be systematically excluded because of the focus on novel ICT (Buchanan et al., 2016), benefits that smart homes in particular could offer in assisted living for the elderly and disabled are expressed (Balta-Ozkan et al., 2014a). Additionally, the value of control was mostly perceived as a barrier due to a perceived loss of consumers' control to electronic devices or energy suppliers. Automated demand-response tariffs were particularly in focus of this concern. However, once the impact of such a tariff was clearly defined, the degree of external control through the tariff was very small, and consumers had the option to override the automation, the perceived loss of control was no longer a problem (Fell et al., 2015).

These examples illustrate the importance of the detailed technological and regulatory context for the effect direction on acceptance. In the example of control, the way an automated demand-response tariff was structured with respect to definition of boundaries of the automation or overriding possibilities was decisive whether control was seen as a barrier or not. The debate to what extent smart metering impacts energy affordability depends on the regulation of electricity prices: if smart meters enable consumers to save costs by using less energy, these savings might be offset because costs for the smart metering infrastructure are socialized, i.e., paid by consumers through the network tariffs on electricity bills.



The examples also illustrate that whether certain values have a positive or negative impact on smart grid acceptance depends on their interpretation by consumers. Values can therefore be characterized as "contestable concepts," having two levels of meaning (Jacobs, 1999). The first level is expressed in a short definition; for example, energy affordability is generally defined as having the financial means to be able to pay for energy. The second level of meaning refers to the value's conception. Here, contestation occurs over how the concept should be interpreted and whether a technology contributes to the value or endangers it (Jacobs, 1999). It is thus important to understand values at the level of conception, since this is the level where controversies arise and the way values impact technology acceptance might depend on their conception (Dignum et al., 2016). In the example of affordability, the debate is not about the definition or importance of affordability, the debate is whether certain features of smart grid technologies are perceived to contribute to energy affordability while others do not. As a consequence, future research should carefully consider different potential conceptions of values when testing their effect on acceptance.

Second, certain values are closely interrelated, increasing the complexity in deriving their separate effects on smart grid acceptance. Probably the most prevalent relationship could be observed between data privacy and security. Both concerns are related to the increased transmission and storing of personal data. They are frequently mentioned in context with each other (Balta-Ozkan et al., 2014a; Ehrenhard et al., 2014; Guerreiro et al., 2015; Muench et al., 2014) or even measured as one construct (e.g., Chou et al., 2015; Chou and Yutami, 2014). However, they are different concepts. Privacy refers to the concern that individuals' personal data can be used externally to infer information about activities that are considered as private (McKenna et al., 2012). Security concerns on the other hand are defined in terms of the risk that personal data is subject to malicious external attacks, e.g., through hacking (Muench et al., 2014). Their conceptual differentiation means on the one hand that different measures need to be taken by policymakers and industry actors responsible for smart grid introduction to protect consumers' privacy and data security. On the other hand, their conceptual differentiation could imply different effects on consumer acceptance. They should therefore be treated as separate concepts in academic studies on smart grid acceptance.

Distributive justice is connected to affordability concerns. Consumers were concerned that they will have to bear the costs for e.g., the smart meter introduction, whereas energy providers would profit from financial savings (Hall et al., 2016). Consumers perceived an unfairness that smart grid technologies might lead to higher energy costs and a lower affordability of energy (Guerreiro et al., 2015). As a consequence, concerns about fairness and affordability might reinforce each other in their negative effect on smart grid acceptance.



In addition, several values were connected with the perceived trust of consumers in energy companies and government authorities. Concerns about distributive justice were connected with the lack of trust that energy companies are not open about their benefits and would not pass on financial savings to consumers (Balta-Ozkan et al., 2014a; Hall et al., 2016). Also, trust was related to privacy and security concerns: Perceived consumer trust about the protection of personal data (Gerpott and Paukert, 2013). This points to the central importance of trust between consumers and authorities or organizations charged with the implementation and management of smart grid technologies as potential antecedent for several other values; a relationship that is worth considering in smart grid acceptance studies. Trust is also suggested as antecedent for consumer beliefs by Huijts et al. (2012) in their conceptual development of a framework for acceptance of energy technologies. Trust is suggested as influencing positive and negative affect, perceived costs, risks and benefits, and also procedural justice.

## 5.2 Combining insights from ethics with technology acceptance literature

In contrast to our results, current theoretical frameworks for technology acceptance and adoption do not seem to pay attention to moral values as factors for acceptance (see Section 2.2). Frameworks for technology acceptance and adoption in technology and innovation management fields focus on market-, firm-, and technology-specific characteristics (Schilling, 1998; Suarez, 2004; Van de Kaa et al., 2011). In social psychology, technology acceptance models focus on factors pertaining to technology beliefs, social influences, and personality beliefs (Stern, 2000; Venkatesh et al., 2012).

Therefore, we propose that moral values should be included more systematically in studies on the acceptance or adoption of smart grid technologies, and potentially technology acceptance in general. Scientific understanding of the role of values for technology acceptance can be gained by combining insights from ethics of technology with literature on technology acceptance.



Ethics of technology and particularly VSD approaches can be beneficial for the identification and conceptualizations of relevant values for a particular technological context. In their tripartite approach, VSD scholars place great emphasis on identifying relevant values. They do this both from an ethical normative perspective and a descriptive perspective relying on the opinions of key stakeholders involved with a technology (Flanagan et al., 2008; Friedman et al., 2013). In addition, they acknowledge that values can be interpreted and prioritized differently by different stakeholder groups and therefore integrate considerations around conceptions of values explicitly in their empirical approaches (Davis and Nathan, 2015; Dignum et al., 2016). Their in-depth understanding of different conceptualization of values can contribute to the two complexities about the relationships between values and social acceptance we encountered in our results, namely that these relationships hinge on detailed interpretations of values and that there are mutual interdependencies between different values. Methods of elicitation of technology specific values from VSD can be used by researchers studying smart grid acceptance. This includes what VSD researchers call conceptual investigations, philosophically informed considerations of how stakeholders might be affected by the technology. It also includes empirical investigations, in which VSD scholars use the entire range of qualitative and quantitative empirical methods to answer questions such as how stakeholders interpret different values for the given technological context or which values are prioritized by different stakeholder groups affected by the technology (Friedman et al., 2002).

Ethicists and VSD scholars focus on the understanding of values and possibilities to integrate them into technological design. However, their research aims do not include testing whether a design for values increases the acceptance and adoption of technologies. Their approach seems to underlie the implicit proposition that a proper integration of values that are judged as important for the context of a specific technology will contribute to enhancing acceptance in society (Manders-Huits, 2011).

The literature on technology acceptance is complementary to that because it does study the impact of a diverse range of factors on technology acceptance and adoption. Thus, it provides not only rigorous quantitative methods to test relationships but also measurement scales for values and acceptance in surveys or experiments (Huijts et al., 2012; Steg et al., 2005; Venkatesh et al., 2012).

More specifically, our results indicate that adaptations of technology acceptance models from social psychology might be suitable to include moral values (see Section 2.2.2. for a review). Half of the publications in our systematic literature review including values as factors and using deductive theory testing approaches investigate smart grid acceptance based on models used in social psychology (e.g., Chou et al., 2015; Fell et al., 2015; Gerpott and Paukert, 2013; Guerreiro et al., 2015; Römer et al., 2015). Although they only include a sub-set of relevant values in their models, these studies provide first indications how to integrate values in acceptance models and which other model variables values might be related to.



Most of these scholars study values as direct antecedents of intentions to use or use of smart grid technologies. For example, Fell et al. (2015) find that control over comfort and timing of activities are related to intentions to adopt a demand-side management scheme and Römer et al. (2015) relate security of supply concerns to purchase intentions of household storage systems.

A number of studies show effects of values on several different variables in technology acceptance models, particularly perceived risk and perceived usefulness or ease of use, concepts that are used in both UTAUT and TAM. Chou et al. (2015) find that concerns on data privacy and security impact perceived risk. In a similar vein, Guerreiro et al. (2015) stress the connection between health concerns and perceived risk. Park et al. (2014) find that perceived security of supply and environmental sustainability impact perceived usefulness, and perceived security and health concerns affect perceived risk. Perceived usefulness and risk impact in turn impacts intentions to use smart grid technologies.

The indication from our results that technology acceptance models from social psychology might be suitable to include moral values is in line with a proposed framework for public acceptance of sustainable energy technologies such as wind mills or hydrogen vehicles by Huijts et al. (2012). The authors stress the importance of procedural and distributive justice measured as perceived fairness of the decision process leading up to the technology's introduction as well as the perceived fair distribution of costs and benefits, affecting attitudes toward the technologies. Additionally, they hypothesize that the degree of trust in actors that are responsible for the technology is seen as influencing positive and negative affect, perceived costs, risks and benefits, which in turn affect attitudes toward the technologies. Positive attitudes toward technologies are then related to intentions to accept and technology acceptance.

## 6 Conclusions

Smart grid technologies are seen as an important enabler in the transition to more sustainable energy systems, but the development has been challenged among others by societal concerns (Muench et al., 2014; Raimi and Carrico, 2016). In this chapter, we showed that societal concerns about smart grid technologies reflect moral values, which are (perceived) technology characteristics about ethical and social consequences of technologies such as justice, trust, or privacy. We proposed that concerns related to moral values might hinder the wider acceptance and adoption of smart grid technologies. The paper set out to address the questions which moral values are relevant for smart grid technologies and how they influence smart grid acceptance.



Our results show that moral values can act as drivers and barriers for consumer and citizen acceptance of smart grid technologies. On the one hand, values such as environmental sustainability and security of supply positively influence smart grid acceptance. On the other hand, concerns about privacy, security, or health negatively impact their acceptance. In addition, several values were mentioned both as driving factors for smart grid acceptance and as concerns (e.g., affordability, inclusiveness). Studying the impact of values on acceptance is not only made complex by these ambiguous interpretations, but also by instrumental relationships between certain values such as affordability and distributive justice. It is thus important to consider the detailed technological and regulatory context, the nature of values as contestable concepts, and interdependencies between them.

Based on our results, we propose that future research should strive for a better understanding of the role of moral values as factors for smart grid acceptance in order to contribute to embedding values in smart grid design. This can be done by bridging literature from ethics of technology with technology acceptance. Ethicists study in depth which values are implied in certain technologies. In their focus on a normative perspective, however, they do not relate values to the empirical acceptance of technologies (Manders-Huits, 2011). Technology acceptance studies provide a complementary perspective because they test the impact of a wide range of factors on acceptance, yet typically without considering values as factors (Schilling, 2002; Stern, 2000; Suarez, 2004; Venkatesh et al., 2012). The results of our systematic literature review show that especially acceptance models widely used in social psychology such as TAM, TPB, or UTAUT offer a good foundation to study the effect of values as perceived technology characteristics on smart grid acceptance.

## *Appendix. Overview of articles considering values for smart grid acceptance*

**Table 3-4: Overview of articles considering values for smart grid acceptance**

| ID | Authors | Year | Journal | Citations* | Main Contribution | Method | Technology |
|---|---|---|---|---|---|---|---|
| 1 | Aduda et al. | 2016 | Sustainable Cities and Society | 18 | Investigate effect of demand-side management on building performance indicators | Field study with follow-up survey | DSM |
| 2 | Balta-Ozkan et al. | 2013 | Energy Policy | 88 | Explore key barriers to smart home adoption in the UK | Expert interviews, deliberative public workshops | Smart Home |
| 3 | Balta-Ozkan et al. | 2013 | Energy | 28 | Explore key barriers to smart home adoption in the UK | Expert interviews, deliberative public workshops | Smart Home |
| 4 | Balta-Ozkan et al. | 2014 | Technology Analysis and Strategic Management | 11 | Explore technical and economic drivers and barriers to smart home market development in three European countries (UK, DE, IT) | Deliberative public workshops | Smart Home |
| 5 | Balta-Ozkan et al. | 2014 | Energy Research & Social Science | 22 | Explore drivers and barriers to smart home market development in three European countries (UK, DE, IT) | Deliberative public workshops | Smart Home |
| 6 | Barnicoat & Danson | 2015 | Energy Research & Social Science | 17 | Explore how older tenants in rural Scotland interact with technology | In-depth interviews | Smart Home |
| 7 | Begier | 2014 | Journal of Information, Communication and Ethics in Society | 0 | Explore strategies to build relationships with energy consumers during exchange of energy meters | Focus groups, survey | Smart Metering |
| 8 | Berry et al. | 2017 | Energy Efficiency | 0 | Explore residential consumers' attitudes towards and experiences with an in-home display and energy management system | In-depth interviews | Smart Home |

| ID | Authors | Year | Journal | Citations* | Main Contribution | Method | Technology |
|---|---|---|---|---|---|---|---|
| 9 | Buchanan et al. | 2016 | Energy Policy | 6 | Explore opportunities and threats of smart metering initiatives | Focus groups | Smart Metering/Smart Services |
| 10 | Buryk et al. | 2015 | Energy Policy | 11 | Investigate impact of disclosing environmental benefits on DSM adoption | Choice experiment | DSM |
| 11 | Chen et al. | 2017 | Energy Research & Social Science | 8 | Investigate social-psychological factors affecting smart meter support and adoption intention | Survey | Smart Metering |
| 12 | Cherry et al. | 2017 | Energy Research & Social Science | 6 | Explore experts' and public's visions of smart homes | Semi-structured interviews | Smart Home |
| 13 | Chou & Yutami | 2014 | Applied Energy | 16 | Investigate antecedents of willingness to adopt smart meter | Survey | Smart Metering |
| 14 | Chou et al. | 2015 | Renewable and Sustainable Energy Reviews | 6 | Investigate antecedents of willingness to adopt smart meter | Survey | Smart Metering |
| 15 | Dedrick et al. | 2015 | Electronic Markets | 3 | Examine factors influencing smart grid adoption among US utilities | Semi-structured interviews | Smart Grid |
| 16 | Ehrenhard et al. | 2014 | Technological Forecasting and Social Change | 19 | Explore acceptance of smart home among the elderly | In-depth interviews | Smart Home |
| 17 | Fell et al. | 2015 | Energy Research & Social Science | 18 | Investigate factors for acceptance of different demand-side response tariffs | Experiment | DSM |
| 18 | Gerpott & Paukert | 2013 | Energy Policy | 27 | Investigate factors for willingness-to-pay for smart meters | Survey | Smart Metering |
| 19 | Ghazal et al. | 2015 | Renewable and Sustainable Energy Reviews | 3 | Investigate factors for consumer acceptance of a smart plug system | Survey | Smart Home |
| 20 | Goulden et al. | 2014 | Energy Research & Social Science | 90 | Explore perceptions of centralized and decentralized smart grid platforms | Focus groups | Smart Grid |
| 21 | Guerreiro et al. | 2015 | Energy Efficiency | 3 | Understand socio-psychological and technological aspects | Survey, discourse analysis | Smart Metering |

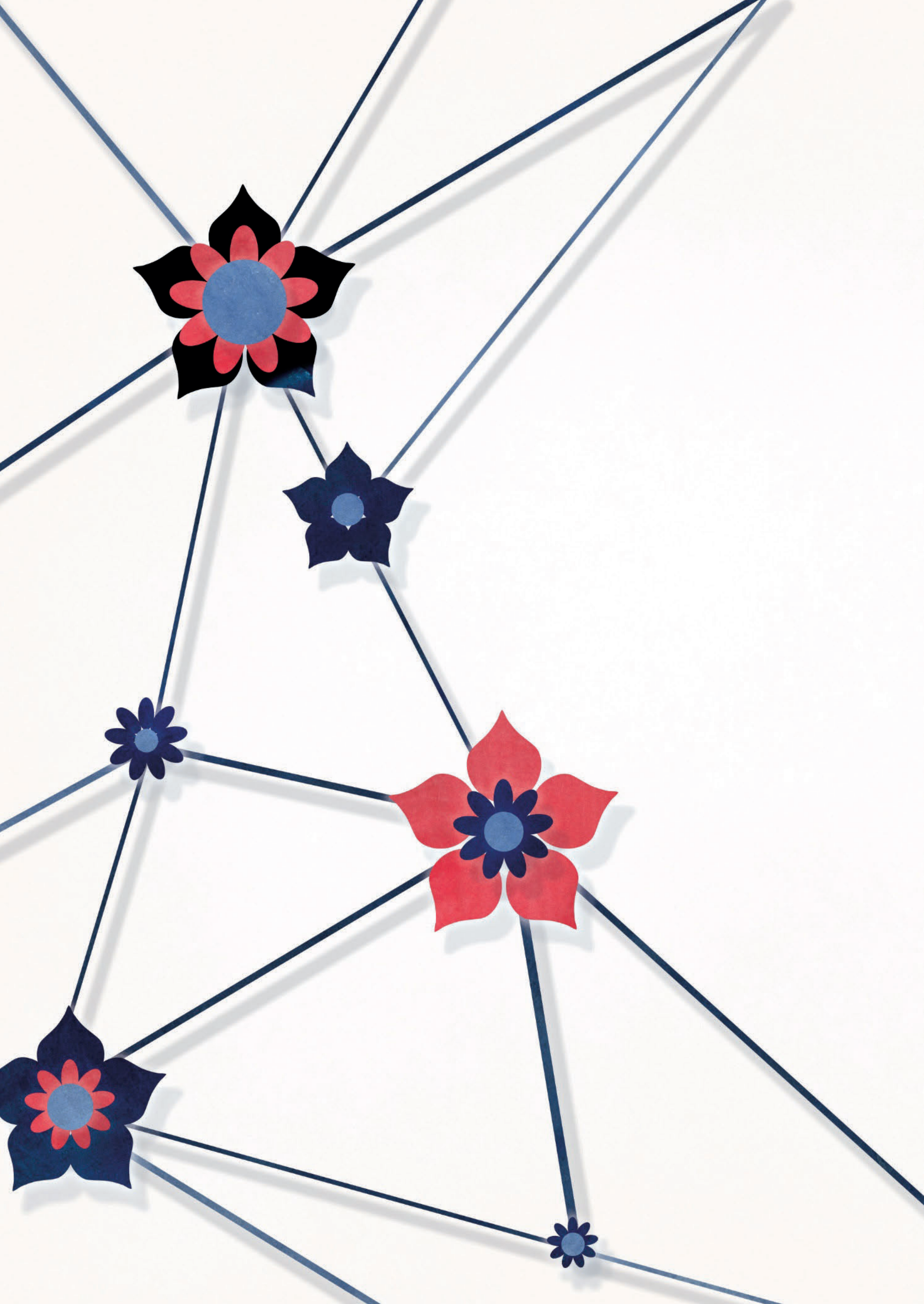
| ID | Authors | Year | Journal | Citations* | Main Contribution | Method | Technology |
|---|---|---|---|---|---|---|---|
| | | | | | that influence use of smart meters | | |
| 22 | Hall et al. | 2016 | Energy Policy | 6 | Explore consumer interest and responses to the concept of cost-reflective pricing | Focus groups | DSM |
| 23 | Hammer et al. | 2015 | User Modelling and User-Adapted Interaction | 5 | Build user-trust model for decision making on energy management systems in office buildings | Survey experiment, (Living Lab) model | Energy management systems |
| 24 | Hess & Coley | 2014 | Public Understanding of Science | 16 | Explore complaints in the public debate on wireless smart meters in California | Discourse analysis | Smart Metering |
| 25 | Kahma & Matschoss | 2017 | Energy Research & Social Science | 4 | Investigate the non-adoption of smart energy services through focus on non-users | Survey | Smart Home |
| 26 | King & Jessen | 2014 | International Journal of Law and Information Technology | 5 | Explores the key privacy and data protection concerns for both the EU and USA consumers related to data sharing in smart metering systems | Secondary data analysis (of legal regimes) | Smart Metering |
| 27 | Krishnamurti et al. | 2012 | Energy Policy | 93 | Explore consumer beliefs about smart meters in the US | In-depth interviews, survey | Smart Metering |
| 28 | Li et al. | 2017 | Applied Energy | 1 | Investigate user perception of smart grids and energy flexible buildings to identify suitable user groups | Survey | Smart Grid |
| 29 | Luthra et al. | 2014 | Renewable and Sustainable Energy Reviews | 61 | Explore barriers to smart grid adoption | Expert interviews | Smart Grid |
| 30 | Matschoss et al. | 2015 | Energy Efficiency | 4 | Identify pioneering customers for novel energy efficiency services enabled by smart grid technologies | Survey | DSM |
| 31 | Mesarić et al. | 2017 | Sustainability | 2 | Explore the influence of users' energy-related | Focus groups | DSM |

3

| ID | Authors | Year | Journal | Citations* | Main Contribution | Method | Technology |
|---|---|---|---|---|---|---|---|
| | | | | | behavior on smart grid processes | | |
| 32 | Michaels & Parag | 2016 | Energy Research & Social Science | 7 | Investigated perceptions of demand reduction, load shifting, and energy storage as prosumer activities in Israel | Survey | DSM |
| 33 | Moser | 2017 | Energy Efficiency | 1 | Investigate factors for social acceptance of load-shifting programs for smart appliances | Experiment | DSM |
| 34 | Muench et al. | 2014 | Energy Policy | 21 | Explore barriers to smart grid implementation | Expert interviews | Smart Grid |
| 35 | Ornetzeder et al. | 2009 | WIT Transactions on Ecology and the Environment | 1 | Explore public's opinion on future sustainable energy technology research | Participatory technology assessment workshop | Smart Metering Smart Home |
| 36 | Paetz et al. | 2012 | Journal of Consumer Policy | 85 | Explore behavioral aspects, motives, and barriers for smart home acceptance | Focus groups | Smart Home |
| 37 | Park et al. | 2014 | Energy Policy | 19 | Tested factors for consumer acceptance of smart meters | Survey | Smart Metering |
| 38 | Park et al. | 2017 | Sustainability | 0 | Investigate consumer acceptance of a home energy management system | Survey | Smart Home |
| 39 | Raimi & Carrico | 2016 | Energy Research & Social Science | 4 | Examine the American lay public's level of knowledge about smart meters | Survey | Smart Metering |
| 40 | Römer et al. | 2015 | Electronic Markets | 4 | Investigate factors for household acceptance of electricity storage systems | Survey | Household Storage |
| 41 | Sandström & Keijer | 2010 | OPEN HOUSE INTERNATIONAL | 0 | Explore attitudes and acceptance of residents towards smart homes | Survey | Smart Home |

| ID | Authors | Year | Journal | Citations* | Main Contribution | Method | Technology |
|---|---|---|---|---|---|---|---|
| 42 | Schmalfuß et al. | 2015 | Energy Research & Social Science | 3 | Investigate user experience with smart charging system | Field study with follow-up interviews | Smart Charging |
| 43 | Schweitzer et al. | 2016 | Psychology & Marketing | 2 | Investigate impact of perceived disempowerment on adoption intention of smart home applications | Experiment | Smart Home |
| 44 | Shrouf & Miragliotta | 2015 | Journal of Cleaner Production | 54 | Explore experts view on energy-efficient production management practices supported by the Internet of Things | Expert interviews | Smart Metering and appliances in factory production processes |
| 45 | Spence et al. | 2015 | Nature Climate Change | 14 | Investigate public perceptions of different demand-side management possibilities in the UK | Survey | DSM |
| 46 | Will & Schuller | 2016 | Transportation Research Part C: Emerging Technologies | 8 | Investigate factors for the acceptance of smart charging | Survey | Smart Charging |
| 47 | Wilson et al. | 2017 | Energy Policy | 12 | Identify perceived benefits and risks of smart home technologies | Survey | Smart Home |
| 48 | Yang et al. | 2017 | Industrial Management and Data Systems | 4 | Investigate customers' adoption intentions of smart home services | Survey | Smart Home |
| 49 | Zhou & Brown | 2017 | Journal of Cleaner Production | 10 | Compare factors for smart metering penetration rates across five European countries | Case study research (secondary data) | Smart Metering |

* Number of citations according to Scopus/Web of Science.



CHAPTER 4:

# ENERGY JUSTICE AND SMART GRID SYSTEMS: EVIDENCE FROM THE NETHERLANDS AND THE UNITED KINGDOM

This chapter has been published as:

Milchram, C., Hillerbrand, R., van de Kaa, G., Doorn, N., Künneke, R., 2018. Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom. Appl. Energy 229, 1244–1259. https://doi.org/10.1016/j.apenergy.2018.08.053

*The previous chapter identified distributive and procedural justice as two of the core values relevant for smart grid systems. Chapter 4 builds on these findings and aims to understand in greater detail potential justice implications of smart grids. It thereby extends existing energy justice conceptualizations to systems that represent a convergence between the energy and ICT sectors. It is, to the best of our knowledge, the first published paper that explicitly applies the three-dimensional framework of distributive, procedural, and recognition justice in this context. The chapter presents findings from a content analysis of the public debate about smart grid systems in the Netherlands and the United Kingdom between 2006 and 2017. In doing so, it focuses specifically on the reflection of distributive and procedural justice in instrumental and conflicting relationships with other values, for example privacy and data security.*

*The chapter starts with outlining the relevance of justice for smart grids and identifies a gap in the energy justice literature. Subsequently, Section 2 presents the theoretical background on smart grids, values in design, and energy justice. Section 3 details the content analysis methodology. Section 4 presents and discusses the findings of this analysis, comparing the Netherlands and the United Kingdom. Special attention is paid to how smart grids have the potential to effectively address justice issues in the energy transition, but how they might also reinforce distributive and procedural injustices, depending on the detailed technological and institutional design. Section 5 concludes with a context-specific conceptualization of justice and outlines the theoretical and practical contributions of the study.*

## 1 Introduction

Driven by policy objectives on climate change mitigation and advancements in communication technologies, electricity distribution networks are changing to become 'smarter' (Muench et al., 2014; Wissner, 2011). 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" (ETP Smart Grids, 2015). The definition reflects the European energy policy triad of environmental sustainability, economic efficiency, and the security of power supply (European Commission, 2018; Heffron et al., 2015). 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 (Pront-van Bommel, 2011). They also target demand reductions by visualizing energy use and connecting it with daily behavior like the use of household appliances (Vassileva et al., 2013). Smart grids are thus framed as key enablers in the transition to more sustainable energy 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 (Balta-Ozkan et al., 2014a; Goulden et al., 2014; Michaels and Parag, 2016). 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 (Cuijpers and Koops, 2013; Raimi and Carrico, 2016). Such concerns can form barriers for the acceptance and adoption of smart grids and have already proven challenging in smart grid pilot projects (Bager and Mundaca, 2017). 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” (Taebi and Kadak, 2010, 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 (Shrader-Frechette, 1997).[4]

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 (Miller et al., 2013; Sovacool et al., 2016). In the words of Sovacool & Dworkin (Sovacool and Dworkin, 2015, 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 (Forman, 2017), 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 chapter, 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 policymakers 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

[4] This conceptualization of ‘value’ 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 (Schwartz, 1994). ‘Values’ in philosophy and particularly ethics of technology are normative principles for system design (Shrader-Frechette, 1997).

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 (Cuijpers and Koops, 2013; Gangale et al., 2017; Zhou and Brown, 2017). 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 chapter 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 (Colak et al., 2015; Tuballa and Abundo, 2016). 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 (Bale et al., 2015; Hughes, 1983). 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 (Pront-van Bommel, 2011). Institutions are the legislation and regulations around smart grids; they form the (human-made) rules that govern their development and introduction (North, 1991). 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 (Goulden et al., 2014).

### 2.2 Considering values in the design of smart grid systems



This chapter 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 (Lilliestam and Hanger, 2016). In an extensive review of energy research, for example, Sovacool (2014) found a prevalence of economics, mathematics, physics, and engineering and an underrepresentation of the social sciences and humanities. Only 20% of the authors of 4,444 analyzed academic research papers were affiliated to a social sciences discipline.

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 (Muench et al., 2014). 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 (Cuppen et al., 2016). 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* (Pommeranz et al., 2012; Shrader-Frechette, 1997).

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 (Demski et al., 2015). 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 (Demski et al., 2015; Shrader-Frechette, 1997). 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 (Verein Deutscher Ingenieure, 2000). 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 (Van de Poel, 2009). 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 (Verein Deutscher Ingenieure, 2000).

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 (Verein Deutscher Ingenieure, 2000). 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) (Van de Poel and Royakkers, 2011). 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 (Künneke et al., 2015). 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 (Dignum et al., 2016). 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 (1971), referring to earlier work by Herbert Hart (1961). 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 (Dignum et al., 2016).

### 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 (Miller et al., 2013; Sovacool et al., 2016). 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" (Miller et al., 2013, 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) (Schlosberg, 2007; Walker, 2009). The scope has grown over time to include both local and global issues, with increased interest in climate change induced injustices (McCauley et al., 2013). In the 2000s, the World and the Global Energy Assessment recognized the importance of equity in context with energy provision and sustainable development (GEA, 2012; United Nations Development Programme, 2004, 2000). 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 (GEA, 2012; United Nations Development Programme, 2004).

Justice theories and principles, explicitly using the concept of energy justice, have recently been applied to energy policy (Heffron et al., 2015; McCauley et al., 2013), climate change and the transition to low-carbon energy systems (Healy and Barry, 2017), energy supply (Cowell et al., 2011; Heffron and McCauley, 2014; Wolsink, 2013), energy communities (Forman, 2017; Johnson and Hall, 2014), energy use (Hall, 2013), pollution from fossil fuel combustion and nuclear waste (Sovacool et al., 2016; Taebi and Kadak, 2010), and energy poverty (Bouzarovski and Simcock, 2017; Gillard et al., 2017). Details are briefly reviewed in the next paragraph[5].

Targeting energy policy, Heffron et al. (2015) developed a decision-making tool that relies on energy justice and expands the energy policy triad. Healy and Barry (2017) 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 (2014) 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 (2014) 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 (2013) analyzed how the energy justice field could benefit from literature on ethical consumption. Taebi and Kadak (2010) considered intergenerational equity in the assessment of alternative fuel cycles for nuclear power. Finally, Bouzarovski and Simcock (2017) 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 (Heffron and McCauley, 2014; McCauley et al., 2013; Schlosberg, 2007; Walker, 2009). These three dimensions are drawn from environmental justice, and are largely based on (a) theoretical work, for example, by Rawls (1971), Young (1990), and Fraser (1997), and (b) empirical insights on how justice is conceptualized within environmentalist movements in the USA (cf. Schlosberg, 2007).

Distributive justice is concerned with the distribution of benefits, burdens or costs, and responsibilities among stakeholders of an energy system (McCauley et al., 2013). Research has mostly focused on identifying and evaluating injustices, for example, in siting decisions of wind parks or unequal access to energy services (Jenkins et al., 2016). Energy poverty has been defined as a form of injustice that is particularly faced

---

[5] More detailed reviews of this emerging field can be found in Jenkins et al. (2016) and in Sovacool and Dworkin (2015).

by economically vulnerable consumer groups such as low-income families, the elderly, or the disabled (Gillard et al., 2017). 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 (Johnson and Hall, 2014).

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 (Walker, 2009). 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 policymakers and industry on the other (Jenkins et al., 2016; Miller et al., 2013).



Justice as recognition is concerned with the equitable appreciation of stakeholder groups involved in energy systems (McCauley et al., 2013). Processes of disrespect that "devalue some people and place identities in comparison to others" (Walker, 2009, 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 (McCauley et al., 2013). 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 (Batel et al., 2013). 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 (Hall et al., 2013; Oosterlaken, 2014). The NIMBY label has thus been criticized in academic literature as overly simplistic, outdated, and as disrespecting concerns voiced by local stakeholders (Devine-Wright, 2005; Hall et al., 2013; Oosterlaken, 2014; Wolsink, 2007).

### 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

(Hall et al., 2016) while also being burdened with the responsibility to save energy (Buchanan et al., 2016). 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 (Balta-Ozkan et al., 2014a; Buchanan et al., 2016). 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 (Cuppen et al., 2016; Demski et al., 2015). Qualitative content analysis, where text data is interpreted through a systematic process of coding to identify themes or patterns (Krippendorff, 2004), 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 (Krippendorff, 2004). 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 (Cuppen et al., 2016). 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) (Gangale et al., 2017). The legislative development for smart metering started at similar times and relatively early, in 2006 (NL) and 2007 (UK) (European Commission, 2020). 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 subsystems 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 (Wissner, 2011). 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 (Krippendorff, 2004). 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 (Friese, 2012). 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 (Friedman et al., 2013; Ligtvoet et al., 2015). 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.”) (Demski et al., 2015). 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 (Bowen, 2008). To address the limitation that qualitative content analysis relies on interpretative work by researchers, an inter-coder agreement check was performed (Krippendorff, 2004). 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 (Figure 4-1) 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 (European Union, 2006; Tweede Kamer der Staten-Generaal, 2006). 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

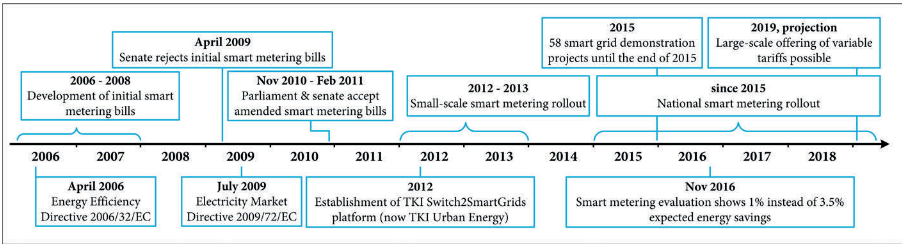



**Figure 4-1: Smart grid development in the Netherlands**

to DSOs. A pilot rollout from 2012 to 2013 was positively reviewed (Autoriteit Consument & Markt, 2013). The national rollout to private and small corporate consumers started in January 2015 (Energieleveranciers.nl, 2014; Ministerie van Economische Zaken, 2016). 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) (Gangale et al., 2017).

Our data collection resulted in a sample of 75 newspaper articles from January 2006 to June 2017 in ten national newspapers (Table 4-1). 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%).

**Table 4-1: Dutch newspapers**

| Newspaper type | Newspaper |
|---|---|
| Quality | NRC Handelsblad, NRC.Next, Trouw, Volkskrant, Het Financieele Dagblad |
| Popular | Algemeen Dagblad, De Telegraaf, Metro / Spits[6] |

## 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. Figure 4-2 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 (Xenias et al., 2015). 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 (Department of Trade and Industry, 2007), 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 (European Union, 2009, 2006; Sovacool et al., 2017b). From 2007 to 2010, a large-scale trial found that smart metering with in-home displays could lead to average energy savings of 3% (Ofgem, 2011). In 2008, the British government announced the 100% rollout of smart metering to all private and small corporate consumers until 2020 (Sovacool et al., 2017b; Warren, 2014). Smart meters were combined with an in-home display and the energy suppliers were made responsible for providing and paying for smart metering (Xenias et al., 2015). In 2012, the rollout was changed to be voluntary (Sovacool et al., 2017b). Smart Energy GB was founded in 2013 as the main campaign body to increase consumer awareness and engagement (Wilson et al., 2017). The Data and Communications Company (DCC) was granted the license for the control of the communication system (Department of Energy & Climate Change, 2013). 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) (Gangale et al., 2017).

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

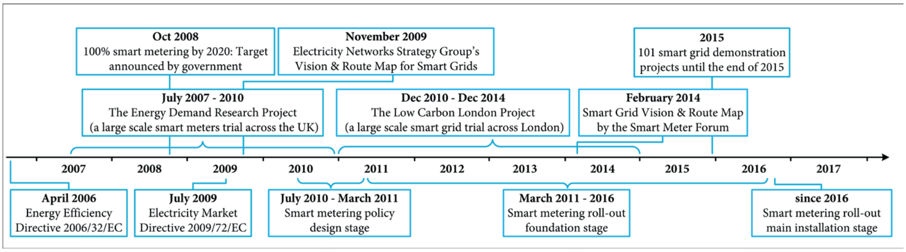



**Figure 4-2: Smart grid development timeline in the UK**

In the UK, we analyzed 71 articles from January 2007 to June 2017 in 17 national newspapers (Table 4-2). 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 sub-system, 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%).

**Table 4-2: British newspapers**

| Newspaper type[7] | 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 |

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

# 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 4-3 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. 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 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 (Vringer and Dassen, 2016).

**Table 4-3: Overview of results: Smart grid values reflected in Dutch and British newspapers**

| **Values**<br>Frequencies* | **Sentiment** | **Conceptions**<br>(NL, **UK**, **both countries**) | **Example Statements** | **Source Attributions** |
|---|---|---|---|---|
| **Economic Development**<br>NL: 35%<br>UK: 69% | Positive | **Energy savings**, **cost savings (consumer & operational / supply side)**, improved business models, **accurate billing** | *"Households are equipped with smart meters to realize 3.5% energy savings (Algemeen Dagblad (AD), 2 Dec 2016)."*<br><br>*"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)."* | Media<br><br>Consumer Representation |
| | Negative | **Energy savings too low**, **unequal profits**, **expedient spending of public money**, waste of resources, energy intensive ICT, dependence on ICT, **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)."*<br><br>*"There could be serious implications for energy prices if utility companies pass on the cost to consumers (Daily Mail (DM), 23 May 2007)."* | Consumer<br><br>Government |
| **Environmental Sustainability**<br>NL: 29%<br>UK: 16% | Positive | **Energy savings**, **integrating renewables** | *"Smart grids contribute to two worldwide trends: sustainable energy and decentral power generation (Het Financieele Dagblad (FD), 24 Oct 2011)."*<br><br>*"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<br><br>Media |
| | Negative | **Energy savings too low**, waste of resources, energy intensive ICT, designing long-lasting systems | *"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**<br>NL: 10%<br>UK: 5% | Positive | **Balancing supply & demand** | *"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 | Role of DSO, dependence on ICT | *"[…] commercial side activities of network operators […] can endanger their core task – security of energy supply (FD, 28 May 2016)."* | Regulator (ACM) |
| **Transparency / Accuracy**<br>NL: 15%<br>UK: 17% | Positive | **Information on energy use**, **Information on price**, **billing accuracy** | *"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 | Insufficient information on energy use, meter reading accuracy, data access issues | *"Where did it go wrong? The smart meter registers the consumption and sends it to the energy supplier, who informs consumers bi-monthly how* | Media |

| **Values**<br>Frequencies* | **Sentiment** | **Conceptions**<br>(NL, **UK**, **both countries**) | **Example Statements** | **Source Attributions** |
|---|---|---|---|---|
| | | | *much […] was used. They did not choose for a display where consumers could read directly how much they use (DT, 20 Nov 2016).”* | |
| **Comfort**<br>NL: 5%<br>UK: 4% | Positive | **Automation is convenient** | *“[…] 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**<br>NL: 11%<br>UK: 7% | Positive | **Power to consumers/the people**, **participation (voluntary)** | *“Consumers become stage-managers of their energy consumption (VK, 6 March 2010).”* | Certification Body for Power Systems |
| | Negative | Participation (forced), knowledge is power, **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**<br>NL: 2%<br>UK: - | Positive | Power to consumers / the people, citizen representation in parliament | *“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**<br>NL: 2%<br>UK: - | Positive | Private-private & public-private | *“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 | Knowledge is power | *“[…] non-expert civil servants might let themselves be misled by technology companies (NRC.Next, 17 Oct 2015).”* | Research |
| **Autarky**<br>NL: -<br>UK: 2% | Positive | **Temporal self-sufficiency** | *“Energy self-sufficiency is becoming more achievable (Daily Telegraph (DaT), 1 Oct 2016).”* | Prosumer |
| **Accountability**<br>NL: 1%<br>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**<br>NL: 7%<br>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 |

| **Values** Frequencies* | **Sentiment** | **Conceptions** (NL, **UK**, **both countries**) | **Example Statements** | **Source Attributions** |
|---|---|---|---|---|
| **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)."* | Certification Body for Power Systems |
| | | | *"It is also fair that citizens can decide themselves if they want to participate or not (NRC.Next, 9 April 2009)."* | 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)"* | Municipal Government |
| | | | *"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)."* | 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)."* | Research |
| | | | *"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)."* | 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)."* | Research |
| | | | *"Difficulties in making the meters work in tall buildings and when customers switch supplier (DaT, 7 March 2015)."* | 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)."* | Research |
| | | | *"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)."* | Consumer Representation |

| **Values** Frequencies* | **Sentiment** | **Conceptions** (<u>NL</u>, **UK**, **<u>both countries</u>**) | **Example Statements** | **Source Attributions** |
|---|---|---|---|---|
| **Health / Safety** NL: 1% UK: - | Positive | <u>Improved home ventilation</u> | *"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 | <u>Radiation</u> | *"[…] disadvantages from radiation […], which are not revealed (AD, 19 Feb 2013)."* | Consumer |

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

## 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 (European Union, 2006).

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 (Cuijpers and Koops, 2013). 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 (Allcott and Mullainathan, 2010; Bager and Mundaca, 2017; Ehrhardt-Martinez et al., 2010). 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 (Bager and Mundaca, 2017).



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, policymakers, 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 (Ligtvoet et al., 2015). 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 (Balta-Ozkan et al., 2014a; Goulden et al., 2014; Michaels and Parag, 2016).

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 (Thomas, 2012). 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)"*, Etzkowitz and Leydesdorff (2000)) 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 (Chen et al., 2017; Chou et al., 2015; Hess and Coley, 2014; King and Jessen, 2014; Krishnamurti et al., 2012). 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 (Hess and Coley, 2014), and if such data is sold for commercial purposes (Michaels and Parag, 2016). 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 (Cuijpers and Koops, 2013). Additionally, automated data transmission from smart meters is seen as critical due to data access challenges. Statements reflect a conflict between policymakers 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) (Chou et al., 2015; Muench et al., 2014; Park et al., 2014). 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 chapter, 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. Bale et al., 2015).

The findings are also valuable for policymakers 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 policymakers 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. Van de Poel, 2013), 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.

## ***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

**Table 4-4: List of analyzed newspaper articles**

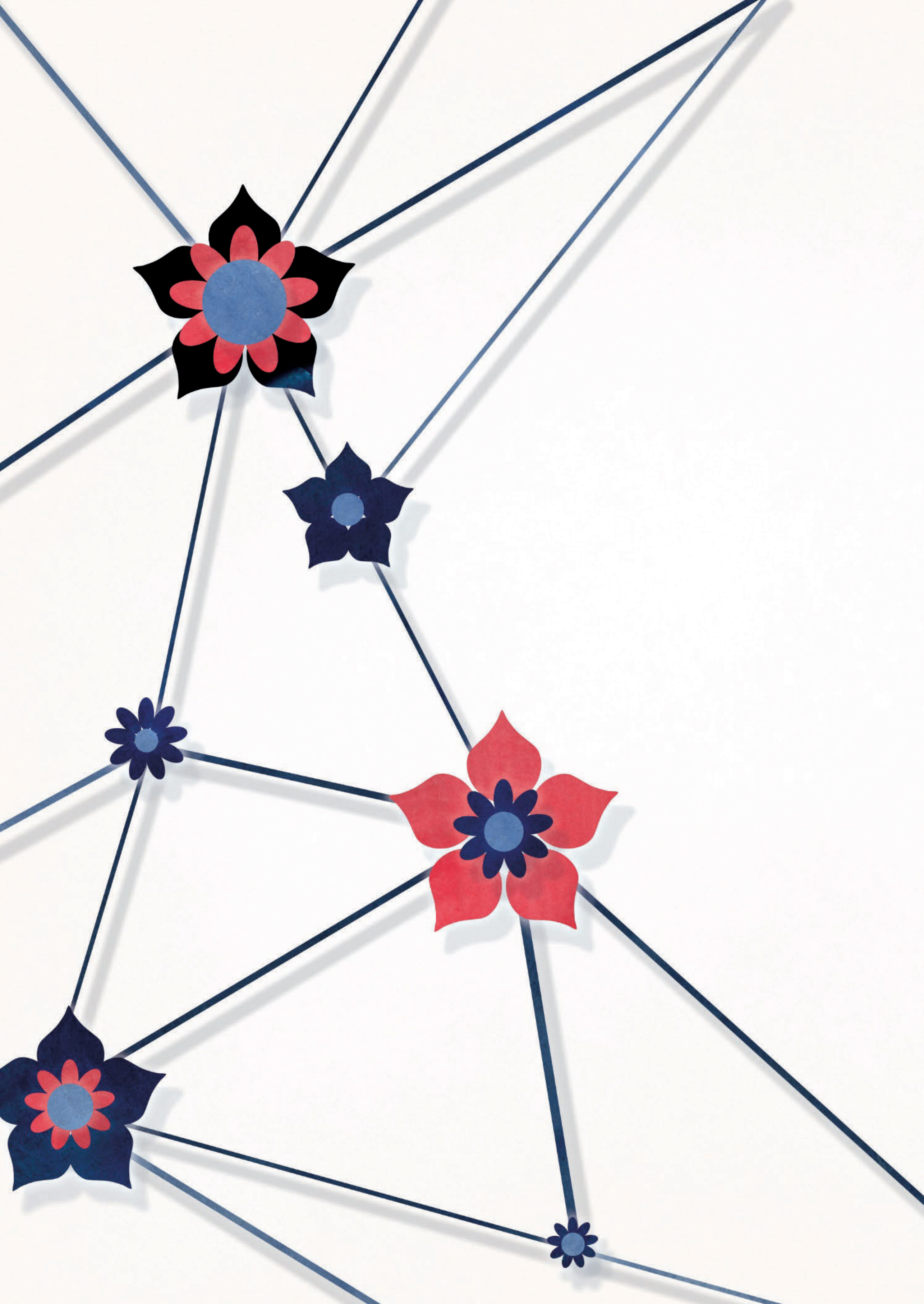
| Publication | Headline | Date |
|---|---|---|
| **Netherlands** | | |
| AD/Algemeen Dagblad | Energiebedrijven zien niets in splitsingsplan van Brinkhorst | 11 February 2006 |
| AD/Algemeen Dagblad | Consumentenbond wil keuze bij meters | 14 April 2009 |
| AD/Algemeen Dagblad | Rekening stroommeter 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 |
| 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 |

| Publication | Headline | Date |
|---|---|---|
| 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 |

| Publication | Headline | Date |
|---|---|---|
| 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 | 4m Brits in energy price cut | 25 June 2016 |
| Financial Times | Smart meters could save Pounds 40m on energy | 04 August 2007 |
| Financial Times | Big six groups face challenge from residential gas supplier | 12 January 2009 |
| 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 |

| Publication | Headline | Date |
|---|---|---|
| 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 £4,000 | 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 |

| Publication | Headline | Date |
|---|---|---|
| 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 £9,000 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 £4.5m fine | 08 December 2016 |
| The Times | Customers to pay £70 more after SSE raises electricity prices | 14 March 2017 |



CHAPTER 5:

# DESIGNING FOR JUSTICE IN ELECTRICITY SYSTEMS: A COMPARISON OF SMART GRID EXPERIMENTS IN THE NETHERLANDS

This chapter has been published as:

Milchram, C., Künneke, R., Doorn, N., Van de Kaa, G., Hillerbrand, R., 2020. Designing for justice in electricity systems: A comparison of smart grid experiments in the Netherlands. Energy Policy (in press). https://doi.org/10.1016/j.enpol.2020.111720

*Whereas Chapter 4 presented an analysis of the national public debate on smart grid technologies in general, Chapter 5 focuses more concretely on the design of real-life smart grid implementations in local experiments. The aim of this chapter is to understand how the design features of smart grid systems can enable energy justice and based on that develop recommendations for policymakers and technology designers how to consciously design for justice in smart grids. To achieve this, four smart grid pilot projects are evaluated in a comparative qualitative case study research design. The evaluation framework for comparing the four cases builds on the conceptualization of energy justice for smart grids in Chapter 4. The chapter contributes to energy justice literature, which remains limited regarding smart grids and regarding concrete guidelines for designers and policymakers.*

*The chapter contains, firstly, an introduction which outlines knowledge gap, aim, and contribution of the chapter. Section 2 provides a background on smart grid systems, and develops an evaluation framework for energy justice in smart grids, which forms the theoretical basis for the case comparison. Section 3 gives methodological details on the comparative case study research design, introduces the empirical context of smart grids in the Netherlands, and describes the four cases. Findings from the case comparison, which provides insight regarding the design for distributive, recognition, and procedural justice, are discussed in Section 4. The chapter is concluded in Section 5 by design implications and recommendations for policymakers.*

## 1 Introduction

In the transition to low-carbon energy supply, urban electricity systems need to become more flexible (Muench et al., 2014; Powells and Fell, 2019; Verbong et al., 2013). Growing shares of intermittent renewables, especially from solar photovoltaic (PV) systems, increased electricity demand from electric vehicles, and the electrification of heat put pressure on urban electricity grids (Connor and Fitch-Roy, 2019). Smart grid systems respond to these challenges by applying advanced information technologies (IT) to bridge temporal gaps between electricity supply and demand. Technologies such as smart metering, storage, or home energy management systems (HEMS) also imply a more active role of electricity users. Consumers become prosumers[8], can increase their self-consumption through the addition of storage, or offer batteries as flexibility resources to the grid (Goulden et al., 2014; Renström, 2019). Hence, consumer adoption is a prerequisite for smart grids to be successful.

However, the deployment of smart grids has moral implications which form barriers to the systems' adoption (Milchram et al., 2018b). For example, the reliance on real-time sharing of household data raises concerns regarding privacy violations (Cuijpers and Koops, 2013). Another example is increased automation in digital systems, which might result in reduced user autonomy while giving energy companies more control over households' electricity use (Michalec et al., 2019). Also, changing actor roles, e.g. the greater importance of software providers and more active roles of households, raise uncertainties regarding the distribution of responsibilities and risks (Connor and Fitch-Roy, 2019; Diestelmeier, 2019a).

Over the past ten years, 'energy justice' has been increasingly used as a framework to understand and address moral implications of energy decision-making, but justice concerns arising from an increased digitalization in electricity systems have not yet attracted much attention. 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" (Miller et al., 2013, p. 143). Drawing from environmental justice (Schlosberg, 2007), a three-dimensional understanding of 'justice' is dominant: distributive justice (addressing the allocation of benefits and harms), justice as recognition (giving attention to inclusiveness and potential misrecognition of vulnerable stakeholder groups), and procedural justice (concerned with equitable decision-making processes).

[8] Prosumers are defined as actors that are both producers and consumers of renewable energy (Kubli et al., 2018; Parag and Sovacool, 2016).

Milchram et al. (2018a) was among the first to conceptualize justice for the context of smart grid systems, raising attention to how smart grids might impact distributive and procedural justice. Additionally, some scholars have analyzed distributive implications of variable energy tariffs enabled by smart metering, which pose disadvantages for energy vulnerable populations. Low-income groups with low demand flexibility are the most adversely affected consumers, for example because peak hours may become too expensive for them (Neuteleers et al., 2017); they live in poor quality housing (McGann and Moss, 2010); they cannot afford flexibility technologies (e.g. batteries, smart appliances) and they spend a higher share of disposable income on energy costs compared to higher-income groups (Powells and Fell, 2019).

Whereas this literature is valuable for justice conceptualizations and understanding of distributive impacts of smart metering with variable tariffs, it offers little holistic insight into how energy justice can be achieved through smart grid design. This chapter contributes such insight by analyzing how design features of implemented smart grid systems influence perceptions of distributive, recognition, and procedural justice. It aims to operationalize the three dimensions of energy justice, evaluate smart grid implementations, and develop design and policy recommendations for just and smart grids. Hence, the paper asks: How do design choices in smart grid projects impact energy justice? To address this question, we analyze the design of four implemented smart grid pilot projects in the Netherlands in a comparative case study research. Thereby, the paper contributes to making energy justice measurable so that existing technologies and their institutional embeddedness can be evaluated and compared with respect to their justice implications, enabling justice to become an (operationalized) design goal in smart grid systems.

The following section introduces smart grids and develops an evaluation framework, which forms the theoretical basis for the case comparison. Section 3 outlines the comparative case study research method and describes the empirical context of smart grids in the Netherlands as well as the four cases. Findings from the case comparison are discussed in Section 4. Section 5 outlines design implications and recommendations for policymakers.

# 2 Background

## 2.1 Smart grids

In smart grids, information technology (IT) systems are used to bridge temporal gaps between the supply and demand of electricity. Due to the use of digital technologies and the reliance on the collection and sharing of real-time household energy generation and use data, the concept ‘smart grid’ is often used as an umbrella term for digitalization in the electricity network. Up to now, smart grids are mostly implemented in pilot projects, combining (some of) the sub-systems depicted in Figure 5-1 (Geelen et al., 2013). In such systems, micro-generators, like for example PV or small wind turbines, generate electricity on household or community level. To match supply and demand, a range of flexibility-providing units can be applied (Eid, 2017). These are storage systems to use electricity at different times than it was produced or avoid the purchase of electricity from the grid during peak hours (Geelen et al., 2013); smart household appliances (e.g. heating/cooling systems, white goods), which automatically shift operation to times when renewable energy is available; or variable tariffs, which incentivize consumers to shift their electricity use to times when renewable supply is available or away from times of peak demand (Warren, 2014). Smart metering provides (near) real-time information on electricity supply, distribution, demand, and storage, and bidirectional communication of data to and from end users (Warren, 2014). This is needed for monitoring and control systems to visualize electricity flows. Home energy management systems (HEMS) and their user interfaces (e.g. in-home displays, apps, web portals) provide end-users information on electricity flows and the possibility to steer their electricity use (Wilson et al., 2015).

## 2.2 Developing an evaluation framework for energy justice in smart grids

To compare the design of smart grid systems for their influence on energy justice, this section develops an evaluation framework, in which the three dimensions of energy justice (Jenkins et al., 2016) are operationalized into more concrete and context-specific evaluation criteria (Table 5-1). The evaluation framework includes aspects that are highlighted in existing conceptualizations of energy justice (e.g. Jenkins et al., 2016; McCauley et al., 2013; Schlosberg, 2007) and draws to a great extent from a review of (potential) injustices associated with smart grid systems in Milchram et al. (2018a).

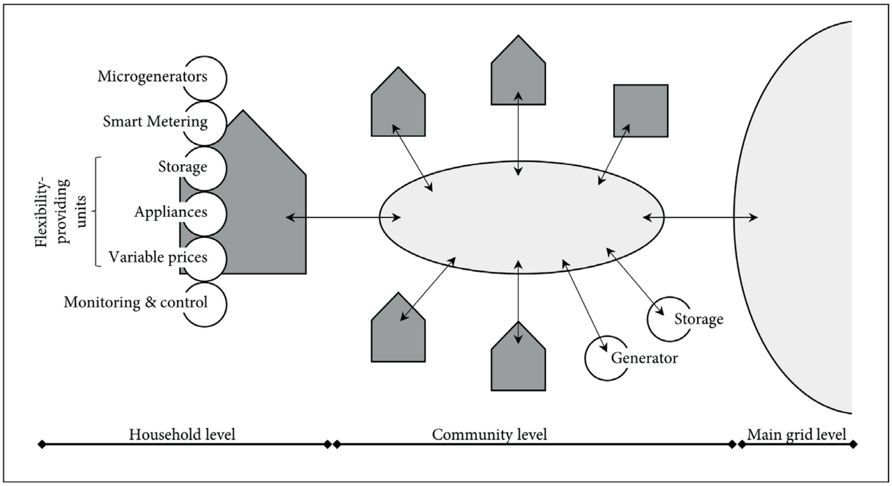



**Figure 5-1: Schematic overview of a smart grid system**

Source: adapted from Geelen et al. (2013)

5

### 2.2.1 Evaluation criteria for distributive justice

Distributive justice is the equitable distribution of benefits and harms among stakeholders affected by energy systems (Walker, 2009). Evaluation criteria therefore focus on the objects of distribution: *What* are benefits and harms to be distributed? (Sovacool and Dworkin, 2015).

The first two criteria are the *distribution of profits and costs* between smart grid users, which might have implications for the affordability of energy. The need to ensure that lower income households do not spend a disproportionally larger share of their income on energy services compared to higher income groups is an important topic in energy transition research (Miller et al., 2013). Unfair cost distributions result for example from smart metering and variable tariffs when lower income groups with a low flexibility to shift their energy use are adversely affected (Powells and Fell, 2019).

A second monetary criterion is the *perceived justice in public funding of smart grid pilots*. EU-wide, national governments and/or the European Commission co-fund 85% of those projects. In the Netherlands, these two sources make up 41% of the total investment (Gangale et al., 2017). We also consider financing by distribution system operators (DSOs) as public funding, because Dutch network operators are owned by national and regional governments (Mulder and Willems, 2019).

**Table 5-1: Evaluation framework for energy justice in smart grids**

| **Justice Evaluation Criteria** | **Definition**<br>(Perceived justice of …) |
|---|---|
| **Distributive** | |
| Distribution of profits | … profit division among participating households |
| Distribution of costs | … cost distribution among participating households |
| Public funding | … financing smart grid pilots with government subsidies or by distribution system operators |
| Knowledge sharing | … the availability of project learnings and results to the wider public |
| Data governance | … household data collection, storage, access, and use by project consortium |
| **Recognition** | |
| Selection of community | … the process to choose a neighborhood for the project |
| Selection of participants | … participation criteria for households |
| Technology accessibility | … usability and inclusiveness for diverse user groups |
| IT literacy required | … IT knowledge required to use the systems |
| **Procedural** | |
| Household participation (general) | … user inclusion in decision-making processes |
| Household participation (data) | … user inclusion in decision-making on data governance |
| Control vs. automation | … the extent to which households can control the system vs. how much is automated |
| Transparency (general system) | Potential for households to comprehend effect of their behavior on electricity use |
| Transparency (data) | Potential for households to understand who has access to their data and how |

Additionally, we evaluate *the extent to which knowledge gained in a smart grid pilot project is shared with the wider public*. Smart grid projects are implemented to gain experience how the technologies impact the grid, develop new business models, and ultimately to learn for future large-scale offering of such services (Gangale et al., 2017).

We also include the *perceived justice in the collection and use of household data*. Smart grid services rely on real-time household energy generation and consumption data. Hence, consumers do not only pay money, they also ‘pay’ with their data, similar to data becoming increasingly important as a currency to pay for services in a digitized society (Kool et al., 2017).

### 2.2.2 Evaluation criteria for justice as recognition

Justice as recognition addresses the inclusiveness of energy systems, especially for vulnerable stakeholder groups (Schlosberg, 2007). The guiding question here is *who* is (not) affected by a system and if there is equitable recognition of vulnerabilities.

An important design choice is firstly the *selection of the community* and the *selection of households*, which will have implications for generalizing learnings beyond the pilot project context (Milchram et al., 2018a).

In addition, our framework assesses the *accessibility and inclusiveness of the system*. We ask to what extent the technologies applied in a smart grid are accessible in a fair way to different user groups (e.g. high and low income households, house owners and tenants). Smart grids have been criticized for their lack of accessibility in particular to lower-income populations, tenants, and elderly and disabled people (Milchram et al., 2018a; Powells and Fell, 2019). Whereas these accessibility issues constitute inequalities, at first glance they do not seem to be an issue of injustice. Novel technologies usually need investment by higher income early adopters for prices to decrease over time, thereby increasing accessibility (Rogers, 2003). In energy systems, however, socialization of electricity network costs and subsidies for renewables mean that higher income groups with suitable houses, who are able to install PV, can benefit by saving energy costs. Lower income households, who cannot afford their own generation, might face rising energy bills from increased implementation of renewables (Chapman et al., 2016).

5

Attention has also been raised to varying degrees of *IT literacy* as a factor for exclusion in smart grids systems (Buchanan et al., 2016). In a survey of smart grid projects targeted at social housing tenants, Gangale and Mengolini (2019) find that low technological skills represent serious challenges for such projects. Therefore, we include a separate criterion on the IT literacy required for participation.

### 2.2.3 Evaluation criteria for procedural justice

Procedural justice focuses on equitable decision-making procedures (McCauley et al., 2013). The guiding question is thus the *how* of decision-making, with focus on the *meaningful participation* of the local community and the *transparency* of such procedures (Boudet, 2019).

Regarding participation, we evaluate the mechanism through which households are *included in decision-making* regarding system design and the collection and use of household data. Participatory decision-making has a significantly positive impact on the adoption of smart metering and related services (Guerreiro et al., 2015). Yet, research has criticized lacking user participation and engagement in smart metering rollouts and smart grid experiments (Gangale and Mengolini, 2019; Sovacool et al., 2017b).

We also assess how the system itself allows *user participation and control relative to the degree of automation*. Smart grids can allow users to take a more active role in controlling their electricity use (Geelen et al., 2013). Yet, the application of complex digital technologies also requires expertise and the involvement of software providers and aggregators, potentially shifting power away from users and raising the concern of losing autonomy to IT systems (Milchram et al., 2018a).

Regarding *transparency*, the framework considers to what extent the HEMS user interface enables users to understand the causality between their energy-related behavior and their electricity use (and consequently their bill). How households receive feedback regarding energy use, generation, and system functioning matters for procedural justice, because the information is a key enabler for capitalizing on demand flexibility (Powells and Fell, 2019).

Additionally we include a criterion on the extent to which households have *transparency over the collection and use of their energy-related data*. Although smart grids have the opportunity to make energy more visible, the functioning of IT systems, algorithms, and the way they use data are often opaque for users (Kloppenburg and Boekelo, 2019).



## 3 Methodology

Since smart grids are to date mostly implemented as pilot projects (Gangale et al., 2017) and an analysis of how design influence energy justice requires in-depth and real-world context-dependent knowledge, a qualitative comparative case study research design was chosen (Flyvbjerg, 2006; Yin, 2014). Four smart grid pilot projects in the Netherlands served as cases: A virtual power plant in Amsterdam (subsequently abbreviated as VPP), a community battery storage pilot in Rijsenhout (CBS), a local energy market in Hoog Dalem (LEM), and the project 'Gridflex' in Heeten (GF). Selection aimed at 'maximum variation cases' (Flyvbjerg, 2006): VPP was chosen as a typical smart grid case, led and developed by a DSO, and implemented in a top-down fashion. CBS was chosen because it works with social housing tenants, LEM because it was started on household initiative, and GF because it is led by an energy cooperative under a legal exemption. Additionally, projects had to be implemented in or after 2017 to ensure use of the system and possibility for project stakeholders to recollect their experiences. Selection was also guided by accessibility of interviewees and documents.

## 3.1 Data collection and analysis

Data was collected through 33 semi-structured interviews and a content analysis of project documents. We interviewed people who were directly involved in the design, implementation, and use of the system (Table 5-2). Interviewees were recruited based on purposive and snowball sampling. This limits generalizability but is in line with our our overall qualitative approach and the aim to study in-depth how and why design choices are evaluated as (un)fair (Yin, 2014). The main aim of the interviews was to evaluate the cases' design with respect to justice. Interviews had two parts (see Appendix A): firstly, the interviewee's role in the project and a description of the system; secondly, the evaluations of justice. For justice evaluations, we operationalized the framework presented in Section 2 into interview questions. The questions were answered on a five-point scale, which either ranged from 'very unfair'



**Table 5-2: Overview of interviews and interviewees**

| Case | Number of Interviews | Interviewees[1)] |
|---|---|---|
| Virtual Power Plant (Amsterdam) | N = 11 | DSO (2x)<br>Energy supplier / Aggregator (1x)<br>Software provider (1x)<br>Research institute (1x)<br>Municipality representative (1x)<br>Participating households (5x) |
| Community Battery (Rijsenhout) | N = 4 | DSO (2x)<br>Local energy supplier (1x)<br>Participating household (1x) |
| Local Energy Market (Hoog Dalem) | N = 7 | DSO (2x)<br>Hardware provider (2x)<br>Consulting (1x)<br>Participating household (2x) |
| Gridflex (Heeten) | N = 11 | DSO (2x)<br>Energy cooperative (1x)<br>Hardware provider (1x)<br>Software provider (1x)<br>Aggregator (1x)<br>Consulting (3x)<br>Participating households (2x) |

to 'very fair'[9] or from 'very opaque' to 'very transparent'. Each closed question was followed by an open question to discuss the rationale for the quantitative rating and collect further information about the projects design choices. Interviews were conducted in English and Dutch between September 2018 and May 2019. They lasted between one and two hours, were recorded with the permission of the interviewees, and transcribed before the analysis.

Secondary data was used to confirm interview findings regarding the system design. The document analysis included the projects' (progress and final) reports, presentations given by project members, and news reports.

The interview transcripts and secondary material were analyzed with the qualitative and mixed-methods software MAXQDA. Quantitative analyses involve descriptive statistics and median comparisons of the evaluation criteria (Field, 2013). Qualitative analysis of open interview questions and project documents was done through inductive coding (Mayring, 2014). The coding was conducted by the first author. The co-authors performed an intercoder check.

### 3.2 Smart grid development in the Netherlands



In the Dutch energy transition, smart grids are attributed a special importance as an alternative to electricity network expansion. The share of electricity demand from renewable sources – 18% in 2019 with the majority from wind and solar energy – is forecasted to grow substantially in the next ten years in order to reach 2030 emission targets (Afman and Rooijers, 2017; CBS, 2020a). At the same time, however, renewable energy developers have already faced difficulties in connecting wind and solar parks to the electricity grid, due to lacking, insufficient, and ageing infrastructure (Ekker and van de Wiel, 2019).

The Dutch government incentivized experimentation with smart grid pilots, the majority of which have taken place in low-voltage residential areas. Most pilot projects are initiated and led by the DSOs (Cambini et al., 2016). Initially only focusing on the demonstration of new technologies, the government also fosters legal experimentation since creating the 'Experimentation Decree' in 2015 (Ministerie van Economische Zaken, 2015). It grants energy cooperatives exemptions from the strict

[9] The adjective 'fair' is chosen here instead of 'just', because several pilot interviews indicated that interviewees were unfamiliar with 'just' and found 'fair' more comprehensible. As a consequence, this chapter uses 'fair' and 'just' interchangeably, although we acknowledge that justice is more encompassing than fairness.

ownership unbundling in the Dutch Electricity Act[10]. They are thereby not only allowed to own renewable generation, but also supply their members directly with electricity, operate the part of the distribution grid belonging to the project, and determine their own network tariffs (Diestelmeier, 2019b). Although still small in number, cooperative smart grid initiatives are rising as a result (hier opgewekt, 2019).

Recently, smart grid pilots are also motivated by the expected phase-out of net metering for residential prosumers from 2023 onwards (Directoraat-generaal Klimaat en Energie, 2019a). With net metering, the most beneficial option for prosumers is to feed excess electricity into the grid as they get exactly the same price per kWh feed-in as they pay for kWh use from the network (Huijben and Verbong, 2013). Consequently, there is no financial incentive for household storage to increase self-consumption. The replacement of net metering is expected to decrease this feed-in compensation and hence increase the financial viability and deployment of storage (Directoraat-generaal Klimaat en Energie, 2019a).

## 3.3 Case descriptions



The following section provides a description of the four cases. Table 5-3 gives an overview of their set-up.

### 3.3.1 Virtual power plant in Amsterdam (VPP)

The Virtual Power Plant (VPP) is located in Amsterdam Nieuw-West and part of a five-year European Union funded program to demonstrate technologies for energy efficient cities (City-zen, 2019). It is led by DSO Alliander. The capacity of home batteries is aggregated and the resulting flexibility is used for trading on the day-ahead wholesale market. The project ran from 2016 to April 2019, with the VPP operated in trading mode from April 2018 to March 2019. The aim of the pilot was to test storage systems, develop a business case for trading local flexibility on the wholesale market, and thereby give residential prosumers access to energy markets. 48 households participated, and all of them had owned PV systems before project start.

[10] The Dutch electricity market is characterized by full ownership unbundling. Commercial activities (generation, trading, and retailing) are thus under separate ownership than network operation. Network ownership and operation are in the hands of one transmission system operator (TSO) and several distribution system operators (DSOs), which are owned by local and national governments (Mulder and Willems, 2019).

**Table 5-3: Overview of smart grid set-up in the four cases**

| | VPP | CBS | LEM | GF |
|---|---|---|---|---|
| **Project Consortium Members and Responsibilities** | | | | |
| DSO | Alliander (project leader) | Alliander (project leader) | Stedin (project leader) | Enexis |
| Supplier | NeoSmart | Tegenstroom (perceived project leader by households) | - | - |
| Energy cooperative | - | - | - | Endona (project leader) |
| Aggregator | NeoSmart | - | - | University of Twente |
| Software Provider | EXE (an Alliander subsidiary), Sympower | Lyv Smart Living | iLeco | ICT group |
| Hardware Provider | - via Alliander | - via Alliander | ABB | Dr. Ten |
| Consultants | - | - | Energy.21 (development of Layered Energy System concept) | Escozon (supporting Endona); Enpuls (Enexis subsidiary supporting battery system); Buukracht (Enexis subsidiary; user engagement) |
| **Project Participants** | | | | |
| Participating households | 48 households (mostly owner-occupier) | 35 households (social housing tenants, renting the solar panels) | 16 households (owner-occupiers) | 47 households (owner-occupiers) |
| **Composition of the Smart Grid** | | | | |
| Microgenerators | Rooftop PV systems (all participating households) | Rooftop PV systems (all participating households) | Rooftop PV systems (subset of households) | Rooftop PV systems (50% of households) |
| Smart Metering | ✓ | ✓ | ✓ | ✓ |
| Flexibility-providing units | Home batteries (5 kWh, all participating households) | Community battery (128 kWh virtually distributed to the households, every household has access to 3 kWh) | 3 home batteries (12 kWh); heat pumps (all households) | 20 home batteries (5 kWh, sea salt batteries); variable network tariffs |
| Monitoring & Control System | VPP steering software (buy and sell electricity based on wholesale price, battery capacity, available solar power, and network load); Transaction platform (clearing and settlement of electricity deals); Online portal as HEMS (electricity use, generation, battery status); | Battery steering software; HEMS (electricity use, generation, battery status) | Local energy market software connected to consortium blockchain to register transactions between households; App as HEMS (electricity use, generation, battery status; allows trading) | Battery steering software; App as HEMS (electricity use, generation, status regarding the two pricing mechanisms) |

5

### 3.3.2 Community battery storage in Rijsenhout (CBS)

This community battery storage (CBS) was implemented in a suburban village close to Amsterdam, in cooperation between DSO Alliander and the municipal energy supplier Tegenstroom. Here, the excess solar generation of one neighborhood is stored in a community battery. The project ran from 2015 to 2018, and the battery was implemented in spring 2017 (Van Santen, 2017). The aim was to understand how a community battery can mitigate supply peaks and keep the voltage level in the local low-voltage grid stable. 35 social housing tenants, who rented PV systems, participated in the project.

### 3.3.3 Local energy market in Hoog Dalem (LEM)

The LEM case study is located in a new residential area and led by DSO Stedin. Previous to this project, a first smart grid pilot had been implemented in the area to test home batteries, smart household appliances, heat pumps, and PV (Stedin, 2019). LEM was initiated in 2017 by a group of households who had already participated in the first pilot and was ongoing at the time of data collection. Eventually, 16 home owners participated in LEM. The aim of the project is to maximize the use of electricity generated within a neighborhood by incentivizing households to trade electricity with each other (Energy.21 and Stedin, 2018). The project is the first implementation of the so-called 'Layered Energy System', a peer-to-peer trading (P2P) system that was developed by the DSO Stedin and the IT consultancy energy.21. In this system, transactions between households are registered in a consortium blockchain. Community electricity markets form the lowest level of the electricity system and have prices that are lower than the prices on the national market (Energy.21 and Stedin, 2018). At the time of data collection, home batteries and a beta-version of the app was available, in which households could trade electricity on a virtual market place, i.e. they could see monetary consequences of their trading in the app.

### 3.3.4 Gridflex in Heeten (GF)

GF is being implemented in a new residential area and led by energy cooperative Endona, a citizen-led local energy initiative. The system is a combination of battery storage, an energy management system, and variable electricity tariffs. 47 home owners participated. The project was started in 2017 and was ongoing at the time of data collection: the implementation of the batteries had just started and the variable tariffs had just been developed. The main aim of the project is to maximize the self-consumption of locally generated renewable electricity by individual households and by the neighborhood as a community in order to minimize the load on the neighborhood's transformer (Enexis, 2017).

GF experiments with variable network tariffs. This is unusual[11] and relevant for later justice evaluations. Experimenting with two mechanisms, the network tariff component of the household electricity bill is variable depending on the network load. The first pricing mechanism is a collective one in which the households pay a low/medium/high price depending on low/medium/high load on the neighborhood's transformer. The entire neighborhood load determines the network tariffs paid by the households. In the second pricing mechanism, a household's network tariff is based on its individual load. Network tariffs are higher at peak times than at off-peak times and cost is determined by the individual household load.

## 4 Results and discussion



The four pilot projects were evaluated and compared regarding perceptions of justice. The following section presents and discusses the results of the case comparison. First, we address results for the three justice dimensions separately. In Sections 4.2 and 4.3, we turn to more general discussions on design considerations arising from interrelations between the three dimensions and from justice implications that go beyond a single pilot project.

### 4.1 Case comparison: evaluations of justice

This section discusses why certain design choices received higher justice evaluations than others. On average, on the five-point scales, many design choices were evaluated as somewhat or very fair. This may be traced back to a social desirability bias as interviewees had a tendency to give evaluations in line with what they thought would be socially preferred answers (Fisher, 1993). It is not problematic, however, because consistent with our qualitative research design, case comparisons were mainly based on the inductive analysis of reasoning behind justice evaluations. The descriptive quantitative ratings provided indications of potential differences in evaluations. The combination of both answer types gives valuable insights regarding a fair smart grid design, as the following paragraphs will show. First, Table 5-4 gives an overview of the design choices that were decisive for justice evaluations as well as the direction of

[11] The charging of dynamic network tariffs is made possible by the exemption from the current Dutch electricity law, which was granted to Endona under the Experimentation Decree (see also Section 3.2).

their influence. Appendix B contains the detailed description of relevant design choices in the four pilot projects.

Before discussing the detailed results in the following paragraphs, a comparison of evaluations for the three dimensions of justice reveals on average lower evaluations for recognition and procedural justice (Figure 5-2). This indicates that lacking inclusiveness and participation are more challenging than distribution of benefits and

**Table 5-4: Overview of results: Design choices influential for justice evaluations**

| Justice Evaluation Criteria | Design choice decisive for justice evaluation | Influence on justice evaluations* |
|---|---|---|
| **Distributive** | | |
| Distribution of profits | Individual vs. collective profit allocation | ~ |
| Distribution of costs | No additional cost for households | + |
| Public funding | Share of funding from public sources | + |
| Knowledge sharing | Extent of knowledge sharing with wider public and other projects | + |
| Data governance | Sharing of household data among project consortium<br>Anonymization | ~ |
| **Recognition** | | |
| Selection of community | Structured selection process<br>Technical criteria for community selection | ~ |
| Selection of participants | Self-selection | ~ |
| Technology accessibility | Absence of requirement to own PV system and battery<br>Experimentation with social housing tenants | + |
| IT literacy required | High ease-of-use | + |
| **Procedural** | | |
| Household participation (general) | Degree of user participation in project decisions | ~ |
| Household participation (data) | Degree of user participation in project decisions | ~ |
| Control vs. automation | Degree of household control | + |
| Transparency (general system) | Extent of information shown on user interface | + |
| Transparency (data) | Extent of user comprehension on data usage | + |

* + … positive influence; ~ ambiguous influence (see text for details)

5

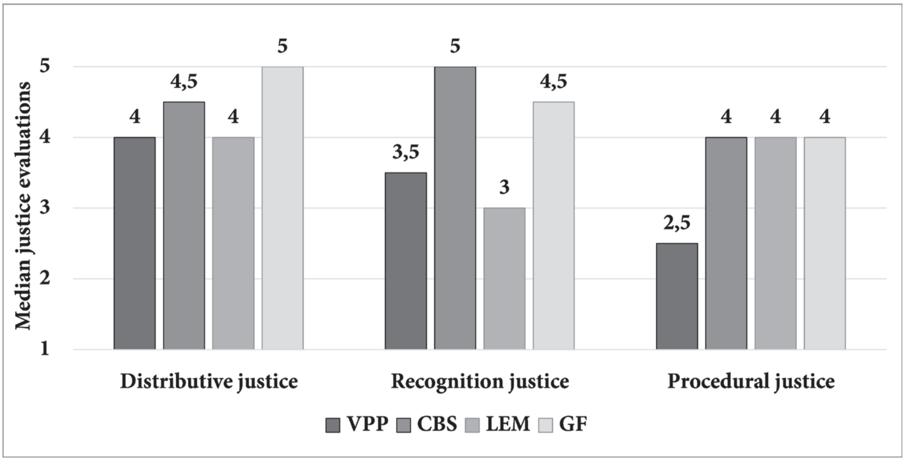



**Figure 5-2: Justice evaluations across cases**

harms. It can also be traced back to a general technology-oriented mindset that can be found in many smart grid projects (Hansen et al., 2020; Obinna et al., 2016). The testing of novel technologies is more in focus than social and moral aspects. This is also reflected in the projects' aims, and more strongly so for VPP and CBS than LEM and GF.

5

### 4.1.1 Evaluations of distributive justice

From the perspective of distributive justice, GF received the highest evaluations, followed by CBS, LEM, and VPP. Figure 5-3 shows the aggregated evaluations.

***Distribution of profits and costs***

Justice evaluations regarding the distribution of profits were dependent on the projects' choice for an individual or collective profit allocation mechanism. The comparison of VPP and GF is particularly interesting, because both were characterized by collective action situations (Ostrom, 2005): in VPP, the aggregated battery capacity is a common resource; in GF, a pricing mechanism incentivizes the community to keep their collective load as low as possible. Whereas VPP chose for an individual profit allocation, GF opted to allocate profits to the community as a collective.

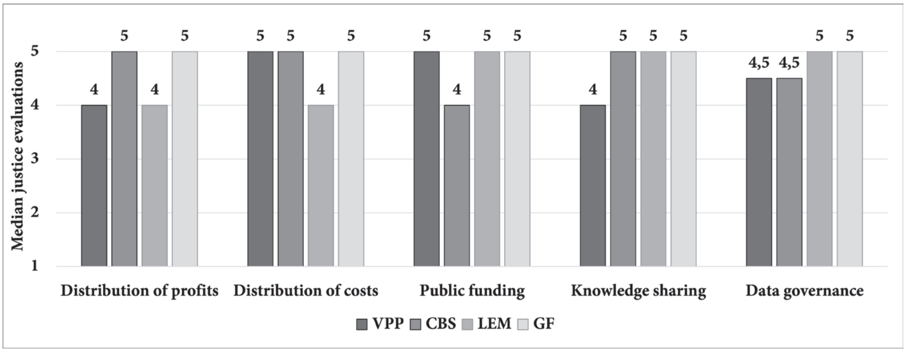



**Figure 5-3: Evaluations of distributive justice across cases**

In VPP, profits occurred through trading the aggregated battery capacity on the wholesale market. Profits were allocated equally to individual households[12]. The distribution principle was not evaluated as very fair, because households had no control over (dis)charging, the (dis)charging frequency was unequal, and this led to unequal increases in energy bills due to on average 34% battery losses. To remedy this problem, the project decided to compensate households for battery losses. This solution was acceptable in the pilot, but not realistic in a market setting. In a market setting, our interviews indicate that a model where suppliers/aggregators rent part of the battery for a fixed fee, leaving households to use the remaining capacity for self-consumption, would be acceptable for prosumers.

In GF, monetary benefits occurred if participating households shift their energy demand as incentivized by variable network tariffs. The collective mechanism – in which network tariffs vary depending on the load on the community's transformer (cf. section3.3.4) – was perceived as more fair than the individual mechanism. It was considered less disruptive for households because they might benefit from solidarity in the community to shift demand. In the individual mechanism, any inability to shift peak demand would directly result in higher costs. Any profits that would occur through the variable tariffs are allocated to the community for a collective benefit, which was evaluated as fair and consistent with the collective process: a community effort to achieve energy savings should be rewarded by a collective benefit for the entire community. This reflected the understanding that not all households have the same ability to shift demand. Vulnerable groups with low demand flexibility might

[12] This was the principle for distributing potential profits. In reality, at the end of the project no profits were made. Although the VPP succeeded in lowering electricity cost per kWh, due to the battery losses more electricity was used and had to be bought: on average 34%. As a result, the total cost of energy was €852 higher than it would have been without the batteries.

indeed be adversely affected from variable tariffs (Powells and Fell, 2019). The collective mechanism was a way to protect households from potential negative effects occurring in individual mechanisms.

Summarizing, findings indicate that individual profit allocation is appropriate if (a) individual households can control their benefits directly, (b) have transparency over their influence, and (c) there is no energy community. Collective allocation would be perceived as fair if (a) benefits depend on collective action, and (b) households are part of an energy community who collects and disburses monetary gains.

From a theoretical perspective, high justice evaluations of the collective mechanism for variable tariffs and profit distribution suggest that governing local smart grids as commons can enable distributive justice. Governance as commons refers to the community-based governance of a shared resource in which outcomes are determined by collective effort and require community coordination (Euler, 2018; Ostrom, 2005). To make this successful, however, it is necessary to avoid that individuals rely on others in the community to keep the collective load stable rather than taking action themselves. Whereas some households might have legitimate reasons not to shift their demand (for example, due to sickness), others might free ride. To avoid this, smart grid designers might follow a set of governance principles, among which are participatory decision-making processes regarding system governance; monitoring of individual users' behavior by people who are accountable to the community; sanctions for users who violate collective rules; access to conflict-resolution mechanisms; and recognition of the community-governance by external governmental authorities (Ostrom, 2005).



***Public funding and knowledge sharing***

Evaluating justice regarding public funding and knowledge sharing, findings show a clear pattern across all cases: Public funding is justified if knowledge gained from the project is shared externally so that pilot projects deliver learnings for a future sustainable electricity system. Government subsidies are thereby considered necessary to incentivize innovation and small-scale experimentation with novel technologies. Once technologies and business models are judged feasible, market parties should implement solutions on a bigger scale.

Despite its importance and high justice evaluations, knowledge exchange with and from other projects is seen as challenging. First, in most smart grid projects aggregators or small energy suppliers develop and test proprietary business models. Interviewees recognized that public money is spent on private business model development, and that such insights are not shared widely by entrepreneurs. Second, interviewees highlighted that 'learning by doing' is more effective than 'learning by reading'. A better codification of learnings throughout the project through an explicit project role for documenting learnings, decisions, and ensuring accessibility to the public at the end of the project would improve knowledge sharing. In addition, knowledge exchange can be facilitated if members of past projects are involved, for example in the form of steering committees. It should include households who participated in similar projects and the DSO would be a suitable organization to organize and oversee such (a) committee(s).

***Data governance***

In all projects, smart metering data is used for automation and shared within the project consortium. This was evaluated as somewhat or very fair, under the conditions of anonymization, appropriate data protection, and data use that corresponded to the project purpose. Many interviewees did not judge data governance as an issue of fairness, indicating that smart grid systems are predominantly seen as energy systems rather than data-based systems. Household data were not considered to be part of the 'costs' households pay for the service. Households judged data collection and use as appropriate because they saw the nature of the projects as *research*. The involvement of public companies and universities spurred household trust and increased the perception that data were used in a fair way. These findings differ from justice in research on digital platforms and internet systems. There, consumers' privacy concerns are related to perceptions of distributive fairness (how benefits from data collection and use are distributed between consumers and firms who collect data) and procedural fairness (how respectfully consumers were treated in the process of data collection) (Ashworth and Free, 2006). This should also apply to the collection of personal data in smart grid systems. Based on this literature and our findings that trust in the involved public organizations was key to see data collection as appropriate, we might predict that the more the systems will be understood as data-driven systems, and the more they are offered as a market service, the more potential unfairness in data governance will become salient for users. Our findings indicate that services offered by cooperatives as well as the continued involvement of DSOs as public 'guardians of fairness' might have an advantage over market services offered by bigger 'untrusted' companies.

### 4.1.2 Evaluations of justice as recognition

With respect to justice as recognition, CBS received the highest evaluations, followed by GF, VPP, and LEM (Figure 5-2, Figure 5-4).

***Selection of community and participants***

In all projects, the communities were selected without a wider process of screening for suitable places. In VPP, CBS, and GF, the selection was mainly done for technological reasons, which was considered as fair if that meant that the project could realize cost savings. In LEM, the fact that the project was initiated bottom-up by the participating households was seen critically because the community had already participated in (and benefitted from) a previous smart grid pilot. This confirms that bottom-up initiatives might not always be positively associated with enactment of justice (Breukers et al., 2017; Catney et al., 2014; Forman, 2017). Interviewees thus recommended a public selection process for future projects.

All cases used a self-selection process for participating households, meaning that households signed up for the project. This is problematic for generalization and risks structural misrecognition of the needs of other – especially more vulnerable – groups in society. Participants in three out of four cases were home owners who were already interested in energy, and had invested in renewable generation or energy efficiency measures.

***Accessibility***

Justice evaluations of the accessibility of technologies in the four cases were dependent on whether participating households needed to own PV systems and/or

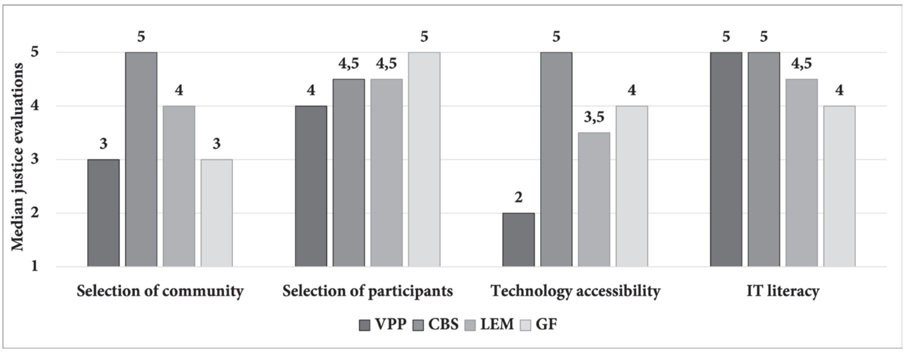



**Figure 5-4: Evaluations of justice as recognition across cases**

5

batteries, reflecting the lacking inclusiveness of PV and storage systems due to requirements regarding income, space, and house ownership. These factors for exclusion often co-occur, e.g. for lower income households living in dense urban areas with little space as (social housing) tenants. Such households are at higher risk of energy poverty and disproportionally vulnerable to changes in the energy system (Gillard et al., 2017; Poruschi and Ambrey, 2018). Although interviewees acknowledged that income barriers are only problematic in a transition phase until PV and battery prices will fall further (Kalkbrenner, 2019), they also stressed that even in this transition phase, mechanisms to make the technologies already accessible for lower-income households are important as the systems enable energy and costs savings.

Our findings highlight such mechanisms. CBS, which was evaluated as the most inclusive, demonstrated the benefits of a community battery for tenants of a social housing association. The involvement of social housing tenants is rare as most smart grid pilot projects work with home owners due to relatively easier implementation (Lammers and Heldeweg, 2016). The combination of rented solar panels and the community battery increased the system's affordability and was seen as a good role model for future applications in social housing communities.



GF and LEM promote accessibility by not requiring households to own or install large technologies. Households only needed smart metering and HEMS, which were provided to them during the project. Additionally, GF offers a role model how energy cooperatives could set up a smart grid. Cooperatives are often regarded as a more inclusive governance mechanism for energy projects and smart city initiatives as they allow citizens direct participation in decision-making (Martin et al., 2018). Cooperative smart grid initiatives are rising in the Netherlands, but are still uncommon since such projects are technologically more complex than the dominant cooperative activities, namely setting up energy generation facilities (hier opgewekt, 2019). However, GF operates under the Experimentation Decree, is thus generally not in line with current electricity legislation and scaling-up would necessitate legal changes. LEM on the contrary would be easier to scale up, because it is congruent with the existing energy market, operating with open standards and protocols in order to enable services by all potential aggregators, software and hardware providers.

***IT literacy***

Across all projects, we found similar results with respect to the IT literacy required from users: Pilot systems were judged as easy to use; all potential users were IT literate enough, as the systems required only knowledge how to use a smartphone app or an online portal; and the lower the IT knowledge required from the users, the more inclusive and accessible the system would be. These opinions were particularly held by consortium members, whereas several households mentioned that the user interface should have been simpler, a discrepancy that highlights the importance of user-centric design.

In addition, our findings show that the projects attracted people who are interested in new technologies. Such a self-selection bias raises again questions how insightful findings are for future scaling-up. It also means that the potential for exclusion might not lie in the actual IT knowledge required to use interfaces, but more in the perceived complexity, lacking knowledge about the opportunities of home automation, and little interest in such systems that prevents people from even considering adoption. Hence, lacking knowledge of and about such systems might be a greater barrier for inclusiveness than the knowledge needed to operate them.

### 4.1.3 Evaluations of procedural justice

From a procedural perspective, on average a higher degree of household participation, control, and transparency led to higher perceptions of justice (Figure 5-5). However, there are exceptions to this pattern, as shown in the following paragraphs.



***<u>Household participation</u>***

Comparing the cases, household participation did not always lead to higher justice evaluations. Participation was a challenge in all cases. First, justice evaluations depended on the details of the household representation. Two projects, GF and LEM,

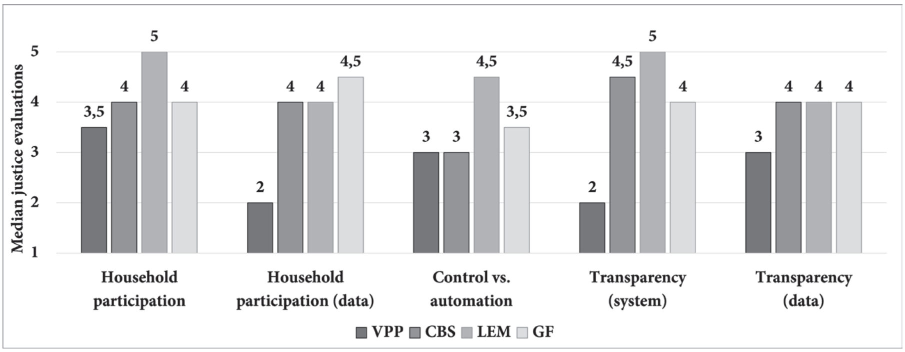



**Figure 5-5: Evaluations of procedural justice across cases**

had a formal representation mechanism, with clear communication channels between the representatives and the project consortium. In GF, however, the communication between the representatives and the remaining households was less clear than in LEM. Interviewees questioned the extent to which the team really represented the neighborhood. Therefore, participation in GF was evaluated less favorable than in LEM, confirming the importance of establishing clear participation procedures *within* a community (Forman, 2017).

Second, a technology-focused approach made participation challenging. In GF, technical issues with the battery system shifted the user-centric mindset of many consortium members to a technology-oriented mindset. The problems were a side effect of the higher complexity than in other projects: implementing sea salt rather than lithium-ion batteries, a choice for sustainability over technological maturity; and testing multiple smart grid innovations, storage systems and variable network tariffs. This shows that an overreliance on technology can be detrimental to the communication with users and hence their participation (Hansen et al., 2020). In this study, even GF, a project that had all intentions to be very community-oriented and user-centric became absorbed by technological challenges. The electricity system is complex enough as it is and for user-centric design, the application of relatively mature technologies might be advantageous. Third, comparing VPP and CBS shows that justice evaluations depended on the extent to which decisions with the most visible impact on households were participatory. Both projects had a top-down approach. There was no participatory decision-making in VPP, which was evaluated as somewhat unfair. CBS also had a top-down approach, yet household participation was evaluated as somewhat fair. This might be because households could influence one of the most important decisions regarding the community battery: the exact location and visual design of the battery container. Additionally, the main visible technology – the battery – was not installed in the homes and thus seen as more removed from the private space than in the other projects. This confirms that for participation to be fair, the project decisions with high importance for users and low degree of reversibility should be participatory (Sovacool and Dworkin, 2015).

None of the projects implemented household participation through collaborative ownership of assets, although this is a very important aspect of citizen participation in other areas of the energy transition, e.g. in the implementation of wind and solar parks, and has been shown to foster the acceptance of such energy projects (Cowell et al., 2011). Collective ownership of smart grid assets might be especially relevant for community storage. Accordingly, Kalkbrenner (2019, p. 1361) argues that co-ownership, collaborative business models, and shared resources could be encouraged as tools to engage citizens in local energy systems and "represent a step toward more sustainable production and consumption patterns".

***Control vs. automation***

Our results generally show that higher user control would lead to increased justice evaluations. User control depends on the design of the user interface of the HEMS and ideally, interviewees agreed, meaningful household control would involve that users are able to decide how much they want to control. In the LEM project, for example, which received the highest justice evaluations, the P2P trading is fully automated in the default settings, but households can view what the algorithm has come up with, and have the option to configure trading settings.

At the same time, however, as much automation as possible was considered necessary to guarantee ease-of-use, comparing use to the simple act of switching on lights. Ease-of-use is also important for high accessibility to people with low IT literacy. The VPP and CBS project chose as a consequence for full automation of the batteries. In VPP, this was seen as somewhat unfair, because households did not have insight into the why and how of battery steering. Yet it had an impact on them; it influenced their energy costs, and batteries were noisy and heated up during (dis)charging. In CBS, external control might have been more acceptable than in VPP due to the greater physical distance between households and the community battery (installed at the street corner) compared to VPP batteries (installed in homes).

These findings highlight a fundamental tension for digitalization in energy systems. Smart grids aim to decrease complexities of governing electricity systems under large shares of renewables and are also supposed to give prosumers more control over their electricity use (Michalec et al., 2019). Yet the management of these IT systems relies on considerable expertise to create and operate software, which mediates users' control of the system. This potentially decreases users' control, increases IT dependency, and shifts power towards software operators (Buth et al., 2019). Our findings suggest that transparency is key to design for fair control and reduce this tension. A higher degree of automation is acceptable as long as users have insight into the system steering and can understand e.g. battery behavior. We will focus on system transparency next.

***Transparency***

Similar to our results for household control, transparency is determined largely by the design of the HEMS user interfaces and higher transparency was evaluated as more fair. GF's user interface was evaluated as transparent and relatively easy to use.

The app reflected the project's variable tariffs using green/orange/red traffic lights to show network load levels affecting the tariff. The traffic lights gave households the possibility to make an informed decision regarding energy use. However, acting in response did require conscious efforts by users. The app would not show the source of the load, or the household's contribution to the collective load. The latter is critical information, though, since the collective community load determines benefits. For successful collective action, the user interface should show real-time feedback on individual's contribution and include features that allow individuals to coordinate their actions (Bourazeri and Pitt, 2018).

VPP provides an example of insufficient transparency. (Dis)charging was done to optimize trading and not coupled with use and generation patterns of the households. The user interface did not show information regarding external actions by the aggregator, and the battery behavior was thus not comprehensible for households. The lack of transparency interrupted households' trajectory to energy conscious citizens, which had started when they first installed solar panels. Many households saw participation in VPP as a logical next step in their engagement with the electricity system. However, the 'black box' VPP, in addition to the full external control, led to less engagement and monitoring of energy patterns (Gerritse et al., 2019). This highlights again the paradoxical situation that technologies which are in principle intended to increase the accessibility of the electricity system for consumers and enable them to take a more active role in the energy transition interrupted the process of prosumer engagement with the system (Goulden et al., 2014). Especially with electricity, which is invisible and removed from people's consciousness, designers should ensure that users can understand and meaningfully act in response to the information they get.



### 4.2 Dynamic interrelations between dimensions of justice

After discussing the evaluation criteria one-by-one in the previous section, we now address design complexities that arise from interrelations between the three dimensions of justice. Indeed, our results show that the separation in three dimensions is analytically useful, but that in practice they are closely interrelated (Bulkeley et al., 2014). These interrelations need to be analyzed to fully understand injustices and address them through design. First, and with respect to distributive justice, we find that it was related to perceptions of fair and transparent processes. For example, allocating profits to individuals or to the collective was perceived as fair depending on whether there was an individual or collective process of achieving those profits. Additionally, fairness of data governance depended on transparency and participatory decision-making. These findings confirm that perceptions of procedural justice are instrumentally linked to perceptions of distributive justice (Folger, 1987; Mundaca et al., 2018). Fair procedures can be enabled, among others, by material participation through community co-ownership (Bidwell, 2016; Cowell et al., 2011). Our findings add a form of material participation through household control of smart grid technologies. In fact, the smart grid itself is a process to achieve outcomes – for example energy savings – and the extent of household control over this process influenced perceptions of distributive justice.

Secondly, our findings confirm the importance of recognition as a separate justice dimension (Schlosberg, 2007). Especially accessibility and inclusiveness of smart grid systems influenced general justice perceptions across cases. Recognition thus underpins and enables procedural and distributive justice. A lack of recognition of specific groups and their characteristics will not result in a truly just process that is participatory for this group (Schlosberg, 2007). Distributive outcomes are also likely to be affected, with misrecognition of those people's needs resulting in unequitable distribution of benefits and harms (Bulkeley et al., 2014). The attention to justice as recognition thus gives legitimate reasons to address distributive injustices in smart grid design and policies.



Thirdly, our findings reveal a conflict between procedural and recognition justice that pertains to the design of user interfaces and algorithms. Procedurally, high user control and transparency is considered fair and necessary. Households need to be able to influence how their profits and costs are generated, understand who gains and pays what, and know how their personal data is used. Yet a high degree of transparency and control might increase the complexity of the user interface design, potentially compromising the ease-of-use and therefore inclusive accessibility. This tension highlights the necessity for simple solutions that are still transparent for users (Paetz et al., 2011). GF's traffic light system is an example of such a solution.

Incorporating all three dimensions of justice in this study was useful to understand in depth why design choices regarding distributive aspects are seen as (un)fair. Therefore, highlighting interrelations between the dimensions is needed to provide recommendations how design can contribute to justice. These insights would not have been possible with a narrow focus on distributive issues that is taken in the few existing studies on energy justice for smart grids (e.g. Neuteleers et al., 2017).

### 4.3 Design for replication and expansion

The design considerations above have focused on the scope of a pilot project. Yet, pilot projects are implemented to serve as experience for future applications in different contexts (replication) and at a larger scale (expansion) and this should be taken into account in the design of pilots. However, our findings indicate that this is typically not the case. This is problematic and risks embedding injustices in future smart electricity systems, since a range of design choices were only seen as acceptable in the context of the pilot project, but not fair in context of a regular retail market offering. Examples are the equal distribution of profits to participating households in VPP, and the use of personal household data and full automation of batteries in VPP and CBS.

These design choices were justified in the project context based on the projects' aim and budget and on their framing as research and development. Thereby, the involvement of the DSOs and universities, and the public funding of the projects instilled trust in households that the project would be designed and operated in an acceptable manner. It is unlikely, however, that future market-based smart grid services will be offered in similar private-public collaborations; the electricity sector actors most likely to offer such services are energy suppliers and aggregators.



Considering the system's future applications from the design onwards might avoid embedding structural injustices. Two design choices seem especially important for replication and expansion. Firstly, a greater emphasis on a structured approach to knowledge sharing than we found in our case studies. Secondly, accessibility can be enhanced by not requiring all participants to own PV and batteries, implementing community storage, or a collective generation facility. Whereas our framework was used in this study to evaluate the structural design of smart grids and compare in a cross-sectional manner four different projects, it might also be used in a longitudinal evaluation of justice over the course of projects.

## 5 Conclusions and policy implications

This chapter analyzed how design choices in four Dutch smart grid pilot projects influenced evaluations of energy justice. It contributes to energy justice literature by providing insight how to design for distributive, recognition, and procedural justice. Based on the findings, we put forth the following recommendations to organizations that want to implement smart grids, be that distribution system operators, hardware and software developers, aggregators, or energy cooperatives. From a distributive perspective, designing for justice involves not only the fair distribution of financial profits and costs, but also the extent of public funding, the active sharing of projects' learnings with the wider public, and fairness in the collection and use of household data. Design for justice as recognition entails ensuring the accessibility of benefits from smart grids to all energy users. This covers in particular accessibility for low-income groups, tenants, households without the physical space for PV systems and batteries, and users with low IT literacy. To enable procedural justice, designers should open decision-making processes to user participation, allow material participation through user control of HEMS, and focus on system transparency. Participatory decision-making should thereby apply most importantly to decisions on cost/profit distribution, data governance, the design of the user interface, and the physical design and placement of storage systems. Designing smart grids for justice should also include conscious design for a fair expansion to larger-scale market services, in order to avoid embedding injustices structurally in the technologies. To do so, designers should especially focus on knowledge sharing and system accessibility.

The comparison of four cases limits generalizability, but our approach was consistent with the aim to analyze *why* certain design choices are considered more fair than others (Yin, 2014). It provided detailed and context-dependent insights into interrelations between justice dimension, and how these can be addressed through design. Future research should focus more on justice as recognition, which is undertheorized (Bulkeley et al., 2014). Yet misrecognition of vulnerable groups can be the starting point for procedural and distributive injustices.



Future research might also explore the feasibility and effects of governance as commons and collective ownership in smart grid systems. High justice evaluations of the collective effort to generate and use electricity locally and therefore gain collective benefits suggest that this can be useful to enable distributive justice. Additionally, collective ownership is an important aspect of citizen participation in the energy transition. This would be a fruitful avenue for (energy) justice research, not the least because there is a knowledge gap regarding commons governance in socio-technical systems (Acosta et al., 2018; Melville et al., 2017). The question whether notions of commons governance and collective ownership might be extended from the boundaries of local smart grids to national electricity networks more broadly might also warrant academic discussions.

Although we did not detail the role of trust, our findings are consistent with previous research showing that trust between households and consortium members positively influenced justice evaluations (Dwyer and Bidwell, 2019). Thus, future research could emphasize how to build trust in a smart grid context and how user interfaces mediate trust between users and software developers.

Our study has implications for policymakers. As smart grid pilots rely on public funding (Gangale et al., 2017), funding organizations – in the Netherlands for example the Netherlands Enterprise Agency (RVO) – can use the evaluation framework developed in this chapter to incorporate energy justice in funding criteria. We particularly emphasize that funds should be directed to projects that are complementary and replicable. A barrier for knowledge sharing is likely to remain, because of tensions between design for openness and development of proprietary business models. However, public money should be spent for public benefits, and funds primarily given to projects that develop open platforms and business models. Additionally, funding bodies should ensure that benefits from smart grid technologies are accessible to diverse societal groups. The focus on home owners in most projects risks structural misrecognition of the needs of other groups in society. More targeted experimentation with vulnerable groups which face higher complexities for smart grid deployment, particularly social housing and low-income communities, is needed to understand those users' preferences and energy practices.

Moreover, our findings have implications for electricity sector regulation, especially for storage. Storage is one of the most important local flexibility-providing technologies, but faces institutional barriers. Among others, the current net metering scheme implies that storage has no financial viability for residential prosumers. A replacement rule for net metering, which will be phased out from 2023 onwards, decreases the reward for feed-in of renewable generation, thus making storage financially more attractive (Directoraat-generaal Klimaat en Energie, 2019b). Policymakers should strike a balance between incentivizing self-consumption while not deterring renewable generation and endangering renewables targets. Next, policymakers should facilitate the collective ownership of community storage as this is already an important mechanism to enable procedural and distributive justice for e.g. wind and solar parks. In addition, storage falls within the definition of both producer and consumer of energy, and as a consequence of this and strict ownership unbundling of commercial activities and network operation, DSOs are prohibited to own and operate storage (Mir Mohammadi Kooshknow and Davis, 2018). Policymakers should adjust regulation so that DSOs can benefit from storage owned by market parties for grid-stabilizing services.

Finally, this study is a response to the increasing importance of justice in energy transitions. The value of justice has gained remarkable salience in the political debate on sustainability transitions (European Commission, 2019c; UNFCCC, 2018). Academic literature on energy justice has been growing as well, but has little impact on policymakers and technology developers (Galvin, 2020; Jenkins, 2018). Our study contributes here by giving actionable recommendations how technology developers and policymakers can consciously design smart grid systems that are not only smart, but also equitable and inclusive.

## *Appendix A. Interview guidelines*

**PART 1: PROJECT AND INTERVIEWEE'S ROLE**

1. Could you explain what your role in the project is?
2. When did you become involved in the project? At what stage of the project was that?
3. In your opinion, what was the main reason for starting the project?
4. Do you think the project was successful? Why / why not?

**PART 2: EVALUATIONS OF JUSTICE**

***Allocation mechanisms***

| | | |
|---|---|---|
| 5. | How fair / unfair do you think are profits divided among the households? Why?<br><br>Probing categories: Monetary benefits, energy savings, high and low income households, people who own vs. people who rent their homes, prosumers vs. consumers | *1 = very unfair*<br>*2 = somewhat unfair*<br>*3 = neither unfair nor fair*<br>*4 = somewhat fair*<br>*5 = very fair*<br>*don't know* |
| 6. | How fair / unfair do you think are costs divided among the households? Why? | *1 – 5 = very unfair – very fair*<br>*(don't know)* |
| 7. | What do you think about the spending of public money on this smart grid experiment? Why?<br><br>Probing categories: by the government, by the DSOs | *1 – 5 = very unfair – very fair*<br>*(don't know)* |
| 8. | When you think about the knowledge that is gained from the project: What do you think about the availability of knowledge to the wider public? Why? | *1 – 5 = very unfair – very fair*<br>*(don't know)* |

***IT Systems***

| | | |
|---|---|---|
| 9. | How much IT knowledge must users have? How fair or unfair is this in your opinion? Why? | *1 – 5 = very unfair – very fair*<br>*(don't know)* |
| 10. | Think about how the extent to which households can control the system in comparison to how much is automated: How fair or unfair is this? Why?<br><br>Probing question: What options do users have to overrule automated system functions? | *1 – 5 = very unfair – very fair*<br>*(don't know)* |
| 11. | When you think about the way households get informed of their electricity use: How transparent is it for users to understand the effect of their behavior on electricity use? Why?<br><br>Probing question: How do users receive this information? | *1 = very opaque*<br>*2 = somewhat opaque*<br>*3 = neither opaque nor transp.*<br>*4 = somewhat transp.*<br>*5 = very transparent*<br>*don't know* |

***Management of household data***

| | | |
|---|---|---|
| 12. | How fair or unfair do you find the way how household data is collected and used by the project partners? Why?<br><br>Probing questions: What data is collected? How and by whom are data collected, accessed, used? | *1 – 5 = very unfair – very fair*<br>*(don't know)* |
| 13. | Did users have an influence on decisions how to collect, access, use, their data? How fair or unfair do you think is that? Why? | *1 – 5 = very unfair – very fair*<br>*(don't know)* |
| 14. | How transparent is it for households who has access to their data and how? Why? | *1 – 5 = very opaque – very transparent*<br>*(don't know)* |

***Collaboration in the project***

| | | |
|---|---|---|
| 15. | When you think back how you selected the community: Why did you decide for [community]? How fair or unfair is that? Why? | *1 – 5 = very unfair – very fair (don't know)* |
| 16. | How fair or unfair do you think were the criteria for selecting households? Why? | *1 – 5 = very unfair – very fair (don't know)* |
| | Probing questions: Selection criteria for households? How were households approached, selected, and how did they decide about participating? | |
| 17. | How are users included in decision-making processes? How fair or unfair is this in your opinion? Why? | *1 – 5 = very unfair – very fair (don't know)* |

***Scaling-up and replication***

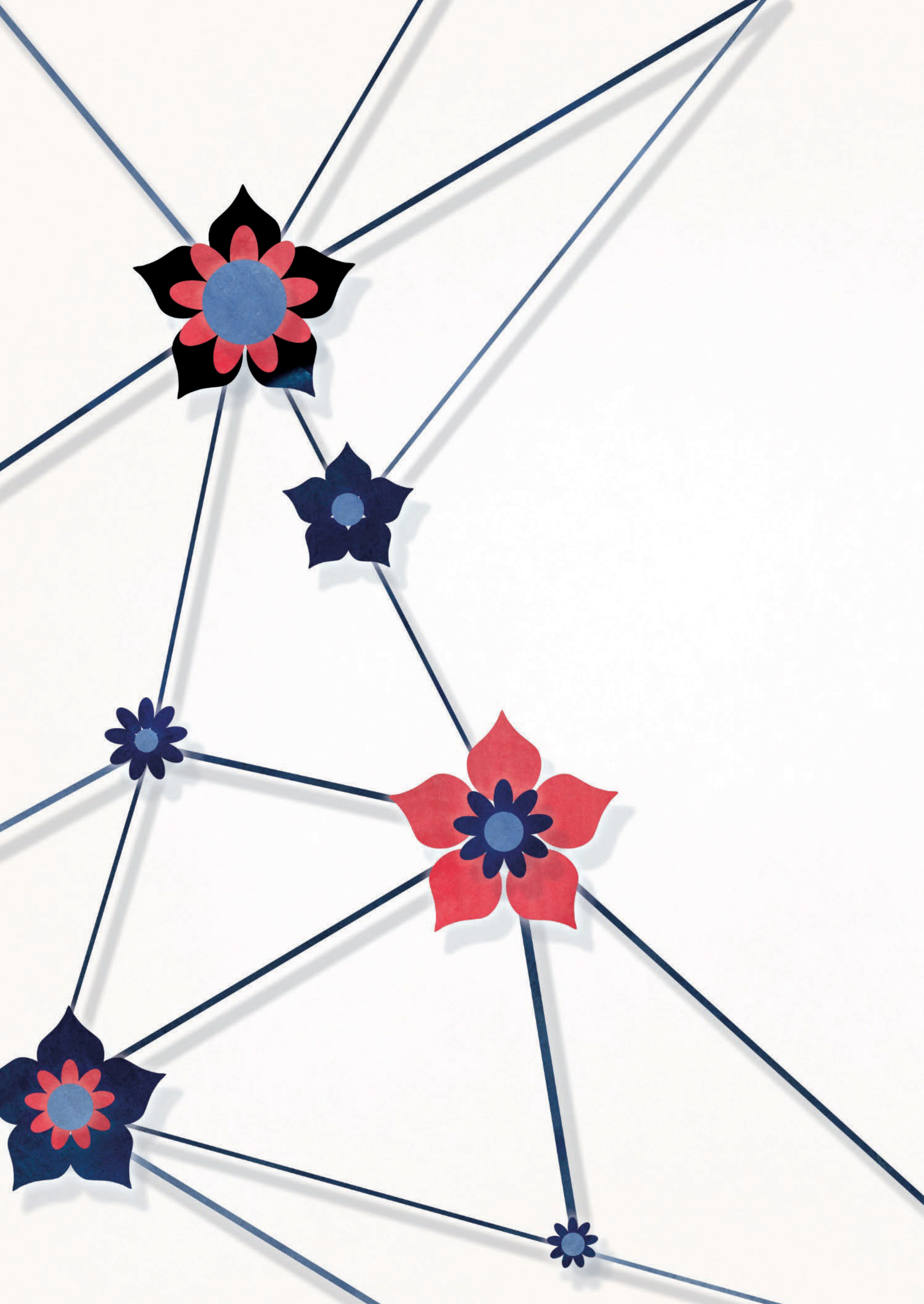
| | | |
|---|---|---|
| 18. | To what extent would the technology be accessible for different user groups? How fair or unfair do you find that? Why? | *1 – 5 = very unfair – very fair (don't know)* |
| | Probing categories: people who own their home and live in it, people who live in a rented home, people who live in social housing, low-income citizens, people who do not produce their own electricity | |

## Appendix B. Overview of design choices relevant for energy justice across cases

**Table 5-5: Design choices relevant for energy justice across cases**

| Justice Evaluation Criteria | VPP | CBS | LEM | GF |
|---|---|---|---|---|
| **Distributive** | | | | |
| Distribution of profits | Individual: Profits from trading mode distributed equally to households<br><br>Allocation of batteries: 1 battery / household | Individual: 50% discount on rent of PV for one year for all households<br><br>Allocation of battery capacity: same capacity for all households | Individual: Profits from P2P trading based on household's choices<br><br>Allocation of batteries: 3 batteries / 16 households, diversity-based allocation | Collective: Electricity cost savings distributed to collective for collective spending<br><br>Allocation of batteries: 20 batteries / 47 households, space-based allocation |
| Distribution of costs | 'Not more than usual' principle for households<br>Compensation of battery losses | 'Not more than usual' principle for households | No household cost for smart grid system<br>No compensation of battery losses | 'Not more than usual' principle for households<br>Compensation of battery losses |
| Public funding | Yes: European Union | Yes: national subsidy | Yes: partly DSO-funded | Yes: national subsidy |
| Knowledge sharing | High | Moderate | Moderate | Moderate |
| Data governance | Smart meter data linked to households shared within project consortium<br>One smart meter per household | Smart meter data linked to household shared within project consortium | Smart meter data linked to households shared within project consortium<br>Separate meters for generation, appliances, heat pump, storage | Smart meter data anonymized before sharing within project consortium<br>'Privacy by Design' designation |
| **Recognition** | | | | |
| Selection of community | Selection based on existing infrastructure / technology | Selection based on existing infrastructure / technology | Self-selection by community | Selection based on existing infrastructure / technology |
| Selection of participants | Self-selection | Self-selection | Self-selection | Self-selection |
| Technology accessibility | Low<br>Participation requirements: Location, PV system, Home battery | Moderate<br>Participation requirements: Location, PV system | High<br>Participation requirements: Location | Moderate to high<br>Participation requirements: Location |
| IT literacy required | Low | Low | Moderate | Moderate |

| **Justice Evaluation Criteria** | **VPP** | **CBS** | **LEM** | **GF** |
|---|---|---|---|---|
| **Procedural** | | | | |
| Household participation (general) | Low:<br>no formal procedures information evenings for households | Low:<br>no formal procedures information evenings for households | Medium:<br>participation through one dedicated user representative | High:<br>participation through dedicated user representation committee |
| Household participation (data) | Low:<br>consent | Low:<br>consent | Medium:<br>influence on data collection mechanism | Medium:<br>influence on data collection mechanism |
| Control vs. automation | No household control<br>Full automation | No household control<br>Full automation | High household control<br>Full automation possible | Moderate household control<br>Full automation possible |
| Transparency (general system) | User interface:<br>generation, use, storage | User interface:<br>generation, use, storage | User interface:<br>generation, use, storage, settings for P2P trading | User interface:<br>generation, use, storage, pricing status |
| Transparency (data) | Data collection and use specified in user contract | Data collection and use specified in user contract | Data collection and use specified in user contract | Data collection and use specified in user contract |



CHAPTER 6:

# CONCLUSION

*This dissertation has aimed to analyze the moral implications of smart grid systems, and provide guidance for designers and policymakers on how to address these implications in smart grid technologies and institutions, with the ultimate motive to increase the systems' ethical acceptability. Chapters 2 to 5 have addressed this aim by, firstly, identifying and conceptualizing the role of moral values in the energy transition and smart grid systems (Part A; Chapters 2 and 3) and, secondly, understanding potential implications of smart grid systems for energy justice (Part B; Chapters 4 and 5).*

*The following concluding chapter synthesizes the findings by reflecting on the research questions outlined in Chapter 1. It discusses implications for academic research and develops avenues for future research. Additionally, it outlines the practical implications of the dissertation for the design of smart grid technologies and energy policy. The chapter ends with a reflection on the wider importance of researching values and technologies based on the experience gained during the development of this dissertation.*

## 1 Summary of findings

Smart grid systems are widely considered as a crucial enabler in the transition to renewable energy systems. However, their introduction comes with serious moral repercussions, for example regarding data privacy and security, autonomy and control, transparency, and inclusiveness.

This dissertation has *analyzed the moral implications of smart grid systems, and provided guidance for designers and policymakers on how to address these implications in smart grid technologies and institutions, with the ultimate motive to increase the systems' ethical acceptability*. This has been done through two approaches:

A. Part A (Chapters 2 and 3) focused on identifying and conceptualizing the role of moral values for institutional development within the energy transition and for smart grid technology design.
B. Part B (Chapters 4 and 5) concentrated on understanding potential impacts of smart grid systems on energy justice, and developing design and policy recommendations for just and smart grids.

The approach used in Part A was motivated by the complexities that arise from different perspectives on values in various academic disciplines – most importantly moral philosophy, social psychology, and institutional economics – and the need to have more clarity on how these conceptualizations are related to the development of socio-technical systems. Additionally, I aimed to create an inventory of the underlying normative convictions behind smart grid systems; this concerns both what values are underlying reasons to develop the systems and what values might be negatively impacted.

The approach in Part B was motivated by the proposition that energy justice is one of the most comprehensive approaches to consider moral implications of changing energy systems (Miller et al., 2013; Sovacool et al., 2016), but that this literature had so far not addressed potential justice implications of smart grids. I therefore showed that energy justice in this context needs to pay attention to repercussions arising from digitally connected systems, automation, and the recording and sharing of real-time energy data. From a practical perspective, the focus on energy justice was also motivated by an increased salience of justice arguments in public controversies regarding the energy transition, the recognition in political debates that a 'just transition' is needed, and the concurrent limitations of the energy justice literature to provide concrete guidelines for technology designers and policymakers.

The following paragraphs synthesize the findings of this dissertation by answering the research questions articulated in Chapter 1.

***A/1. How do values and value changes influence institutional change, and how can this influence be illustrated in the energy transition?***

To address this question, Chapter 2 presented an interdisciplinary framework explicating how values influence institutional change in the case of the energy transition. The conceptual analysis built on a dynamic Institutional Analysis and Development (IAD) framework (Ostrom, 2005; Pahl-Wostl, 2009), which was expanded by perspectives on values in moral philosophy, institutional economics, and social psychology.

The IAD framework situates institutional development (e.g. the adoption of a new energy policy) in 'action situations', in which 'participants' (e.g. policymakers, regulatory authorities) take decisions and actions (e.g. to write, discuss, and vote on policy) (Ostrom, 2011, 2005). Decision-making in action situations is influenced by a number of 'exogenous variables', which are analytically separated in the existing rules, the material and technical conditions of the system or infrastructure concerned, and attributes of the community in which the action situation takes place. Decisions in actions situations lead to 'outcomes', which are typically new or amended institutions. These are, once implemented, scrutinized through a process of evaluation that can trigger social learning processes leading in turn to new action situations and finally institutional change.



The process of institutional change can be influenced by values in multiple ways. Conceptualizing values from the perspective of moral philosophy, institutional economics, and social psychology allowed mapping these levels in greater detail. In doing so, the chapter showed that the three perspectives on values are complementary.

In moral philosophy, values are defined as normative human convictions that can be intersubjectively justified and are worth striving for to lead a good life and achieve a just society. Technologies can endorse or harm (embed) specific values through their design and use (Shrader-Frechette and Westra, 1997a; Van de Poel and Royakkers, 2011). Typical values relevant for energy systems are affordability of energy, environmental sustainability, and justice. Relating this to the IAD framework, values influence institutional development in three main ways. Firstly, they do so through their embeddedness in existing material conditions, e.g. technologies. For example, large hydropower dams have implications for *affordability of energy*, providing access to relatively affordable renewable energy, but have repercussions for *environmental* *protection* of river systems and *distributive justice* due to effects on downstream water supply. The value implications of existing infrastructures provide the basis on which rules for this infrastructure are adapted during action situations. Secondly, values exert an influence as intersubjective convictions that can be shared by a community. For example, the changes in the core objectives of the European Union's energy strategy from *market efficiency* to *security of supply, affordability, and sustainability* during the 2000's shows how changing normative values can broaden policy objectives considered in action situations. Thirdly, values act as evaluation criteria for new or amended institutions. For example, a new rule for incentivizing investment in solar power generation might be assessed for *economic efficiency* and its potential to stimulate *consumer participation* in the energy transition. The result of this assessment will influence subsequent institutional change. If new policies do not adhere to values that are regarded as important in a society, value controversies put pressure on policymakers and might induce processes of social learning. This can potentially result in incremental changes in the new policy (single-loop learning), changes in the actor constellations for deciding on new policies (double-loop learning), or even more systematic changes in the environmental, political, and economic context (triple-loop learning).

In institutional economics, values are defined consistent with moral philosophy, and the relationship between values and technology is applied to the relation between values and institutions (Correljé and Groenewegen, 2009). As such, within the IAD framework, values are embedded in existing rules and new/adapted rules that are the result of an action situation. For example, *environmental sustainability* as a core value of European energy policy became embedded in rules regarding the reduction of greenhouse gas emissions, national support schemes for renewables, or rules for the energy efficiency of buildings. Existing rules can thus cause path-dependency in the development of new institutions, which will adhere to the same values or consciously overturn existing value embeddedness.

Social psychology defines values as personality characteristics that influence human decision-making and behavior, for example altruism, self-respect, or freedom (Rokeach, 1973; Schwartz, 1992). In the IAD framework, this conceptualization is relevant for understanding an individual's decision-making in an action situation. For example, participants in action situations with strong biospheric values – e.g. valuing unity with nature and environmental protection – have been shown more likely to support renewable energy. Values thus influence what policies and technologies are preferred by participants and how they are discussed in an action situation.

The main result of Chapter 2 is the expanded dynamic IAD framework. By making explicit how values can influence institutional development on multiple levels – influences that have until now been largely neglected in IAD literature – it furthers the understanding of institutional change. Examples from the energy transition illustrate the potential influence of values and value change. The conceptual framework that results from this analysis enables a value-based analysis of institutional change more broadly and is open to include a variety of relevant values.

Due to the interdisciplinary character and consequential broad scope of the framework, the chapter recommends researchers and policymakers who use the framework for a specific case study to select one of the three value perspectives that best fits the research focus. Overall, the perspective on value embeddedness from ethics of technology proved to be the most insightful for the aim of this dissertation to understand how values are endorsed and harmed by smart grid systems. The remaining part of the dissertation thus took this as leading definition and was guided by the more specific theorizing on values in the value-sensitive design literature.

***A/2. Which moral values can be seen as drivers and barriers for the implementation of smart grid systems?***



Chapter 3, addressing this question, identified and conceptualized moral values that are relevant for the development and implementation of smart grid technologies. The findings were based on a systematic literature review of empirical studies on smart grid systems.

The literature review identified a range of values that can form drivers and barriers for the implementation of smart grids. Drivers are underlying motivations for smart grid development or values that are positively influenced by the technologies. Barriers are values that might be negatively impacted by smart grids. Judging from the number of articles mentioning a value, environmental sustainability, which is defined as reduction of greenhouse gas emissions from the electricity sector, is the most important driver for smart grid implementation. Other drivers involve security of energy supply, and transparency. On the side of barriers, data privacy – concerns that the increased sharing of energy use data automatically and in real time might allow external parties insight into private household activities – is the value mentioned most frequently. Others are data security, (mis)trust, health, justice, and reliability.

Beyond that, a range of values partly form drivers and partly barriers to smart grid implementation: these are control, inclusiveness, quality of life, and affordability.

Whether smart grids affect these values positively or negatively depends on the detailed technological and regulatory context. For example, the concern of losing control to IT systems depends on the existence of features to manually override the system automation. In addition, the effect depends on the conception of a value, which might be contested. Contestations, and possibly controversies occur when there are different interpretations on the meaning of a value - i.e. different value conceptions – and thus different judgements how a technology might impact a value (Hart, 1961; Rawls, 1971). For example, the extent to which smart meters contribute to affordability of energy depends whether one includes effects on energy savings or broader cost savings. Smart metering might not contribute to the latter if a households' energy savings are offset by socialized costs for the smart metering infrastructure.

Based on findings from the literature review, the chapter argued for moral values to be incorporated more explicitly in technology acceptance studies as potential variables that impact user acceptance. To do so, it suggested that researchers combine insights from value-sensitive design and technology acceptance literature. Value-sensitive design can offer a normative perspective on the identification and conceptualization of values as well as on a values' relation to technology characteristics. Technology acceptance literature offers the empirical tools to test the relationship between moral values and the acceptance of a technology by its users.



***B/3. In what ways do smart grids potentially impact justice and what does this imply for current conceptualizations of energy justice?***

Chapter 4 addressed this question through an exploration of public debates on smart grid developments in the Netherlands and the United Kingdom. The smart grid development in both countries started around the same time, in 2006 and 2007 respectively, and both have witnessed controversies during the national smart metering roll-outs.

The chapter defined energy justice as 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" (Miller et al., 2013, p. 143). It followed the dominant conceptualization in the field to break down justice in the three interrelated dimensions: Distributive justice, procedural justice, and justice as recognition (Jenkins et al., 2016; Schlosberg, 2007).

Findings from analyzing the public debate show that pro and contra smart grid arguments reflect implications for distributive and procedural justice. Most of these implications are connected to the roll-out of smart metering, which is the dominant topic in the debates in both countries. This is due to the special role of smart metering as an enabler for other smart grid applications and because its implementation is done in the form of national roll-outs, which increases its reflection in national media (whereas until now other sub-systems are mostly deployed in the form of small pilot projects).

Positive justice implications, generally speaking, are that smart grids are seen as part of a development towards more democratic and open energy systems, with higher citizen participation and empowerment. This is, firstly, because smart grids facilitate small-scale electricity generation, temporal self-sufficiency for prosumers, and are thus a key technology for role shifts from 'passive consumers' towards 'energy citizens'. This gives a larger number of users a more powerful position in the energy market and a wider choice in their energy-related behavior. In addition, smart metering, in-home displays and/or apps enhance the transparency of energy use for consumers and provide a precondition for more conscious energy-related behavior and ultimately energy (cost) savings. More timely insight into energy use and costs is especially relevant for lower-income households. Also, the choice of a voluntary over a mandatory smart metering roll-out, after initial controversies, increases consumer choice and constitutes more equitable roll-out procedures.



Negative justice implications, however, are reflected in the debate whether current smart grid designs can live up to their promise or exacerbate existing injustices. Potential distributive injustices concern the distribution of benefits and harms between consumers and energy companies. Energy companies and governments have framed smart metering as benefitting mostly consumers through energy savings. In these arguments, the relationship between increased transparency of energy use and energy savings is often depicted as causal. However, criticism from consumer organizations point out that the assumption that increased transparency of energy use will lead to savings is just what it is: an assumption. The responsibility for saving energy still rests on consumers, who need to actively interpret and act upon the information they get. Additionally, consumers might benefit less than energy companies, for whom smart metering offers the opportunity for additional revenues and more cost efficient billing processes. It is not only questioned whether consumers benefit as much as expected, but also whether the distribution of costs is fair. On the one hand, this concerns the costs for the smart metering roll-out, which are socialized and thus in the end covered by consumers. On the other hand, it is related to data privacy and security challenges: it can be questioned whether it is fair that consumers should accept potential privacy violations in return for uncertain monetary benefits. Injustices might also arise in the distribution of benefits and costs between different consumer segments, as complex technologies requiring specific knowledge might discriminate towards groups with low IT literacy. Additionally, several aspects of smart grid pilot projects are criticized as unfair: the selection procedures for consumers who participate in these projects, the strong involvement of distribution system operators and experimentation using public money, and the increased reliance on specialized IT knowledge which might shift power from public bodies (e.g. municipalities) to private software companies.

The findings in Chapter 4 provided a basis to broaden existing conceptualizations of energy justice from aspects pertaining to energy supply and use to include implications that are caused by an increased convergence of the energy and ICT sector. This involved relating (in)justices to transparency, control, privacy, and security. This broader conceptualization is especially needed if the 'energy justice' concept is to live up to its proposition of being one of the most comprehensive approaches to considering social and moral values in energy systems.

### ***B/4. How does the design of smart grid projects impact energy justice?***

Question B/4 was addressed in Chapter 5, which investigated real-life implementations of smart grids in four local pilot projects through a comparative case study research design. The four cases were neighborhoods in which distribution system operators, energy suppliers, aggregators, software providers, hardware providers, research institutes, energy consultants, and households worked together to trial how smart grid technologies can help to gain more flexibility in low-voltage grids and especially deal with supply intermittencies caused by solar generation. Thus, the pilot projects combined PV systems, home or community batteries, and smart metering with software platforms to optimize local electricity flows. The chapter evaluated these pilot projects regarding how their design features influenced perceptions of distributive, recognition, and procedural justice. The evaluation framework was developed based on the energy justice conceptualization from Chapter 4.

From a distributive perspective, the chapter finds that evaluations of justice are enabled by three design features:

- A mechanism for allocating profits to households that is congruent with the process to achieve the profits (e.g. a collective allocation mechanism is perceived as fair if profits are dependent on the behavior of all participating households),

- active sharing of project knowledge with external parties to allow other distribution system operators, energy suppliers, aggregators, municipalities, and communities to learn from experiences in the pilot project,
- and collection and use of smart metering data that were anonymized, appropriately protected, and restricted to data needed for the purpose of the project.

From the perspective of recognition, justice can be enabled by
- a systematic and structured selection process for the community and participants, taking into account the generalizability of findings beyond immediate pilot participants,
- more experimentation with people who are not owner-occupiers of their homes, such as tenants and social-housing communities,
- increasing the accessibility of smart grid technologies – especially costly PV systems and batteries – for lower income households, through rental mechanisms, community storage, and smart grid communities that do not require all participants to install these technologies,
- and increasing the ease-of-use of home energy management apps and displays to lower the IT knowledge required from users.

From the perspective of procedural justice, projects are evaluated as more fair if
- households participate in decision-making processes, at least for the decisions that have the most visible impact on them (e.g. placing of a community battery),
- participatory decision-making includes a formal household representation mechanism and communication channels between the community representatives and the project consortium as well as between the community representatives and the remaining participants,
- users can exert control over functions such as using batteries for self-consumption, shifting energy use to reduce peaks, or peer-to-peer trading, implemented through the user interface of the home energy management system,
- and this user interface is easy to use and enables users to transparently understand system functions and consequences for the households' electricity use and cost.

Smart grid designers should implement these measures when designing for justice, but are not the only parties that should be held responsible for design for justice. Policymakers and agencies that support innovation in smart grids with public funding can and should have a strong influence. Energy justice should be integrated in funding criteria for pilot projects, and the evaluation framework in Chapter 5 can form a basis for that. Funding agencies should particularly emphasize projects that can be replicated and expanded in a fair way. To do so, greater emphasis needs to be placed on structured sharing of knowledge for future applications, learning from past pilot projects, and the development of open platforms and business models to ensure complementarity between projects and replicability. In addition, focus should be put on accessibility to a wide range of users. More pilots that experiment with vulnerable groups – particularly social housing tenants and low-income communities – should take place, as these groups are currently underrepresented in smart grid pilot projects.

## 2 Theoretical implications and future research

This section reflects on broader theoretical implications of my findings and outlines avenues for future research. It discusses, firstly, implications of the overall aim to support the ethical acceptability of smart grids and how this might relate to their social acceptance (Section 2.1). Secondly, with respect to the objective of conceptualizing relevant smart grid values, it picks up the approach of studying perceptions of value embeddedness and suggests how indicator-based research might provide valuable supplementary findings (Section 2.2). Thirdly, two sections (2.3 and 2.4) reflect on energy justice and propose how to address knowledge gaps related to the role of trust and interrelations between the three dimensions of energy justice.

### 2.1 The relationship between a system's acceptability and acceptance



Philosophers might argue that, despite claiming that this dissertation aims to address the *acceptability* of smart grid systems, in fact I focus on the systems' *acceptance* on the grounds that most chapters have an empirical component, focus on perceptions of values/justice, and Chapter 3 even mentions user acceptance explicitly.

To untangle this, it helps to recall the definition of acceptability and distinguish it from acceptance. While ethical acceptability is a predominantly normative concept (referring to the extent to which a technology "takes into account the moral issues that arise from its introduction" (Taebi, 2016, p. 1818)), acceptance is a predominantly descriptive concept (and thus an empirical state-of-affairs relating to whether new technologies are accepted by affected stakeholders (Wüstenhagen et al., 2007)). Especially in interdisciplinary settings, it is helpful to clarify the distinction, as it reflects how different disciplines study the reception of potentially controversial technologies in society. Acceptability is a concept that resonates strongly in ethics of technology, whereas acceptance is typically related to social psychology and innovation management.

Expressing that acceptability is a *predominantly* normative and acceptance a *predominantly* descriptive concept already hints that the distinction of the concepts along the lines of normative and descriptive cannot be clearly drawn. Both concepts are 'thick concepts', meaning that they contain both descriptive and normative aspects (Van de Poel, 2016). The normative aspect of acceptance lies in judgements such as 'what constitutes acceptance, is it use, or are intentions/attitudes sufficient?', or 'does the acceptance of all stakeholders weigh equally (or not) when determining overall acceptance?'. Similarly, acceptability has a descriptive component in the sense that moral concerns and reasoning are often behind people's judgement when they accept or do not accept a technology. Therefore, one can study empirically which normative evaluations stakeholders express in context of smart grid systems.

In line with these definitions, the predominant contribution of this dissertation is on the side of ethical acceptability: conceptualizing and understanding implications of smart grids for moral values and particularly for energy justice. By using empirical research to elicit relevant values, understand potential justice implications, and evaluate the influence of smart grid design on justice, the dissertation uses acceptability as a thick concept and studies normative stances of stakeholders who are involved in smart grid development and use. Hence, the fact that many chapters in this dissertation contain empirical studies does not stand in the way of them addressing the ethical acceptability of smart grids.



Despite the predominant focus on acceptability in this dissertation, I do not want to suggest that acceptance is not important or not a relevant concept. Understanding the relationship between acceptability and acceptance empirically is an interesting question for future research. Hence, next steps would be measuring the extent to which smart grids are accepted by relevant stakeholders, and testing explicitly to what extent the design for values influences the acceptance of smart grid systems.

Such research should build on some complexities identified in Chapter 3. As observed there, the influence depends on the detailed technological and regulatory context (for example, whether control was seen as a barrier for the acceptance of an automated demand-response service depended on options to override the automation). It also depends on the conceptions assigned by users to values (for example, perceived sustainability of a technology will differ when it is conceived as 'locally emission free' or as more holistic concept that includes social sustainability). Additionally, the interrelatedness of values makes it more complex to test the separate effect of one value and more interesting to test combined effects (for example, when fairness and affordability concerns reinforce each other in negative acceptance impacts). Accounting for these complexities is particularly important for systems such as smart grids, for which there is considerable uncertainty about future deployment and actual real-life impact, as the systems are not yet widely available.

From a theoretical perspective, such research might look to environmental and social psychology, where scholars have studied for example the impact of perceived environmental sustainability, privacy, security, distributive and procedural justice, control, and other values on consumer's intentions to accept smart grids (Chou et al., 2015; Fell et al., 2015; Guerreiro et al., 2015; Park et al., 2014) and renewable energy systems more broadly (e.g. Cowell et al., 2011; Huijts et al., 2012; Koirala et al., 2018; Liu et al., 2019). The vast majority of this work discusses the impact of *perceived* values, however, and is thus limited with respect to understanding the impact of design for values on user acceptance. The latter would require comparing how designs with varying degrees of value embeddedness are received by users.

From a methodological perspective, I would therefore suggest future research to apply experimental research designs (Creswell, 2009), as this allows manipulating the degree and manner of value embeddedness in the technological design, and test how this influences acceptance as outcome. An experimental design would also enable controlling for other factors likely to impact acceptance and thus isolating any causal effect of design for values. The study might be done both as field experiment – for example, confronting users in a smart grid pilot project with design choices that represent different degrees of value embeddedness and studying the influence on acceptance of the design – or survey experiments – for example, presenting respondents with a hypothetical choice from a set of value-sensitive smart grid designs and studying impacts on their willingness to accept the design. As an alternative, serious games might be chosen as they save time and resources compared to field experiments, and allow simulating real-world environments (Peters et al., 1998; Peters and Van de Westelaken, 2014).

### 2.2 From value perceptions to indicators

Throughout this dissertation, the embeddedness of values in smart grid systems has been a perspective of *perceptions* by smart grid stakeholders on how the system design responds to certain values. This was especially so for Chapters 4 and 5, which focused on perceived justice implications expressed in public debates and justice evaluations of smart grid pilot projects.

Future research might complement this perspective by developing indicators for energy justice that enable larger-N studies, increase chances of generalization beyond one country, and facilitate communication of results. These indicators should operationalize the three dimensions distributive, recognition, and procedural justice.

I use the term 'indicator' here following Meadows (1998, p. 6) as measurements that "arise from values" and "measure what we care about". Importantly, I want to point out that the indicators can and should be developed both in a 'top-down' and 'bottom-up' manner (cf. Magee et al., 2013). Top-down approaches tend to favor formal methods, standardization and comparability (Magee et al., 2013), and – in the context of justice – should build on normative ethical theories. Bottom-up approaches are participatory processes to identify and develop indicators with the involvement of the affected community, and thus allow capturing context-specific issues (Fraser et al., 2006). Using both approaches would permit that the indicator development itself respects principles of justice (especially recognition and procedural justice).

The development of such an indicator system can build on existing literature. This includes the evaluation criteria used in Chapter 5, which represent to the best of my knowledge the first justice evaluation framework specifically for the smart grid context, suitable to capture potential injustices caused by digitalization in electricity networks. In addition, existing efforts in the energy justice literature to operationalize the concept into 'metrics' and 'decision-making tools' can be taken as a starting point (e.g. Fortier et al., 2019; Heffron et al., 2015; Sovacool et al., 2017a). For example, Heffron et al. (2018, 2015) develop an energy justice 'metric' that offers an economic analysis which balances the energy policy trilemma (economics, politics, environment) while focusing more strongly on intergenerational inequalities. Fortier et al. (2019) suggest a framework for addressing energy justice that is based on social life cycle assessments.



Where researchers want to build on normative theories of distributive justice, some effort has already been undertaken in the energy domain. For example, Schlör et al. (2013a) build on Rawls theory of justice to measure the distributive fairness of energy consumption. Neuteleers et al. (2017) use a number of distributive principles (equality, ability to pay, cost, benefits) to assess and compare the fairness of a variety of electricity network tariffs. Another alternative example is the work by Bartiaux et al. (2019), who build on Martha Nussbaum's Capabilities Approach and use secondary data to evaluate inequalities in capability attainment resulting from energy transitions in three European countries.

While these papers are a suitable starting point, the energy justice literature is relatively young and in need of more insight into the operationalization of the three justice dimensions in different contexts. Thus, where energy justice criteria remain too abstract or restricted to distributive indicators, operationalization of the concept can build on several related fields such as energy poverty (e.g. Bouzarovski and Simcock, 2017; Nussbaumer et al., 2012; Thomson et al., 2017), energy democracy

(Szulecki, 2018), or (social) sustainability assessment (Fraser et al., 2006; Magee et al., 2013; Meadows, 1998; Rösch et al., 2018, 2017; Schlör et al., 2013b; Sierra et al., 2018). A more detailed review would go too far here, but these publications represent a selected list of appropriate work.

In addition, when comparing a greater number of smart grid initiatives across countries, researchers should be aware that the availability of comparable data on smart grid projects tends to be poor. Besides the fact that justice-related implications are not typically measured, a side-effect of many projects having a technological focus and aim, project reports are seldom publicly available and results tend to be difficult to compare (Gangale and Mengolini, 2019). As a consequence, the measurement of indicators will most probably require a combination of secondary and primary data collection. In fact, the lack of secondary data and codified experiences in the case studies investigated in Chapter 5 was one reason for choosing to study perceived justice embeddedness.

### 2.3 Justice, trust, and acceptance

Within the inventory of relevant smart grid values, findings from Chapter 3 to 5 suggest a central role of trust for the realization of smart grids, which should be explored in greater detail by future research. Chapters 3 and 4 show that the lack of consumer trust in organizations responsible for the implementation and management of smart grid technologies, such as energy companies and regulatory authorities, is one of the central barriers to smart grid realization. Mistrust also increased perceived data privacy and security risks, and led to feelings of unfair distribution of benefits from smart metering. Chapter 5 confirms the intertwined nature of trust and perceived justice. It also shows that household trust towards pilot project consortium partners was contingent on the pilot project context, and more specifically on the involvement of researchers, public companies, and the close personal collaboration between households and consortium partners. This, combined with the likelihood that the services trialed in pilots will be offered in the future as larger-scale services by energy suppliers and aggregators, might prove challenging for the future success of smart grids.

Vis-à-vis these findings, future research should untangle the relationship between trust and other values such as justice and privacy, and how the design for these values – in combination – might influence smart grid acceptance. Such research can build on work regarding renewable energy projects, which has found that perceptions of justice are closely tied to community trust in project developers, and that both can positively influence community acceptance (Dwyer and Bidwell, 2019; Goedkoop and Devine-Wright, 2016; Gölz and Wedderhoff, 2018).

In addition, researchers should strive to understand how smart grid developers might create or foster user trust through technological and institutional design. Regarding technologies, an essential element of a smart grid from a user perspective is the user interface (e.g. an app or in-home display) that visualizes electricity flows and gives them control over settings such as battery steering and peer-to-peer trading. In this context, the question would be interesting how such user interfaces mediate trust between users and software developers (Verbeek, 2008). Findings from Chapter 5 suggest that the technology can foster trust through transparency and relevancy or break trust for example by showing incomprehensible electricity flows. Future research should thus explore further how the design of smart grid user interfaces can contribute to building users' trust in the system.

Regarding the institutional design, future research might address whether the provision of smart grid services by energy communities and cooperatives are likely to support user trust more than service provision by retail market actors. In the longer run, smart grid services might also be provided by energy cooperatives. Although this is less likely than provision by aggregators and energy suppliers, due to the technological complexities of smart grids, energy cooperatives have started to experiment with smart grids (Chapter 5 and hier opgewekt (2019)). Findings from Chapter 5 suggest that energy cooperatives might be more trusted than established retail market actors due to their embeddedness in and local knowledge about the community. The participatory decision-making mechanisms in cooperatives might also be conducive to user trust.



## 2.4 Interrelated energy justice dimensions

An important insight from Chapter 5 of this dissertation was that the three dimensions of energy justice are closely intertwined, and that various interrelations need closer understanding when one strives to untangle how and why injustices occur, and find ways to design systems accordingly. I emphasize here particularly the foundational role of justice as recognition, which was an underlying issue for procedural and distributive injustices. In contrast to this, a large part of energy justice literature treats distributive, procedural, and recognition justice as dimensions which are of equal importance, almost parallel (e.g. Heffron et al., 2015; Jenkins et al., 2016; McCauley et al., 2013). In the smart grid context, research efforts have largely been reduced to distributive issues and not looked at underlying procedural and recognition injustices (e.g. Neuteleers et al., 2017; Powells and Fell, 2019). Future research should therefore continue to analyze in greater detail the multiple ways distributive, recognition, and procedural injustices occurring in energy systems might be related to one another.

In this context, it is worth noting that there has been a longstanding debate among justice theorists regarding what dimensions of justice should be treated as separate and distinct. While some theorists of justice (e.g. Rawls, Barry, Brighouse) have focused on distributive injustices, other scholars (e.g. Young, Fraser, Honneth) have argued for a separate treatment of distribution, recognition, and procedural injustices in order to enable explicit analysis of those as underlying reasons of maldistribution. Overall, distributive accounts have dominated, defining justice "almost exclusively as a question of equity in the distribution of social goods" (Schlosberg, 2007, p. 12). Justice as recognition is the most undertheorized of all dimensions (Bulkeley et al., 2014).

Against the backdrop of this debate, the biggest knowledge gap pertains to the role of justice as recognition, which entails thorough analysis of the direct and indirect stakeholders affected by system changes as well as explicit identification and respect of the needs and rights of vulnerable groups.

Addressing justice as recognition has both intrinsic and instrumental relevance. First, all people have the right to be respected in what they need to realize a good life, and a lack of recognition represents a direct constraint of those rights. Second, justice as recognition is the foundation for procedural and distributive justice. Put differently, in order for a distribution to be judged as fair, it is necessary that the principles underlying the distribution (e.g. equality, needs) have been agreed upon in a decision-making process in which affected groups are included, their opinions are respected and their participation has an influence on the decision. If an affected stakeholder group does not have a say in a decision-making process, this process is likely to lead to an unfair distribution of benefits and harms (Bulkeley et al., 2014). In turn, an analysis that highlights how misrecognition might be the underlying reason for an unjust distribution – which might be judged as fair if analytic boundaries are set to include only distributive aspects – gives legitimate reasons to address distributive injustices in system design.

## 3 Recommendations for smart grid designers

On a general level, this dissertation provides smart grid designers with an inventory of values that should form goals for technology design. It details value-laden aspects of smart grid systems and ties relatively abstract values to concrete design features, thus providing the basis for value-sensitive design in practice. Based on this dissertation's findings, the following paragraphs outline what designers might do in order to ensure that future smart grids embed relevant values and, particularly, contribute to a more just energy system.

The recommendations relate to, first and foremost, design for justice in smart grid pilot projects. In addition, they address two further design recommendations that I judge particularly important as they relate to tensions caused by the deployment of relatively complex digital technologies in electricity systems.

**Design smart grid pilot projects for recognition, procedural, and distributive justice.** Whereas Chapter 4 clearly finds that justice issues about smart grids are salient in the public discourse, empirical insights from Chapter 5 show that justice or fairness is not yet an explicit consideration in smart grid pilots, which focus on the technological functioning of the systems. Future projects should consciously design for justice. Considering the interrelatedness of the three justice dimensions and the finding that misrecognition can be an underlying reason for procedural and distributive injustices, design for justice should treat recognition aspects as preliminary issue, followed by procedural and distributive justice. More specifically, the following design recommendations are put forward[13]:

For justice as recognition,

- use a structured selection process for community and participants.
- experiment more with people who are not owner-occupiers.
- do not require all participants to own solar panels and batteries.
- make sure that user interfaces are as easy to use as possible.

For procedural justice,

- set up participatory decision-making processes.
- give users control to set their own preferences for batteries, smart appliances, and peer-to-peer trading in the app or in-home display.
- make sure that user interfaces are transparent regarding electricity flows and consequences for household electricity costs.

[13] These recommendations are related to research question B/4. See Section 1 for a more detailed version.

For distributive justice,

- share profits individually or allocate them to the community as a whole depending on whether there was individual control over profit achievement or not.
- emphasize knowledge sharing from and with other projects.
- collect and use as little personal data as needed.

**Avoid gradual loss of autonomy to IT systems by designing for transparency and meaningful user control.** Smart grid systems promise users greater control and self-determination of their electricity-related behavior, including generation, use, storage, and savings. Yet, the extent to which users can materialize this control depends on the design of the user interface and the optimal use of renewable electricity requires software that automatically matches supply and demand. This reliance on the design of IT systems creates a fundamental tension in smart grids. Despite introduced to enable user control, the complexity added through digitalization might imply more dependency on and loss of autonomy to IT systems, as well as power shifts to the software companies that develop these systems.

The tension between digitalization and automation on the one side and user control and autonomy on the other is also a conflict between justice as recognition and procedural justice. From the perspective of recognition, automation is justified as this increases ease-of-use and accessibility for users with low literacy in IT and electricity systems. Hence, designers might be advised to reduce information depicted through user interfaces, and automate steering of batteries or appliances as much as possible to decrease the need for users to act. Procedural justice, however, demands design for user control, in order to enable active user participation in the smart grid and assist users to capitalize on their demand flexibility.

Designers should be aware of this tension and address it by developing user interfaces and algorithms that focus on ease-of-use, yet are transparent and enable meaningful user control. To achieve transparency, the user interface needs to visualize in detail the electricity flows in the system, e.g. from solar panels to batteries, and from batteries to appliances. It should additionally disclose consequences for energy cost. A user interface that depicts as much information as possible graphically rather than using numbers is advantageous here.

Additionally, designing for transparency entails opening up software, including algorithms and the way they use householders' data, and exposing it to public scrutiny such that users can make sense of the manner in which algorithms optimize the use of their appliances. As observed in Chapter 5, the functioning of software in a smart grid often remains opaque to users. Increasing the explicability of algorithms and the results they produce will become even more important – and challenging – with a more wide-spread deployment of artificial intelligence methods, in which decisions are taken by intelligent agents. This is especially so with machine learning algorithms, which make it difficult if not impossible for humans to fully comprehend the algorithms' functioning and outcomes (cf. AI Ethics Impact Group, 2020; Floridi et al., 2018).

Designing for meaningful user control is also a matter of the user interface. For situations with a high degree of automation, users should be able to determine and change key system parameters. This might concern, for example, the share of battery capacity that they want to utilize for self-consumption or the time settings for smart appliances. For situations in which scheduling of appliances is not fully automated, it requires that the user interface gives unambiguous recommendations what a user could do at a given time to e.g. utilize more renewable energy or save electricity cost.

**Design for justice necessitates a shift from a technology-centric mindset to community-centric approaches when setting up smart grid pilot projects.** As much as smart grids are generally presented as a solution to technological challenges of electricity grids, the vast majority of pilot projects implemented so far in the Netherlands had clear technology-centric orientations. This is visible in the common aim of most projects, identified in Chapter 5 and also in the wider screening of projects before selecting cases for the study in Chapter 5: optimizing the use of locally generated renewable electricity, and testing if smart grid technologies are effective in enabling this. The mindset is also reflected in the projects' governance; most projects are initiated and led by distribution system operators, who aim to test the effects of smart grid technologies on the low-voltage grids they operate, and are characterized by top-down approaches to decision-making.



If design for justice, as outlined in the recommendations above, is to be successful, future projects should move away from this technology-centric to a community-centric approach. This is important for recognizing the needs of the community, and also relevant in order to increase community engagement, a lack of which can be detrimental for the success of the project. Two of the cases presented in Chapter 5 – which were consciously selected as they were more strongly community oriented than the majority of existing pilot projects – offer insights how to do that. This is, on the one hand, GridFlex in Heeten, which is led by an energy cooperative and on the other hand the Local Energy Market in Hoog Dalem, which is led by a distribution system operator but was started on initiative of the community. Hence, for smart grid projects led by distribution system operators, designers should ensure that the project is at least developed in a participatory manner, starting with the needs and wants of the local community. Additionally, governance through an energy cooperative ensures direct participation by members in decision-making processes. Even though cooperatives might be deterred by the technological complexity of smart grids – a valid concern as shown in Chapter 5 – the ‘Experimentation Decree’, set up in 2015 to grant cooperatives exemptions from the Dutch Electricity Act, facilitates experimenting with smart grid solutions as it allows for example supplying members directly with electricity and operating part of the distribution grid (hier opgewekt, 2019; Ministerie van Economische Zaken, 2015).

## 4 Policy implications

Similar to values serving as design goals for technology developers, the inventory of values in this dissertation serve as goals for policymaking regarding smart grids. Designing policies that are value-sensitive is of particular relevance in the context of infrastructures such as the electricity systems, in which policymakers should take responsibility to address the acceptability of systems, or in other words, ensure that infrastructures are designed for a collective societal benefit. The following paragraphs outline implications of this research for policymakers regarding the smart metering rollout, funding of smart grid pilot projects, and electricity sector regulation.

### 4.1 Smart metering roll-out

Smart metering is not only the infrastructure forming the basis for other smart grid services, it is also of special importance for policymakers as it falls within the regulated part of the electricity sector.

**Communicate smart metering benefits honestly and transparently to households and ensure households can realize the benefits they were promised.** Findings from Chapter 4 reveal that smart metering is dominantly presented as energy saving that benefits mostly households. This communication is misleading, especially when there are no explicit mechanisms to support consumers in getting the energy saving benefits they got promised. The in-home display provided with smart meters in the United Kingdom is a first step, which recognizes that smart meters alone don’t provide energy savings without a user interface visualizing electricity flows. Leaving the offering of displays to the market, as it is done in the Netherlands, causes uncertainty and a time lag between the roll-out of smart metering and the provision of visualization services, which will affect energy savings.

**Question assumptions on energy-related behavior by households.** Pro smart metering arguments in public and policy discourses, particularly put forward by governmental organizations, reveal the underlying assumption that there is a causal relationship between electricity flow visualization and consumer action to save energy (Chapter 4). This assumption is not supported by empirical data. The combination of smart metering and user interfaces is only a necessary but not a sufficient condition for energy savings. Policymakers should therefore question this assumption and gain a more sophisticated understanding of energy demand as demand which is derived from everyday practices. As hinted here, research on social practices (Shove, 2003; Strengers, 2012) can provide further insights.

### 4.2 Funding of smart grid pilot projects

Due to the importance of small-scale experimentation (co-)funded by public sources, policymakers and funding organizations have the opportunity to steer innovation in smart grids through funding criteria. The following recommendations are derived from Chapter 5.

**Integrate energy justice in the funding criteria for pilot projects.** Funding criteria should be used as a mechanism to incentivize design for values in general and design for justice more specifically. Regarding energy justice, the evaluation framework developed in Chapter 5 of this dissertation may provide these funding criteria.



**Place greater emphasis on learning from single pilot projects for future large-scale applications.** The purpose of smart grid pilot projects is to gain experience for large-scale market services. In the Netherlands, however, my findings from Chapter 5 show that sharing of knowledge and results between projects is limited. Much more knowledge exchange is needed to effectively learn from small-scale experimentation. Policymakers can incentivize knowledge sharing by funding pilot projects that develop open platforms and business models. Tensions between openness and the development of proprietary business models by aggregators and software providers will always remain, but public money should be directed to projects that develop open platforms and business models. Additionally, learning processes can be improved by funding projects that are complementary, for example through targeted smart grid programs such as the Innovation Program for Smart Grids (IPIN in Dutch (RVO, 2019)), in which several projects were set up under the umbrella of a single funding program.

**Ensure that smart grid projects are more inclusive by increasing the diversity of societal groups who are involved in them.** The dominant target group for experimentation with smart grids has been consumers and prosumers who own their house and live in it. This is problematic for generalization and risks structural misrecognition of the needs of other – especially more vulnerable – groups in society, who might be prevented from joining the system due to lack of income, space restrictions, and housing situation. This concerns particularly social housing and low-income communities, which are harder to engage for energy issues and face higher complexities for smart grid deployment. More targeted experimentation with those groups as well as a greater focus on studying social aspects of smart grids, such as user practices and their determinants, are needed. Funding requirements should thus be directed at the inclusiveness of pilot projects, ensuring that benefits from smart grid technologies are accessible to diverse societal groups.

### 4.3 Electricity sector regulation

Approaching research on smart grids through the lens of moral values, and discussing the concept of energy justice with a variety of smart grid stakeholders opened up debates that tend to be technology-dominated and triggered discussions regarding a fair energy transition and what this might imply for electricity sector regulation. This gives rise to the following recommendations:

**Increase the accessibility and inclusiveness of renewable energy and smart grid technologies.** The last recommendation in Section 4.2 addressed the need to make smart grids more inclusive by experimenting more with rental homes, social housing communities, and lower-income households. Additionally, policymakers should develop mechanisms to continuously monitor and if needed adapt electricity sector regulation to increase the inclusiveness of the energy transition for diverse socio-economic groups.



First, this is relevant for photovoltaic systems. Solar energy is the fastest-growing renewable energy technology, but recent data shows that photovoltaic systems are still much more frequently installed on owner-occupied homes (7,4% of all homes) compared to rental homes (1,7%), and most prevalent on detached houses (CBS, 2020c). A first important step would be to monitor which socio-economic groups invest in solar energy, including the accessibility for social housing tenants. In doing so, the impacts of the changing net metering scheme – the most important mechanism to increase financial attractiveness of photovoltaic systems which will be phased out from 2023 to 2030 (cf. Directoraat-generaal Klimaat en Energie, 2020) – on investment in solar energy by tenants and social housing corporations should be closely monitored.

Additionally, policymakers should develop mechanisms to lower investment barriers in battery storage for residential households. Home and community battery storage are among the most important flexibility technologies in a smart grid. Currently, however, storage faces many barriers in the Netherlands, most of which are due to the institutional framework (for a review, see e.g. Mir Mohammadi Kooshknow and Davis, 2018). Here again, the net metering scheme plays an important role. It implies that storage has no financial viability, at least until the start of its gradual phase-out in 2023 (cf. Directoraat-generaal Klimaat en Energie, 2020). Although the phase-out is expected to increase incentives for prosumers to invest in storage facilities, additional efforts are needed to make this investment feasible for tenants and households living in smaller dwellings, considering the physical barriers to the installation of home batteries. Therefore, as outlined in Chapter 5, enabling the collective ownership of community storage facilities might be a way to lower investment barriers, increase accessibility of battery storage, and enable citizens' financial participation in smart grids.

**Address changing conceptions of fairness regarding electricity network tariffs.** In the Netherlands, residential households pay electricity network tariffs based on the principle of non-discrimination or equality. Tariffs are the same for all households and based on an average 4kW capacity used per household. With the rise in network load caused by decentral renewables and electrification of heat and transport, however, there might be a shift in this fairness principle. It is considered as more and more unfair that all residential households pay the same network tariffs whereas some use the network more than others through additional load, especially from solar panels and electric vehicles, and since prosumers and owners of electric vehicles tend to be higher-income groups. The disproportional use of the network by solar prosumers is exacerbated through the net metering rule, which incentivizes prosumers to maximize the feed-in of their solar generation[14].



A potential smart grid solution, which is as of now very rarely considered, is the use of dynamic network tariffs. In the instances that they are considered, e.g. by Neuteleers et al. (2017), they are suggested as incentive to reduce peak load. I do not mean to suggest them in the same sense, because the effectiveness of such incentives is heavily contested (cf. van Mierlo, 2019). Instead, dynamic tariffs might be used to integrate the 'cost-by-cause' or 'polluter pays' principle, ensuring that households who create higher network load pay proportional to their use or, in different words, avoid that households with low network use have to pay a disproportional share. Such dynamic tariffs could in principle be real-time pricing or step-wise differentiated cost-reflective prices (capacity 'bandwidths'). In the latter case, instead of charging

[14] Creating incentives to maximize feed-in increases network load. However, compared to other countries the problem might be less severe in the Netherlands, where network tariffs are capacity-based and thus not subsumed under net metering. In countries with volumetric network tariffs, the problem would be more severe as increased feed-in by prosumers means they also pay proportionally less and less for network costs, which then have to be covered by the remaining consumers.

one fixed price for a 4 kW capacity, a higher price could be charged for the time spans during which a given household exceeds this average capacity. This suggestion is inspired by the GridFlex pilot project presented in Chapter 5, and as such the experiences during this pilot might serve as blueprint for the further development of cost-reflective network tariffs. Importantly, during such a development, any changes need to be thoroughly evaluated (modelled, simulated, and studied in practice) for potential impacts on vulnerable households and on incentives to invest in renewable energy.

## 5 A personal reflection on the acceptability-acceptance divide

Work on this dissertation was accompanied by intense discussions on the relation between ethical acceptability (i.e. value embeddedness and design for values) and social acceptance (i.e. the empirical reception of a technology in society), and the relative importance of the two areas of study. I would like to close the dissertation with a somewhat personal reflection on such discussions. It might not coincide with the image of researchers as detached observers of societal processes, but was central in shaping my work. After all, a PhD dissertation that is centered around values triggers thinking not only about the objects or systems studied but also about fundamental personal convictions of what should matter in academic research.

Explicitly or implicitly, discussions on acceptability and acceptance were often centered on the question whether the endeavor to understand and design for values has academic and societal value in itself or whether it has value only in its instrumental relation to acceptance. My predominant focus and contribution on the side of ethical acceptability is grounded in the conviction that the former position is true. The relevant focus for researchers working on the assessment of potentially controversial technologies should be to (a) understand what moral and social implications these technologies might have for society, and (b) provide normative guidance for governments and policymakers that have the responsibility to protect the interest of its citizens. This is of particular importance for emerging technologies, where users might not be able to grasp potential consequences, and thus studying (user) acceptance is inherently limited in its ability to give policy relevant guidance. The question of acceptability is a "wicked" question; at the least it is riddled with normative uncertainty. But it is also the question that really matters. As such, I am convinced that the study of ethical acceptability has value in itself, and does not need justification through a potential instrumental relationship with social acceptance.

For the energy sector specifically, there are two more reasons why I think acceptability should have priority over acceptance. First, energy infrastructures need to be designed for the collective benefit, since the access to energy is increasingly recognized as a fundamental human right. The collective benefit might not be the same as the sum of all individual benefits; some individuals might need to make trade-offs and take into account reductions in well-being if others are to benefit. An example, albeit simplified, is the suffering of economic interests of fossil fuel extracting industries if we want to achieve more sustainable energy systems. The second reason is that energy infrastructures are designed for the long run, with time horizons of 40+ years. If design recommendations are purely based on present empirical investigations of acceptance, this will overlook the interests of future generations, and thus not fulfill the ambition to design more sustainable systems. Concentrating on values as the fundamental normative underpinnings of technological development, and ideally intrinsic values that are the ends of human existence, provides a better chance to design technologies that are successful in the long run.

This is not to say that acceptance does not matter; the adoption of sustainable energy technologies is needed if the energy transition is to be successful. Therefore, my research showed that the acceptability and acceptance are related in their quality as thick concepts[15] and I have argued in that testing the relationship between acceptability and acceptance is an interesting empirical question for future research. If design for values can help us on our path towards more sustainable societies, all the better. However, if researchers focus their attention on the study of social acceptance alone, give guidance solely on how to increase technologies' acceptance, and conflate empirical facts with the normative guidance on what should be accepted, they are not fulfilling their public function and do not act in the interest of society as a collective. The question of how to increase the acceptance of technologies is empirically interesting, but in the context of long-term infrastructure design and sustainability transitions, acceptability should have priority for academic researchers.



[15] see Section 2.1

# References

Acosta, C., Ortega, M., Bunsen, T., Koirala, B.P., Ghorbani, A., 2018. Facilitating energy transition through energy commons: An application of socio-ecological systems framework for integrated community energy systems. Sustain. 10. https://doi.org/10.3390/su10020366

Aduda, K.O., Labeodan, T., Zeiler, W., Boxem, G., Zhao, Y., 2016. Demand side flexibility: Potentials and building performance implications. Sustain. Cities Soc. 22, 146–163. https://doi.org/10.1016/j.scs.2016.02.011

Afman, M., Rooijers, F., 2017. Net voor de Toekomst [WWW Document]. URL https://www.netbeheernederland.nl/nieuws/resultaten-onderzoek-net-voor-de-toekomst-1204 (accessed 1.21.20).

Ahn, M., Kang, J., Hustvedt, G., 2016. A model of sustainable household technology acceptance. Int. J. Consum. Stud. 40, 83–91. https://doi.org/10.1111/ijcs.12217

AI Ethics Impact Group, 2020. From Principles to Practice: An interdisciplinary framework to operationalise AI ethics. https://doi.org/10.9774/gleaf.4700.2006.wi.00011

Ajzen, I., 1991. The Theory of Planned Behavior. Organ. Behav. Hum. Decis. Process. 50, 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Albrechtslund, A., 2007. Ethics and technology design. Ethics Inf. Technol. 9, 63–72. https://doi.org/10.1007/s10676-006-9129-8

Aligica, P.D., Tarko, V., 2013. Co-Production, Polycentricity, and Value Heterogeneity: The Ostroms' Public Choice Institutionalism Revisited. Am. Polit. Sci. Rev. 107, 726–741. https://doi.org/10.1017/S0003055413000427

Allcott, H., Mullainathan, S., 2010. Behavior and energy policy. Science (80-. ). 327, 1204–1205. https://doi.org/10.1126/science.1180775

Argyris, C., Schön, D., 1978. Organizational learning: A theory of action approach. Addision Wesley, Reading, MA.

Armitage, D., Marschke, M., Plummer, R., 2008. Adaptive co-management and the paradox of learning. Glob. Environ. Chang. 18, 86–98. https://doi.org/10.1016/j.gloenvcha.2007.07.002

Ashworth, L., Free, C., 2006. Marketing dataveillance and digital privacy: Using theories of justice to understand consumers' online privacy concerns. J. Bus. Ethics 67, 107–123. https://doi.org/10.1007/s10551-006-9007-7

Autoriteit Consument & Markt, 2013. Monitoringrapportage Kleinschalige Aanbieding Slimme Meter.

Bager, S., Mundaca, L., 2017. Making 'Smart Meters' smarter? Insights from a behavioural economics pilot field experiment in Copenhagen, Denmark. Energy Res. Soc. Sci. 28, 68–76. https://doi.org/10.1016/j.erss.2017.04.008

Bale, C.S.E., Varga, L., Foxon, T.J., 2015. Energy and complexity: New ways forward. Appl. Energy 138, 150–159. https://doi.org/10.1016/j.apenergy.2014.10.057

Balta-Ozkan, N., Amerighi, O., Boteler, B., 2014a. A comparison of consumer perceptions towards smart homes in the UK, Germany and Italy: reflections for policy and future research. Technol. Anal.

Strateg. Manag. 26, 1176–1195. https://doi.org/10.1080/09537325.2014.975788

Balta-Ozkan, N., Boteler, B., Amerighi, O., 2014b. European smart home market development: Public views on technical and economic aspects across the United Kingdom, Germany and Italy. Energy Res. Soc. Sci. 3, 65–77. https://doi.org/10.1016/j.erss.2014.07.007

Balta-Ozkan, N., Davidson, R., Bicket, M., Whitmarsh, L., 2013a. Social barriers to the adoption of smart homes. Energy Policy 63, 363–374. https://doi.org/10.1016/j.enpol.2013.08.043

Balta-Ozkan, N., Davidson, R., Bicket, M., Whitmarsh, L., 2013b. The development of smart homes market in the UK. Energy 60, 361–372. https://doi.org/10.1016/j.energy.2013.08.004

Barbour, E., Parra, D., Awwad, Z., González, M.C., 2018. Community energy storage: A smart choice for the smart grid? Appl. Energy 212, 489–497. https://doi.org/10.1016/j.apenergy.2017.12.056

Barnicoat, G., Danson, M., 2015. The ageing population and smart metering: A field study of householders' attitudes and behaviours towards energy use in Scotland. Energy Res. Soc. Sci. 9, 107–115. https://doi.org/10.1016/j.erss.2015.08.020

Barry, C., 2001. The Ethical Assessment of Technological Change: An overview of the issues. J. Hum. Dev. 2, 167–189. https://doi.org/10.1080/14649880120067257

Bartiaux, F., Maretti, M., Cartone, A., Biermann, P., Krasteva, V., 2019. Sustainable energy transitions and social inequalities in energy access : A relational comparison of capabilities in three European countries. Glob. Transitions 1, 226–240. https://doi.org/10.1016/j.glt.2019.11.002

Batel, S., Devine-Wright, P., Tangeland, T., 2013. Social acceptance of low carbon energy and associated infrastructures: A critical discussion. Energy Policy 58, 1–5. https://doi.org/10.1016/j.enpol.2013.03.018

Begier, B., 2014. Effective cooperation with energy consumers: An example of an ethical approach to introduce an innovative solution. J. Information, Commun. Ethics Soc. 12, 107–121. https://doi.org/10.1108/JICES-07-2013-0021

Bellekom, S., Arentsen, M., van Gorkum, K., 2016. Prosumption and the distribution and supply of electricity. Energy. Sustain. Soc. 6, 1–17. https://doi.org/10.1186/s13705-016-0087-7

Berkes, F., 2009. Evolution of co-management: Role of knowledge generation, bridging organizations and social learning. J. Environ. Manage. 90, 1692–1702. https://doi.org/10.1016/j.jenvman.2008.12.001

Berry, S., Whaley, D., Saman, W., Davidson, K., 2017. Finding faults and influencing consumption: the role of in-home energy feedback displays in managing high-tech homes. Energy Effic. 10, 787–807. https://doi.org/10.1007/s12053-016-9489-9

Bidwell, D., 2016. Thinking through participation in renewable energy decisions. Nat. Energy 1, 1–4. https://doi.org/10.1038/nenergy.2016.51

Blackmore, C., 2007. What kinds of knowledge, knowing and learning are required for addressing resource dilemmas?: a theoretical overview. Environ. Sci. Policy 10, 512–525. https://doi.org/10.1016/j.envsci.2007.02.007

Blumsack, S., Fernandez, A., 2012. Ready or not, here comes the smart grid! Energy 37, 61–68. https://doi.org/10.1016/j.energy.2011.07.054

Boudet, H.S., 2019. Public perceptions of and responses to new energy technologies. Nat. Energy 4, 446–455. https://doi.org/10.1038/s41560-019-0399-x

Bourazeri, A., Pitt, J., 2018. Collective attention and active consumer participation in community energy systems. Int. J. Hum. Comput. Stud. 119, 1–11. https://doi.org/10.1016/j.ijhcs.2018.06.001

Bouzarovski, S., Simcock, N., 2017. Spatializing energy justice. Energy Policy 107, 640–648. https://doi.org/10.1016/j.enpol.2017.03.064

Bowen, G.A., 2008. Naturalistic inquiry and the saturation concept: a research note. Qual. Res. 8, 137–152. https://doi.org/10.1177/1468794107085301

Breukers, S., Mourik, R.M., van Summeren, L.F.M., Verbong, G.P.J., 2017. Institutional 'lock-out' towards local self-governance? Environmental justice and sustainable transformations in Dutch social housing neighbourhoods. Energy Res. Soc. Sci. 23, 148–158. https://doi.org/10.1016/j.erss.2016.10.007

Broman Toft, M., Schuitema, G., Thøgersen, J., 2014. Responsible technology acceptance: Model development and application to consumer acceptance of Smart Grid technology. Appl. Energy 134, 392–400. https://doi.org/10.1016/j.apenergy.2014.08.048

Buchanan, K., Banks, N., Preston, I., Russo, R., 2016. The British public's perception of the UK smart metering initiative: Threats and opportunities. Energy Policy 91, 87–97. https://doi.org/10.1016/j.enpol.2016.01.003

Bulkeley, H., Edwards, G.A.S., Fuller, S., 2014. Contesting climate justice in the city: Examining politics and practice in urban climate change experiments. Glob. Environ. Chang. 25, 31–40. https://doi.org/10.1016/j.gloenvcha.2014.01.009

Buryk, S., Mead, D., Mourato, S., Torriti, J., 2015. Investigating preferences for dynamic electricity tariffs: The effect of environmental and system benefit disclosure. Energy Policy 80, 190–195. https://doi.org/10.1016/j.enpol.2015.01.030

Bush, P.D., 2009. The Neoinstitutionalist Theory of Value: Remarks upon Receipt of the Veblen-Commons Award. J. Econ. Issues 43, 293–306. https://doi.org/10.2753/JEI0021-3624430202

Buth, A., Wieczorek, A., Verbong, G., 2019. The promise of peer-to-peer trading? The potential impact of blockchain on the actor configuration in the Dutch electricity system. Energy Res. Soc. Sci. 53, 194–205. https://doi.org/10.1016/j.erss.2019.02.021

Cambini, C., Meletiou, A., Bompard, E., Masera, M., 2016. Market and regulatory factors influencing smart-grid investment in Europe: Evidence from pilot projects and implications for reform. Util. Policy 40, 36–47. https://doi.org/10.1016/j.jup.2016.03.003

Catney, P., MacGregor, S., Dobson, A., Hall, S.M., Royston, S., Robinson, Z., Ormerod, M., Ross, S., 2014. Big society, little justice? Community renewable energy and the politics of localism. Local Environ. 19, 715–730. https://doi.org/10.1080/13549839.2013.792044

CBS, 2020a. Sharp rise in green electricity production [WWW Document]. URL https://www.cbs.nl/en-gb/news/2020/10/sharp-rise-in-green-electricity-production (accessed 5.29.20).

CBS, 2020b. Renewable energy consumption up by 16 percent [WWW Document]. URL https://www.cbs.nl/en-gb/news/2020/22/renewable-energy-consumption-up-by-16-percent (accessed 6.5.20).

CBS, 2020c. Slim zonnestroom in kaart brengen [WWW Document]. URL https://www.cbs.nl/nl-nl/over-ons/innovatie/project/slim-zonnestroom-in-kaart-brengen (accessed 4.25.20).

Chapman, A.J., McLellan, B., Tezuka, T., 2016. Proposing an evaluation framework for energy policy


R

making incorporating equity: Applications in Australia. Energy Res. Soc. Sci. 21, 54–69. https://doi.org/10.1016/j.erss.2016.06.021

Chen, C., Xu, X., Arpan, L., 2017. Between the technology acceptance model and sustainable energy technology acceptance model: Investigating smart meter acceptance in the United States. Energy Res. Soc. Sci. 25, 93–104. https://doi.org/10.1016/j.erss.2016.12.011

Cheng, A.S., Fleischmann, K.R., 2010. Developing a meta-inventory of human values. Proc. ASIST Annu. Meet. 47. https://doi.org/10.1002/meet.14504701232

Cherry, C., Hopfe, C., MacGillivray, B., Pidgeon, N., 2017. Homes as machines: Exploring expert and public imaginaries of low carbon housing futures in the United Kingdom. Energy Res. Soc. Sci. 23, 36–45. https://doi.org/10.1016/j.erss.2016.10.011

Chou, J.-S., Kim, C., Ung, T.-K., Yutami, G.A.N., Lin, G.-T., Son, H., 2015. Cross-country review of smart grid adoption in residential buildings. Renew. Sustain. Energy Rev. 48, 192–213. https://doi.org/10.1016/j.rser.2015.03.055

Chou, J.-S., Yutami, G.A.N., 2014. Smart meter adoption and deployment strategy for residential buildings in Indonesia. Appl. Energy 128, 336–349. https://doi.org/10.1016/j.apenergy.2014.04.083

City-zen, 2019. City-zen [WWW Document]. URL http://www.cityzen-smartcity.eu (accessed 9.24.19).

Clastres, C., 2011. Smart grids: Another step towards competition, energy security and climate change objectives. Energy Policy 39, 5399–5408. https://doi.org/10.1016/j.enpol.2011.05.024

Colak, I., Fulli, G., Sagiroglu, S., Yesilbudak, M., Covrig, C.F., 2015. Smart grid projects in Europe: Current status, maturity and future scenarios. Appl. Energy 152, 58–70. https://doi.org/10.1016/j.apenergy.2015.04.098

Cole, D.H., 2017. Laws, norms, and the Institutional Analysis and Development framework. J. Institutional Econ. 13, 829–847. https://doi.org/10.1017/S1744137417000030

Connor, P., Fitch-Roy, O., 2019. The Socio-Economic Challenges of Smart Grids, in: Taşcıkaraoğlu, A., Erdinç, O. (Eds.), Pathways to a Smarter Power System. Elsevier Ltd., London, UK, pp. 397–413. https://doi.org/10.1016/B978-0-08-102592-5.00014-4

Correljé, A., Cuppen, E., Dignum, M., Pesch, U., Taebi, B., 2015a. Responsible Innovation in Energy Projects: Values in the Design of Technologies, Institutions and Stakeholder Interactions, in: Koops, B.-J., Oosterlaken, I., Romijn, H., Swierstra, T., van den Hoven, J. (Eds.), Responsible Innovation 2, Concepts, Approaches, and Applications. Springer International Publishing, pp. 183–200. https://doi.org/10.1007/978-3-319-17308-5_10

Correljé, A., Groenewegen, J., 2009. Public values in the energy sector : economic perspectives. Int. J. Public Pol. 207–225.

Correljé, A., Groenewegen, J., Künneke, R.W., Scholten, D.J., 2015b. Design for Values in Economics, in: van den Hoven, J., Vermaas, P.E., van de Poel, I. (Eds.), Handbook of Ethics, Values, and Technological Design: Sources, Theory, Values and Application Domains. Springer Netherlands, Dordrecht, pp. 639–666. https://doi.org/10.1007/978-94-007-6970-0

Cowell, R., Bristow, G., Munday, M., 2011. Acceptance, acceptability and environmental justice: the role of community benefits in wind energy development. J. Environ. Plan. Manag. 54, 539–557. https://doi.org/10.1080/09640568.2010.521047

Creswell, J.W., 2009. Research design, 3rd ed, Qualitative and Quantitative approaches. Sage, Los Angeles, London, New Delhi, Singapore.

Cuijpers, C., Koops, B.-J., 2013. Smart Metering and Privacy in Europe: Lessons from the Dutch Case, in: Gutwirth, S., Leenes, R., de Hert, P., Poullet, Y. (Eds.), European Data Protection: Coming of Age. Springer Netherlands, Dordrecht, pp. 269–293. https://doi.org/10.1007/978-94-007-5170-5_12

Cundill, G., Fabricius, C., 2009. Monitoring in adaptive co-management: Toward a learning based approach. J. Environ. Manage. 90, 3205–3211. https://doi.org/10.1016/j.jenvman.2009.05.012

Cundill, G., Rodela, R., 2012. A review of assertions about the processes and outcomes of social learning in natural resource management. J. Environ. Manage. 113, 7–14. https://doi.org/10.1016/j.jenvman.2012.08.021

Cuppen, E., Pesch, U., Remmerswaal, S., Taanman, M., 2016. Normative diversity, conflict and transition: Shale gas in the Netherlands. Technol. Forecast. Soc. Change. https://doi.org/10.1016/j.techfore.2016.11.004

Cusumano, M.A., Mylonadis, Y., Rosenbloom, R.S., 1992. Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta. Bus. Hist. Rev. 66, 51–94. https://doi.org/10.2307/3117053

Davis, F.D., Bagozzi, R.P., Warshaw, P.R., 1989. User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. Manage. Sci. 35, 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Davis, J., Nathan, L.P., 2015. Value Sensitive Design: Applications, Adaptations, and Critiques, in: van den Hoven, J., Vermaas, P.E., van de Poel, I. (Eds.), Handbook of Ethics, Values, and Technological Design: Sources, Theory, Values and Application Domains. Springer Netherlands, Dordrecht, pp. 11–40. https://doi.org/10.1007/978-94-007-6970-0_3

Dedrick, J., Venkatesh, M., Stanton, J.M., Zheng, Y., Ramnarine-Rieks, A., 2015. Adoption of smart grid technologies by electric utilities: factors influencing organizational innovation in a regulated environment. Electron. Mark. 25, 17–29. https://doi.org/10.1007/s12525-014-0166-6

Demski, C., Butler, C., Parkhill, K.A., Spence, A., Pidgeon, N.F., 2015. Public values for energy system change. Glob. Environ. Chang. 34, 59–69. https://doi.org/10.1016/j.gloenvcha.2015.06.014

Department of Energy & Climate Change, 2013. Award of Smart Meters DCC Licence: Written statement to parliament [WWW Document]. URL https://www.gov.uk/government/news/award-of-smart-meters-dcc-licence (accessed 9.6.17).

Department of Trade and Industry, 2007. Meeting the Energy Challenge: A White Paper on Energy. https://doi.org/10.1016/j.nucengdes.2006.02.017

Depuru, S.S.S.R., Wang, L., Devabhaktuni, V., 2011. Smart meters for power grid: Challenges, issues, advantages and status. Renew. Sustain. Energy Rev. 15, 2736–2742. https://doi.org/10.1016/j.rser.2011.02.039

Devine-Wright, P., 2005. Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy. Wind Energy 8, 125–139. https://doi.org/10.1002/we.124

Devine-Wright, P., Batel, S., Aas, O., Sovacool, B.K., Carnegie, M., Ruud, A., 2017. A conceptual framework for understanding the social acceptance of energy infrastructure : Insights from energy storage. Energy Policy 107, 27–31. https://doi.org/10.1016/j.enpol.2017.04.020

Diduck, Alan, Bankes, N., Clark, D., Armitage, D., 2005. Upacking Social Learninig in Social-Ecological Systems, in: Berkes, F., Huebert, R., Fast, H., Manseau, M., Diduck, A. (Eds.), Breaking Ice:

Renewable Resource and Ocean Management in the Canadian North. Artic Institute of North America and University of Calgary Press, Calgary, pp. 269–290.

Diestelmeier, L., 2019a. Changing power: Shifting the role of electricity consumers with blockchain technology – Policy implications for EU electricity law. Energy Policy 128, 189–196. https://doi.org/10.1016/j.enpol.2018.12.065

Diestelmeier, L., 2019b. Unlocking Flexibility with Law: Developing a Legal Framework for Smart Electricity Systems. Rijksuniversiteit Groningen.

Dietz, T., Fitzgerald, A., Shwom, R., 2005. Environmental Values. Annu. Rev. Environ. Resour. 30, 335–372. https://doi.org/10.1146/annurev.energy.30.050504.144444

Dignum, M., Correljé, A., Cuppen, E., Pesch, U., Taebi, B., 2016. Contested Technologies and Design for Values: The Case of Shale Gas. Sci. Eng. Ethics 22, 1171–1191. https://doi.org/10.1007/s11948-015-9685-6

Directoraat-generaal Klimaat en Energie, 2020. Kamerbrief over afbouw salderingsregeling [WWW Document]. URL https://www.rijksoverheid.nl/documenten/kamerstukken/2020/03/30/kamerbrief-over-afbouw-salderingsregeling (accessed 4.15.20).

Directoraat-generaal Klimaat en Energie, 2019a. Kamerbrief over nadere uitwerking van afbouw van salderingsregeling [WWW Document]. URL https://www.rijksoverheid.nl/documenten/kamerstukken/2019/10/28/kamerbrief-over-nadere-uitwerking-van-afbouw-van-salderingsregeling (accessed 12.3.19).

Directoraat-generaal Klimaat en Energie, 2019b. Kamerbrief Stimuleringsbeleid lokale hernieuwbare elektriciteitsproductie [WWW Document]. URL https://www.rijksoverheid.nl/actueel/nieuws/2018/06/15/terugleversubsidie-gaat-salderingsregeling-vervangen (accessed 11.12.19).

Dodds, P.E., Staffell, I., Hawkes, A.D., Li, F., Grünewald, P., McDowall, W., Ekins, P., 2015. Hydrogen and fuel cell technologies for heating: A review. Int. J. Hydrogen Energy 40, 2065–2083. https://doi.org/10.1016/j.ijhydene.2014.11.059

Dwyer, J., Bidwell, D., 2019. Chains of trust: Energy justice, public engagement, and the first offshore wind farm in the United States. Energy Res. Soc. Sci. 47, 166–176. https://doi.org/10.1016/j.erss.2018.08.019

Ehrenhard, M., Kijl, B., Nieuwenhuis, L., 2014. Market adoption barriers of multi-stakeholder technology: Smart homes for the aging population. Technol. Forecast. Soc. Change 89, 306–315. https://doi.org/10.1016/j.techfore.2014.08.002

Ehrhardt-Martinez, K., Donnelly, K.A., Laitner, S., 2010. Advanced Metering Initiatives and Residential Feedback Programs : A Meta-Review for Household Electricity-Saving Opportunities. American Council for an Energy-Efficient Economy. Washington, D.C.

Eid, C., 2017. Towards the design of flexibility management in smart grids: A techno - institutional perspective. Delft University of Technology. https://doi.org/10.4233/7C428552-4A92-4955-8401-1CA2DF3DBC34

Eising, J.W., van Onna, T., Alkemade, F., 2014. Towards smart grids: Identifying the risks that arise from the integration of energy and transport supply chains. Appl. Energy 123, 448–455. https://doi.org/10.1016/j.apenergy.2013.12.017

Ekker, H., van de Wiel, M., 2019. Tennet breidt stroomnet uit voor 7 miljoen zonnepanelen [WWW Document]. NOS NIEUWS. URL https://nos.nl/artikel/2305389-tennet-breidt-stroomnet-uit-voor-7-miljoen-zonnepanelen.html (accessed 12.3.19).

Energieleveranciers.nl, 2014. Uitrol slimme meter in 2015 van start [WWW Document]. URL www.energieleveranciers.nl/nieuws/500453-uitrol-slimme-meter-in-2015-van-start (accessed 7.27.17).

Energy.21, Stedin, 2018. Whitepaper Layered Energy System [WWW Document]. URL https://www.stedin.net/over-stedin/duurzaamheid-en-innovaties/een-flexibele-energiemarkt/blockchain (accessed 9.24.19).

Enexis, 2017. GridFlex Heeten Project Plan [WWW Document]. URL https://projecten.topsectorenergie.nl/storage/app/uploads/public/5a0/c1a/b96/5a0c1ab96bba0525772360.pdf (accessed 9.18.19).

ETP Smart Grids, 2015. ETP Documents | SmartGrids [WWW Document]. URL http://www.smartgrids.eu/ETP_Documents (accessed 4.12.16).

Etzkowitz, H., Leydesdorff, L., 2000. The dynamics of innovation : from National Systems and "" Mode 2 "" to a Triple Helix of university – industry – government relations. Res. Policy 29, 109–123.

Euler, J., 2018. Conceptualizing the Commons: Moving Beyond the Goods-based Definition by Introducing the Social Practices of Commoning as Vital Determinant. Ecol. Econ. 143, 10–16. https://doi.org/10.1016/j.ecolecon.2017.06.020

EUR-Lex, 2018. Energy [WWW Document]. URL https://eur-lex.europa.eu/summary/chapter/energy.html?root_default=SUM_1_CODED%3D18 (accessed 3.12.18).

European Commission, 2020. Smart Metering Deployment in the European Union [WWW Document]. URL http://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union (accessed 3.10.20).

European Commission, 2019a. Clean energy for all Europeans package [WWW Document]. URL https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_de (accessed 5.27.20).

European Commission, 2019b. CO2 emission performance standards for cars and vans (2020 onwards) [WWW Document]. URL https://ec.europa.eu/clima/policies/transport/vehicles/regulation_en (accessed 5.6.20).

European Commission, 2019c. Press remarks by President von der Leyen on the occasion of the adoption of the European Green Deal Communication [WWW Document]. URL https://ec.europa.eu/commission/presscorner/detail/en/speech_19_6749 (accessed 12.11.19).

European Commission, 2018. Energy Strategy and Energy Union [WWW Document]. URL http://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union (accessed 1.19.18).

European Commission, 2016. 2030 Energy Strategy [WWW Document]. URL https://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy (accessed 12.16.16).

European Union, 2009. Directive of 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC. Off. J. Eur. Union L 211, 55–93. https://doi.org/10.1126/science.202.4366.409

European Union, 2006. Directive 2006/32 EC of the European Parliament and the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC. Off. J. Eur. Union L 114, 64–84. https://doi.org/10.1016/j.jclepro.2010.02.014

Evers, G., Chappin, M.M.H., 2020. Knowledge sharing in smart grid pilot projects. Energy Policy 143, 111577. https://doi.org/10.1016/j.enpol.2020.111577

Fallah, S., Deo, R., Shojafar, M., Conti, M., Shamshirband, S., 2018. Computational Intelligence Approaches for Energy Load Forecasting in Smart Energy Management Grids: State of the Art, Future Challenges, and Research Directions. Energies 11, 596. https://doi.org/10.3390/en11030596

Fell, M.J., 2020. Just flexibility? Nat. Energy 5, 6–7. https://doi.org/10.1038/s41560-019-0510-3

Fell, M.J., Shipworth, D., Huebner, G.M., Elwell, C.A., 2015. Public acceptability of domestic demand-side response in Great Britain: The role of automation and direct load control. Energy Res. Soc. Sci. 9, 72–84. https://doi.org/10.1016/j.erss.2015.08.023

Field, A., 2013. Discovering Statistics Using SPSS, Sage. SAGE Publications Ltd, London. https://doi.org/10.1111/insr.12011_21

Fisher, R.J., 1993. Social Desirability Bias and the Validity of Indirect Questioning. J. Consum. Res. 20, 303–315. https://doi.org/10.1086/209351

Flanagan, M., Howe, D.C., Nissenbaum, H., 2008. Embodying values in technology: Theory and practice, in: Van Den Hoven, J., Weckert, J. (Eds.), Information Technology and Moral Philosophy. Cambridge University Press, New York, pp. 322–353.

Flipse, S.M., Puylaert, S., 2017. Organizing a Collaborative Development of Technological Design Requirements Using a Constructive Dialogue on Value Profiles: A Case in Automated Vehicle Development. Sci. Eng. Ethics 24, 1–24. https://doi.org/10.1007/s11948-017-9877-3

Flood, R.L., Romm, N.R.A., 1996. Contours of diversity management and triple loop learning. Kybernetes 7, 154–163. https://doi.org/10.1108/03684929610149747

Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., Luetge, C., Madelin, R., Pagallo, U., Rossi, F., Schafer, B., Valcke, P., Vayena, E., 2018. AI4People – An Ethical Framework for a Good AI Society : Opportunities, Risks, Principles, and Recommendations. Minds Mach. 32, 1–24. https://doi.org/10.1093/hmg/ddy137/4972370

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245.

Folger, R., 1987. Distributive and procedural justice in the workplace. Soc. Justice Res. 1, 143–159. https://doi.org/10.1007/BF01048013

Forman, A., 2017. Energy justice at the end of the wire : Enacting community energy and equity in Wales. Energy Policy 107, 649–657. https://doi.org/10.1016/j.enpol.2017.05.006

Fortier, M.O.P., Teron, L., Reames, T.G., Munardy, D.T., Sullivan, B.M., 2019. Introduction to evaluating energy justice across the life cycle: A social life cycle assessment approach. Appl. Energy 236, 211–219. https://doi.org/10.1016/j.apenergy.2018.11.022

Fraser, E.D.G., Dougill, A.J., Mabee, W.E., Reed, M., McAlpine, P., 2006. Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as a pathway to community empowerment and sustainable environmental management. J. Environ. Manage. 78, 114–127. https://doi.org/10.1016/j.jenvman.2005.04.009

Fraser, N., 1997. Justice interruptus: Critical reflections on the “postsocialist” condition. Routledge, New

York.

Friedman, B., Kahn Jr, P.H., Borning, A., Huldtgren, A., 2013. Value sensitive design and information systems, in: Doorn, N., Schuurbiers, D., Van de Poel, I., Gorman, M. (Eds.), Early Engagement and New Technologies: Opening up the Laboratory. Springer Netherlands, Dordrecht, pp. 55–95.

Friedman, B., Kahn, P., Borning, A., 2002. Value sensitive design: Theory and methods, in: University of Washington Technical Report. University of Washington, Washington, D.C., pp. 2–12.

Friese, S., 2012. Qualitative Data Analysis with ATLAS.ti. Sage Publications, London, Thousand Oaks, New Delhi, Singapore.

Gallagher, S., Park, S.H., 2002. Innovation and competition in standard-based industries: a historical analysis of the US home video game market. IEEE Trans. Eng. Manag. 49, 67–82. https://doi.org/10.1109/17.985749

Galvin, R., 2020. "Let justice roll down like waters": Reconnecting energy justice to its roots in the civil rights movement. Energy Res. Soc. Sci. 62, 101385. https://doi.org/10.1016/j.erss.2019.101385

Gangale, F., Mengolini, A., 2019. Energy poverty through the lens of EU research and innovation projects, JRC Science and Policy Reports. https://doi.org/10.2760/972106

Gangale, F., Mengolini, A., Onyeji, I., 2013. Consumer engagement: An insight from smart grid projects in Europe. Energy Policy 60, 621–628. https://doi.org/10.1016/j.enpol.2013.05.031

Gangale, F., Vasiljevska, J., Covrig, C.F., Mengolini, A., Fulli, G., 2017. Smart grid projects outlook 2017, JRC Science and Policy Reports. https://doi.org/10.2790/22075

GEA, 2012. Global Energy Assessment - Toward a Sustainable Future, Global Energy Assessment (GEA). Cambridge University Press, Cambridge UK and New York, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria. https://doi.org/10.1017/CBO9780511793677

Geelen, D., Reinders, A., Keyson, D., 2013. Empowering the end-user in smart grids: Recommendations for the design of products and services. Energy Policy 61, 151–161. https://doi.org/10.1016/j.enpol.2013.05.107

Gerpott, T.J., Paukert, M., 2013. Determinants of willingness to pay for smart meters: An empirical analysis of household customers in Germany. Energy Policy 61, 483–495. https://doi.org/10.1016/j.enpol.2013.06.012

Gerritse, E., van Loon, R., van der Eerden, M., Zweistra, M., Eising, J.W., 2019. City-zen: A balanced approach to the city of the future (Final project report of smart grid solutions in Amsterdam) [WWW Document]. URL http://www.cityzen-smartcity.eu/wp-content/uploads/2019/12/city-zen_d5-7_d5-10_d5-11_d5-12_d7-4_cityzen_smart_grid.pdf (accessed 5.3.19).

Ghazal, M., Akmal, M., Iyanna, S., Ghoudi, K., 2015. Smart plugs: Perceived usefulness and satisfaction: Evidence from United Arab Emirates. Renew. Sustain. Energy Rev. 55, 1248–1259. https://doi.org/10.1016/j.rser.2015.07.096

Ghorbani, A., 2013. Structuring Socio-technical Complexity. Delft University of Technology.

Gillard, R., Snell, C., Bevan, M., 2017. Advancing an energy justice perspective of fuel poverty: Household vulnerability and domestic retrofit policy in the United Kingdom. Energy Res. Soc. Sci. 29, 53–61. https://doi.org/10.1016/j.erss.2017.05.012

Goedkoop, F., Devine-Wright, P., 2016. Partnership or placation? the role of trust and justice in the shared

R

ownership of renewable energy projects. Energy Res. Soc. Sci. 17, 135–146. https://doi.org/10.1016/j.erss.2016.04.021

Gölz, S., Wedderhoff, O., 2018. Explaining regional acceptance of the German energy transition by including trust in stakeholders and perception of fairness as socio- institutional factors. Energy Res. Soc. Sci. 43, 96–108. https://doi.org/10.1016/j.erss.2018.05.026

González, J.M., Mulder, M., 2018. Electrification of heating and transport; a scenario analysis for the Netherlands up to 2050, Centre for Energy Economics Research (CEER) Policy Papers 2, University of Groningen, The Netherlands.

Goulden, M., Bedwell, B., Rennick-Egglestone, S., Rodden, T., Spence, A., 2014. Smart grids, smart users? The role of the user in demand side management. Energy Res. Soc. Sci. 2, 21–29. https://doi.org/10.1016/j.erss.2014.04.008

Grimm, V., Kretschmer, S., Mehl, S., 2020. Green innovations: The organizational setup of pilot projects and its influence on consumer perceptions. Energy Policy 142, 111474. https://doi.org/10.1016/j.enpol.2020.111474

Guerreiro, S., Batel, S., Lima, M.L., Moreira, S., 2015. Making energy visible: sociopsychological aspects associated with the use of smart meters. Energy Effic. 8, 1149–1167. https://doi.org/10.1007/s12053-015-9344-4

Hall, N., Ashworth, P., Devine-Wright, P., 2013. Societal acceptance of wind farms: Analysis of four common themes across Australian case studies. Energy Policy 58, 200–208. https://doi.org/10.1016/j.enpol.2013.03.009

Hall, N.L., Jeanneret, T.D., Rai, A., 2016. Cost-reflective electricity pricing: Consumer preferences and perceptions. Energy Policy 95, 62–72. https://doi.org/10.1016/j.enpol.2016.04.042

Hall, S.M., 2013. Energy justice and ethical consumption: comparison, synthesis and lesson drawing. Local Environ. 18, 422–437. https://doi.org/10.1080/13549839.2012.748730

Hammer, S., Wißner, M., André, E., 2015. Trust-based decision-making for smart and adaptive environments. User Model. User-adapt. Interact. 25, 267–293. https://doi.org/10.1007/s11257-015-9160-8

Hansen, P., Morrison, G.M., Zaman, A., Liu, X., 2020. Smart technology needs smarter management : Disentangling the dynamics of digitalism in the governance of shared solar energy in Australia. Energy Res. Soc. Sci. 60, 101322. https://doi.org/10.1016/j.erss.2019.101322

Hart, H.L.A., 1961. The concept of law, Clarencon. ed. Oxford University Press, Oxford.

Healy, N., Barry, J., 2017. Politicizing energy justice and energy system transitions : Fossil fuel divestment and a " just transition ." Energy Policy 108, 451–459. https://doi.org/10.1016/j.enpol.2017.06.014

Heffron, R.J., McCauley, D., 2018. What is the 'Just Transition'? Geoforum 88, 74–77. https://doi.org/10.1016/j.geoforum.2017.11.016

Heffron, R.J., McCauley, D., 2014. Achieving sustainable supply chains through energy justice. Appl. Energy 123, 435–437. https://doi.org/10.1016/j.apenergy.2013.12.034

Heffron, R.J., McCauley, D., de Rubens, G.Z., 2018. Balancing the energy trilemma through the Energy Justice Metric. Appl. Energy 229, 1191–1201. https://doi.org/10.1016/j.apenergy.2018.08.073

Heffron, R.J., McCauley, D., Sovacool, B.K., 2015. Resolving society's energy trilemma through the Energy

R

Justice Metric. Energy Policy 87, 168–176. https://doi.org/10.1016/j.enpol.2015.08.033

Heikkila, T., Andersson, K., 2018. Policy design and the added-value of the institutional analysis development framework. Policy Polit. 46, 309–324. https://doi.org/10.1332/030557318X15230060131727

Hess, D.J., Coley, J.S., 2014. Wireless smart meters and public acceptance: The environment, limited choices, and precautionary politics. Public Underst. Sci. 23, 688–702. https://doi.org/10.1177/0963662512464936

hier opgewekt, 2019. Lokale Energie Monitor [WWW Document]. URL https://www.hieropgewekt.nl/lokale-energie-monitor (accessed 12.10.19).

Hodgson, G.M., 2015. On defining institutions: rules versus equilibria. J. Institutional Econ. 11, 497–505. https://doi.org/10.1017/S1744137415000028

Hoppe, T., Coenen, F., van den Berg, M., 2016. Illustrating the use of concepts from the discipline of policy studies in energy research: An explorative literature review. Energy Res. Soc. Sci. 21, 12–32. https://doi.org/10.1016/j.erss.2016.06.006

Hughes, T.P., 1983. Networks of Power: Electrification in Western Society, 1880-1930, Economic History Review. The Johns Hopkins University Press, Baltimore [etc.] : https://doi.org/10.2307/3104214

Huijben, J.C.C.M., Verbong, G.P.J., 2013. Breakthrough without subsidies? PV business model experiments in the Netherlands. Energy Policy 56, 362–370. https://doi.org/10.1016/j.enpol.2012.12.073

Huijts, N.M.A., Molin, E.J.E., Steg, L., 2012. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. Renew. Sustain. Energy Rev. 16, 525–531. https://doi.org/10.1016/j.rser.2011.08.018

Ihde, D., 1990. Technology and the lifeworld: From garden to earth. Indiana University Press.

International Energy Agency, 2011. Technology Roadmap - Smart Grids. https://doi.org/10.1007/SpringerReference_7300

Iychettira, K.K., Hakvoort, R.A., Linares, 2017a. Towards a comprehensive policy for electricity from renewable energy: An Approach for Policy Design. Energy Policy 106, 169–182.

Iychettira, K.K., Hakvoort, R.A., Linares, P., de Jeu, R., 2017b. Towards a comprehensive policy for electricity from renewable energy: Designing for social welfare. Appl. Energy 187, 228–242. https://doi.org/10.1016/j.apenergy.2016.11.035

Jacobs, M., 1999. Sustainable Development as a Contested Concept, in: Dobson, A. (Ed.), Fairness and Futurity: Essays on Environmental Sustainability and Social Justice. Oxford University Press, Oxford [England], pp. 21–45.

Jenkins, K., 2018. Setting energy justice apart from the crowd: Lessons from environmental and climate justice. Energy Res. Soc. Sci. 39, 117–121. https://doi.org/https://doi.org/10.1016/j.erss.2017.11.015

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., Rehner, R., 2016. Energy justice: A conceptual review. Energy Res. Soc. Sci. 11, 174–182. https://doi.org/dx.doi.org/10.1016/j.erss.2015.10.004

Joerges, B., 1999. Do Politics Have Artefacts? Soc. Stud. Sci. 29, 411–431. https://doi.org/10.1177/030631299029003004

Johnson, V., Hall, S., 2014. Community energy and equity: The distributional implications of a transition to a decentralised electricity system. People, Place and Policy Online 8, 149–167. https://doi.org/10.3351/ppp.0008.0003.0002

Kahma, N., Matschoss, K., 2017. The rejection of innovations? Rethinking technology diffusion and the non-use of smart energy services in Finland. Energy Res. Soc. Sci. 34, 27–36. https://doi.org/10.1016/j.erss.2017.05.024

Kalkbrenner, B.J., 2019. Residential vs. community battery storage systems – Consumer preferences in Germany. Energy Policy 129, 1355–1363. https://doi.org/10.1016/j.enpol.2019.03.041

Katz, M.L., Shapiro, C., 1985. Network externalities, competition, and compatibility. Am. Econ. Rev. 75, 424–440.

Keen, M., Brown, V.A., Dyball, R., 2005. Social Learning: A New Approach to Environmental Management, in: Keen, M., Brown, V.A., Dyball, R. (Eds.), Social Learning in Environmental Management. Towards a Sustainable Future. Earthscan, London, pp. 3–21.

King, N.J., Jessen, P.W., 2014. Smart metering systems and data sharing: Why getting a smart meter should also mean getting strong information privacy controls to manage data sharing. Int. J. Law Inf. Technol. 22, 215–253. https://doi.org/10.1093/ijlit/eau001

Kloppenburg, S., Boekelo, M., 2019. Digital platforms and the future of energy provisioning: Promises and perils for the next phase of the energy transition. Energy Res. Soc. Sci. 49, 68–73. https://doi.org/10.1016/j.erss.2018.10.016

Knudsen, C., 1993. Modelling Rationality, Institutions and Processes in Economic Theory, in: Mäki, U., Gustafsson, B., Knudsen, C. (Eds.), Rationality, Institutions and Economic Methodology. Routledge, London, UK, pp. 265–299.

Kobus, C.B.A., Klaassen, E.A.M., Mugge, R., Schoormans, J.P.L., 2015. A real-life assessment on the effect of smart appliances for shifting households' electricity demand. Appl. Energy 147, 335–343. https://doi.org/10.1016/j.apenergy.2015.01.073

Koirala, B.P., Araghi, Y., Kroesen, M., Ghorbani, A., Hakvoort, R.A., Herder, P.M., 2018. Trust, awareness, and independence: Insights from a socio-psychological factor analysis of citizen knowledge and participation in community energy systems. Energy Res. Soc. Sci. 38, 33–40. https://doi.org/10.1016/j.erss.2018.01.009

Kool, L., Timmer, J., Royakkers, L.M.M., van Est, R., 2017. Urgent Upgrade: Protect public values in our digitized society, Rathenau Institute Report.

Koster, A.M., Anderies, J.M., 2013. Institutional Factors That Determine Energy Transitions: A Comparative Case Study Approach, in: Michalena, E., Hills, J.M. (Eds.), Renewable Energy Governance: Lecture Notes in Energy 23. Springer, London, UK. https://doi.org/10.1007/978-1-4471-5595-9

Kostyk, T., Herkert, J., 2012. Societal implications of the emerging smart grid. Commun. ACM 55, 34. https://doi.org/10.1145/2366316.2366328

Krippendorff, K., 2004. Content Analysis: An Introduction to its Methodology. Sage Publications, Thousand Oaks, Calif.: https://doi.org/10.2307/2288384

Krishnamurti, T., Schwartz, D., Davis, A., Fischhoff, B., de Bruin, W.B., Lave, L., Wang, J., 2012. Preparing for smart grid technologies: A behavioral decision research approach to understanding consumer

R

expectations about smart meters. Energy Policy 41, 790–797. https://doi.org/10.1016/j.enpol.2011.11.047

Kroes, P., Van de Poel, I., 2015. Design for Values and the Definition, Specification, and Operationalization of Values, in: van den Hoven, J., Vermaas, P.E., van de Poel, I. (Eds.), Handbook of Ethics, Values, and Technological Design: Sources, Theory, Values and Application Domains. Springer Netherlands, Dordrecht, pp. 151–178. https://doi.org/10.1007/978-94-007-6970-0_11

Kroes, P., Verbeek, P.P., 2014. Some Misunderstandings About the Moral Significance of Technology, in: Kroes, P., Verbeek, P.P. (Eds.), The Moral Status of Technical Artefacts. Springer, Dordrecht, pp. 75–88.

Kubli, M., Loock, M., Wüstenhagen, R., 2018. The flexible prosumer: Measuring the willingness to co-create distributed flexibility. Energy Policy 114, 540–548. https://doi.org/10.1016/j.enpol.2017.12.044

Künneke, R.W., Finger, M., 2009. The governance of infrastructures as common pool resources, Fourth Workshop on the Workshop (WOW4), June 2–7.

Künneke, R.W., Mehos, D.C., Hillerbrand, R., Hemmes, K., 2015. Understanding values embedded in offshore wind energy systems: Toward a purposeful institutional and technological design. Environ. Sci. Policy 53, 118–129. https://doi.org/10.1016/j.envsci.2015.06.013

Lammers, I., Heldeweg, M.A., 2016. Smart design rules for smart grids: analysing local smart grid development through an empirico-legal institutional lens. Energy. Sustain. Soc. 6. https://doi.org/10.1186/s13705-016-0102-z

Lammers, I., Hoppe, T., 2019. Watt rules? Assessing decision-making practices on smart energy systems in Dutch city districts. Energy Res. Soc. Sci. 47, 233–246. https://doi.org/10.1016/j.erss.2018.10.003

Leiva, J., Palacios, A., Aguado, J.A., 2016. Smart metering trends, implications and necessities: A policy review. Renew. Sustain. Energy Rev. 55, 227–233. https://doi.org/10.1016/j.rser.2015.11.002

Li, R., Dane, G., Finck, C., Zeiler, W., 2017. Are building users prepared for energy flexible buildings?—A large-scale survey in the Netherlands. Appl. Energy 203, 623–634. https://doi.org/10.1016/j.apenergy.2017.06.067

Ligtvoet, A., Van de Kaa, G., Fens, T., Van Beers, C., Herder, P., Van den Hoven, J., 2015. Value Sensitive Design of Complex Product Systems, in: Janssen, M., Wimmer, A.M., Deljoo, A. (Eds.), Policy Practice and Digital Science: Integrating Complex Systems, Social Simulation and Public Administration in Policy Research. Springer International Publishing, Cham, Switzerland, pp. 157–176. https://doi.org/10.1007/978-3-319-12784-2_8

Lilliestam, J., Hanger, S., 2016. Shades of green: Centralisation, decentralisation and controversy among European renewable electricity visions. Energy Res. Soc. Sci. 17, 20–29. https://doi.org/10.1016/j.erss.2016.03.011

Liu, L., Bouman, T., Perlaviciute, G., Steg, L., 2019. Effects of trust and public participation on acceptability of renewable energy projects in the Netherlands and China. Energy Res. Soc. Sci. 53, 137–144. https://doi.org/10.1016/j.erss.2019.03.006

Lund, H., Hvelplund, F., Østergaard, P., Möller, B., Mathiesen, B.V., Connolly, D., Andersen, A.N., 2014. Analysis: Smart Energy Systems and Infrastructures, in: Lund, H. (Ed.), Renewable Energy Systems. Elsevier, Oxford [England], Waltham [USA], pp. 131–184. https://doi.org/10.1016/B978-0-12-410423-5.00006-7

Lunde, M., Røpke, I., Heiskanen, E., 2016. Smart grid: hope or hype? Energy Effic. 9, 545–562. https://doi.org/10.1007/s12053-015-9385-8

Luthra, S., Kumar, S., Kharb, R., Ansari, M.F., Shimmi, S.L., 2014. Adoption of smart grid technologies: An analysis of interactions among barriers. Renew. Sustain. Energy Rev. 33, 554–565. https://doi.org/10.1016/j.rser.2014.02.030

Magee, L., Scerri, A., James, P., Thom, J.A., Padgham, L., Hickmott, S., Deng, H., Cahill, F., 2013. Reframing social sustainability reporting: Towards an engaged approach. Environ. Dev. Sustain. 15, 225–243. https://doi.org/10.1007/s10668-012-9384-2

Manders-Huits, N., 2011. What values in design? The challenge of incorporating moral values into design. Sci. Eng. Ethics 17, 271–287. https://doi.org/10.1007/s11948-010-9198-2

Martin, C.J., Evans, J., Karvonen, A., 2018. Smart and sustainable? Five tensions in the visions and practices of the smart-sustainable city in Europe and North America. Technol. Forecast. Soc. Change 133, 269–278. https://doi.org/10.1016/j.techfore.2018.01.005

Matschoss, K., Kahma, N., Heiskanen, E., 2015. Pioneering customers as change agents for new energy efficiency services???an empirical study in the Finnish electricity markets. Energy Effic. 8, 827–843. https://doi.org/10.1007/s12053-014-9300-8

Mayring, P., 2014. Qualitative Content Analysis. Klagenfurt.

McCauley, D., Heffron, R.J., Stephan, H., Jenkins, K., 2013. Advancing energy justice: the triumvirate of tenets. Int. Energy Law Rev. 32, 107–110.

McGann, M., Moss, J., 2010. Smart Meters, Smart Justice?, Social Justice Initiative 2010, University of Melbourne.

McGinnis, M.D., 2011a. An Introduction to IAD and the Language of the Ostrom Workshop: A Simple Guide to a Complex Framework. Policy Stud. J. 39, 169–183. https://doi.org/10.1111/j.1541-0072.2010.00401.x

McGinnis, M.D., 2011b. Networks of Adjacent Action Situations in Polycentric Governance. Policy Stud. J. 39, 51–78. https://doi.org/10.1111/j.1541-0072.2010.00396.x

McKenna, E., Richardson, I., Thomson, M., 2012. Smart meter data: Balancing consumer privacy concerns with legitimate applications. Energy Policy 41, 807–814. https://doi.org/10.1016/j.enpol.2011.11.049

Meadows, D., 1998. Indicators and Information Systems for Sustainable Development, A report to the Balaton Group. Hartland VT.

Melville, E., Christie, I., Burningham, K., Way, C., Hampshire, P., 2017. The electric commons: A qualitative study of community accountability. Energy Policy 106, 12–21. https://doi.org/10.1016/j.enpol.2017.03.035

Mesarić, P., Đukec, D., Krajcar, S., 2017. Exploring the Potential of Energy Consumers in Smart Grid Using Focus Group Methodology. Sustainability 9, 1463. https://doi.org/10.3390/su9081463

Michaels, L., Parag, Y., 2016. Motivations and barriers to integrating 'prosuming' services into the future decentralized electricity grid: Findings from Israel. Energy Res. Soc. Sci. 21, 70–83. https://doi.org/10.1016/j.erss.2016.06.023

Michalec, A., Hayes, E., Longhurst, J., Tudgey, D., 2019. Enhancing the communication potential of smart metering for energy and water. Util. Policy 56, 33–40. https://doi.org/10.1016/j.jup.2018.11.002

Milchram, C., Hillerbrand, R., van de Kaa, G., Doorn, N., Künneke, R., 2018a. Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom. Appl. Energy 229, 1244–1259. https://doi.org/10.1016/j.apenergy.2018.08.053

Milchram, C., van de Kaa, G., Doorn, N., Künneke, R., 2018b. Moral Values as Factors for Social Acceptance of Smart Grid Technologies. Sustainability 10, 2703. https://doi.org/10.3390/su10082703

Miller, C., Iles, A., Jones, C., 2013. The Social Dimensions of Energy Transitions. Sci. Cult. (Lond). 22, 135–148. https://doi.org/10.1080/09505431.2013.786989

Ministerie van Economische Zaken, 2016. Tijdpad uitrol slimme meter en dynamische leveringstarieven [WWW Document]. URL https://www.rijksoverheid.nl/documenten/kamerstukken/2016/03/04/kamerbrief-over-tijdpad-uitrol-slimme-meter-en-dynamische-leveringstarieven (accessed 11.25.16).

Ministerie van Economische Zaken, 2015. Besluit experimenten decentrale duurzame elektriciteitsopwekking [WWW Document]. URL https://wetten.overheid.nl/BWBR0036385/2015-04-01/0/afdrukken+informatie (accessed 10.28.19).

Ministerie van Economische Zaken en Klimaat, 2019. Klimaatakkoord.

Mir Mohammadi Kooshknow, S.A.R., Davis, C.B., 2018. Business models design space for electricity storage systems: Case study of the Netherlands. J. Energy Storage 20, 590–604. https://doi.org/10.1016/j.est.2018.10.001

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Altman, D., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J.A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J.J., Devereaux, P.J., Dickersin, K., Egger, M., Ernst, E., Gøtzsche, P.C., Grimshaw, J., Guyatt, G., Higgins, J., Ioannidis, J.P.A., Kleijnen, J., Lang, T., Magrini, N., McNamee, D., Moja, L., Mulrow, C., Napoli, M., Oxman, A., Pham, B., Rennie, D., Sampson, M., Schulz, K.F., Shekelle, P.G., Tovey, D., Tugwell, P., 2009. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Med. 6. https://doi.org/10.1371/journal.pmed.1000097

Moser, C., 2017. The role of perceived control over appliances in the acceptance of electricity load-shifting programmes. Energy Effic. 1–13. https://doi.org/10.1007/s12053-017-9508-5

Mouter, N., de Geest, A., Doorn, N., 2018. A values-based approach to energy controversies: Value-sensitive design applied to the Groningen gas controversy in the Netherlands. Energy Policy 122, 639–648. https://doi.org/10.1016/j.enpol.2018.08.020

Muench, S., Thuss, S., Guenther, E., 2014. What hampers energy system transformations? The case of smart grids. Energy Policy 73, 80–92. https://doi.org/10.1016/j.enpol.2014.05.051

Mulder, M., Willems, B., 2019. The Dutch retail electricity market. Energy Policy 127, 228–239. https://doi.org/10.1016/j.enpol.2018.12.010

Mundaca, L., Busch, H., Schwer, S., 2018. ' Successful ' low-carbon energy transitions at the community level ? An energy justice perspective. Appl. Energy 218, 292–303. https://doi.org/10.1016/j.apenergy.2018.02.146

Neuteleers, S., Mulder, M., Hindriks, F., 2017. Assessing fairness of dynamic grid tariffs. Energy Policy 108,

R

111–120. https://doi.org/10.1016/j.enpol.2017.05.028

North, D.C., 1991. Institutions. J. Econ. Perspect. 5, 97–112. https://doi.org/10.1257/jep.5.1.97

Nussbaumer, P., Bazilian, M., Modi, V., 2012. Measuring Energy Poverty: Focusing on What Matters. Renew. Sustain. Energy Rev. 16, 231–243. https://doi.org/10.1016/j.rser.2011.07.150

Obinna, U., Joore, P., Wauben, L., Reinders, A., 2016. Insights from Stakeholders of Five Residential Smart Grid Pilot Projects in the Netherlands. Smart Grid Renew. Energy 7, 1–15. https://doi.org/http://dx.doi.org/10.4236/sgre.2016.71001

Ofgem, 2011. Energy Demand Research Project: Final Analysis. https://doi.org/60163857

Oosterlaken, I., 2014. Applying Value Sensitive Design (VSD) to Wind Turbines and Wind Parks: An Exploration. Sci. Eng. Ethics 21, 359–379. https://doi.org/10.1007/s11948-014-9536-x

Ornetzeder, M., Bechtold, U., Nentwich, M., 2009. Participatory assessment of sustainable end-user technology in Austria. WIT Trans. Ecol. Environ. 121, 269–278. https://doi.org/10.2495/ESU090241

Ostrom, E., 2011. Background on the Institutional Analysis and Development Framework. Policy Stud. J. 39, 7–27. https://doi.org/10.1111/j.1541-0072.2010.00394.x

Ostrom, E., 2005. Understanding Institutional Diversity. Princeton University Press, Princeton, New Jersey. https://doi.org/10.1007/s11127-007-9157-x

Ostrom, E., 1972. Metropolitan Reform: Propositions Derived from Two Traditions. Soc. Sci. Q. https://doi.org/10.2307/42860228

Ostrom, E., Gardner, R., Walker, J., 1994. Rules, Games, and Common-Pool Resources. University of Michigan Press, Ann Arbor, Michigan. https://doi.org/10.2307/2083092

Ostrom, V., Ostrom, E., 1971. Public Choice: A Different Approach to the Study of Public Administration. Public Adm. Rev. 31, 203. https://doi.org/10.2307/974676

Paetz, A.-G., Dütschke, E., Fichtner, W., 2011. Smart Homes as a Means to Sustainable Energy Consumption: A Study of Consumer Perceptions. J. Consum. Policy 35, 23–41. https://doi.org/10.1007/s10603-011-9177-2

Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Glob. Environ. Chang. 19, 354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001

Pahl-Wostl, C., Becker, G., Sendzimir, J., Knieper, C., 2013. How multi-level societal learning processes facilitate transformative change: a comparative case study analysis on flood management. Ecol. Soc. 18, 58. https://doi.org/10.5751/ES-05779-180458 Research

Pahl-Wostl, C., Holtz, G., Kastens, B., Knieper, C., 2010. Analyzing complex water governance regimes: The Management and Transition Framework. Environ. Sci. Policy 13, 571–581. https://doi.org/10.1016/j.envsci.2010.08.006

Parag, Y., Sovacool, B.K., 2016. Electricity market design for the prosumer era. Nat. Energy 1, 16032. https://doi.org/10.1038/nenergy.2016.32

Park, C.K., Kim, H.-J.H.J.H.-J.H.J., Kim, Y.S.Y.-S.Y.S.Y.-S.Y.S.Y.-S., 2014. A study of factors enhancing smart grid consumer engagement. Energy Policy 72, 211–218.

https://doi.org/10.1016/j.enpol.2014.03.017

Park, E.-S., Hwang, B., Ko, K., Kim, D., 2017. Consumer Acceptance Analysis of the Home Energy Management System. Sustainability 9, 2351. https://doi.org/10.3390/su9122351

PBL, 2019. Het klimaatakkoord: effecten en aandachtspunten - policy brief.

Pesch, U., Correljé, A., Cuppen, E., Taebi, B., 2017. Energy justice and controversies: Formal and informal assessment in energy projects. Energy Policy 109, 825–834. https://doi.org/10.1016/j.enpol.2017.06.040

Peters, V., Van de Westelaken, M., 2014. Simulation Games - A concise introduction to the design process, Samenspraak Advies. Nijmegen, The Netherlands.

Peters, V., Vissers, G., Heijne, G., 1998. The Validity of Games. Simul. Gaming 29, 20–30. https://doi.org/10.1177/1046878198291003

Pojman, L.P., 1997. What Is Moral Philosophy?, in: Shrader-Frechette, K.S., Westra, L. (Eds.), Technology and Values. Rowman & Littlefield Publishers, Lanham, Md., pp. 11–23.

Polski, M.M., Ostrom, E., 1999. An Institutional Framework for Policy Analysis and Design, in: Cole, D.H., McGinnis, M.D. (Eds.), Elinor Ostrom and the Bloomington School of Political Economy: A Framework for Policy Analysis. Lexington Books, Lanham, Md., pp. 13–47.

Pommeranz, A., Detweiler, C., Wiggers, P., Jonker, C., 2012. Elicitation of situated values: Need for tools to help stakeholders and designers to reflect and communicate. Ethics Inf. Technol. 14, 285–303. https://doi.org/10.1007/s10676-011-9282-6

Pooranian, Z., Abawajy, J., P, V., Conti, M., 2018. Scheduling Distributed Energy Resource Operation and Daily Power Consumption for a Smart Building to Optimize Economic and Environmental Parameters. Energies 11, 1348. https://doi.org/10.3390/en11061348

Pooranian, Z., Nikmehr, N., Najafi-Ravadanegh, S., Mahdin, H., Abawajy, J., 2016. Economical and environmental operation of smart networked microgrids under uncertainties using NSGA-II. 24th Int. Conf. Software, Telecommun. Comput. Networks, Split. Croat. 22–24 Sept. 2016. https://doi.org/10.1109/SOFTCOM.2016.7772136

Poruschi, L., Ambrey, C.L., 2018. Densification, what does it mean for fuel poverty and energy justice? An empirical analysis. Energy Policy 117, 208–217. https://doi.org/10.1016/j.enpol.2018.03.003

Powells, G., Fell, M.J., 2019. Flexibility capital and flexibility justice in smart energy systems. Energy Res. Soc. Sci. 54, 56–59. https://doi.org/10.1016/j.erss.2019.03.015

Prior, J., 2016. The norms, rules and motivational values driving sustainable remediation of contaminated environments: A study of implementation. Sci. Total Environ. 544, 824–836. https://doi.org/10.1016/j.scitotenv.2015.11.045

Pront-van Bommel, S., 2011. Smart Energy Grids within the Framewok of the Third Energy Package. Eur. Energy Environ. Law Rev. 20, 32–44.

Raimi, K.T., Carrico, A.R., 2016. Understanding and beliefs about smart energy technology. Energy Res. Soc. Sci. 12, 68–74. https://doi.org/10.1016/j.erss.2015.12.018

Ramaswami, A., Weible, C., Main, D., Heikkila, T., Siddiki, S., Duvall, A., Pattison, A., Bernard, M., 2012. A Social-Ecological-Infrastructural Systems Framework for Interdisciplinary Study of Sustainable City Systems: An Integrative Curriculum Across Seven Major Disciplines. J. Ind. Ecol. 16, 801–813.

https://doi.org/10.1111/j.1530-9290.2012.00566.x

Rawls, J., 1971. A theory of justice. Belknap Press of Harvard University Press, Cambridge, Massachussets.

Reed, M.S., Evely, A.C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., Stringer, L.C., 2010. What is social learning? Ecol. Soc. 15, r1. https://doi.org/10.5751/ES-03564-1504r01

Renström, S., 2019. Supporting diverse roles for people in smart energy systems. Energy Res. Soc. Sci. 53, 98–109. https://doi.org/10.1016/j.erss.2019.02.018

Rodela, R., 2011. Social learning and natural resource management: The emergence of three research perspectives. Ecol. Soc. 16. https://doi.org/10.5751/ES-04554-160430

Rogers, E.M., 2003. Diffusion of innovations, 5th ed. Free Press, New York.

Rokeach, M., 1973. The nature of human values. Free Press, New York.

Römer, B., Reichhart, P., Picot, A., 2015. Smart energy for Robinson Crusoe: an empirical analysis of the adoption of IS-enhanced electricity storage systems. Electron. Mark. 25, 47–60. https://doi.org/10.1007/s12525-014-0167-5

Rösch, C., Bräutigam, K.-R., Kopfmüller, J., Stelzer, V., Fricke, A., 2018. Sustainability assessment of the German energy transition. Energy. Sustain. Soc. 8, 12. https://doi.org/10.1186/s13705-018-0153-4

Rösch, C., Bräutigam, K.R., Kopfmüller, J., Stelzer, V., Lichtner, P., 2017. Indicator system for the sustainability assessment of the German energy system and its transition. Energy. Sustain. Soc. 7, 1–13. https://doi.org/10.1186/s13705-016-0103-y

RVO, 2020. Statistics Electric Vehicles in the Netherlands [WWW Document]. URL https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers (accessed 5.29.20).

RVO, 2019. Smart grids en slimme energiesystemen [WWW Document]. URL https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/smart-grids (accessed 10.28.19).

Sandström, G., Keijer, U., 2010. Smart home systems - Accessibility and trust. OPEN HOUSE Int. 35, 6–14.

Sauter, R., Watson, J., 2007. Strategies for the deployment of micro-generation: Implications for social acceptance. Energy Policy 35, 2770–2779. https://doi.org/10.1016/j.enpol.2006.12.006

Schilling, M.A., 2002. Technology Success and Failure in Winner-Take-All Markets: The Impact of Learning Orientation, Timing, and Network Externalities. Acad. Manag. J. 45, 387–398. https://doi.org/10.2307/3069353

Schilling, M.A., 1998. Technological Lockout: An Integrative Model of the Economic and Strategic Factors Driving Technology Success and Failure. Acad. Manag. Rev. 23, 267–284. https://doi.org/10.5465/AMR.1998.533226

Schlör, H., Fischer, W., Hake, J., 2013a. Sustainable development, justice and the Atkinson index: Measuring the distributional effects of the German energy transition. Appl. Energy 112, 1493–1499. https://doi.org/10.1016/j.apenergy.2013.04.020

Schlör, H., Fischer, W., Hake, J., 2013b. Methods of measuring sustainable development of the German energy sector. Appl. Energy 101, 172–181. https://doi.org/10.1016/j.apenergy.2012.05.010

Schlosberg, D., 2007. Defining Environmental Justice: Theories, Movements, and Nature. Oxford University Press, New York.

Schlüter, A., Theesfeld, I., 2010. The grammar of institutions: The challenge of distinguishing between strategies, norms, and rules. Ration. Soc. 22, 445–475. https://doi.org/10.1177/1043463110377299

Schmalfuß, F., Mair, C., Döbelt, S., Kämpfe, B., Wüstemann, R., Krems, J.F., Keinath, A., 2015. User responses to a smart charging system in Germany: Battery electric vehicle driver motivation, attitudes and acceptance. Energy Res. Soc. Sci. 9, 60–71. https://doi.org/10.1016/j.erss.2015.08.019

Scholz, G., Dewulf, A., Pahl-Wostl, C., 2014. An Analytical Framework of Social Learning Facilitated by Participatory Methods. Syst. Pract. Action Res. 27, 575–591. https://doi.org/10.1007/s11213-013-9310-z

Schuitema, G., Steg, L., Forward, S., 2010. Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. Transp. Res. Part A Policy Pract. 44, 99–109. https://doi.org/10.1016/j.tra.2009.11.005

Schwartz, S.H., 1994. Are There Universal Aspects in the Structure and Contents of Human Values? J. Soc. Issues 50, 19–45. https://doi.org/10.1111/j.1540-4560.1994.tb01196.x

Schwartz, S.H., 1992. Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries. Adv. Exp. Soc. Psychol. 25, 1–65. https://doi.org/10.1016/S0065-2601(08)60281-6

Schwartz, S.H., 1977. Normative Influences on Altruism, in: Berkowitz, L. (Ed.), Advances in Experimental Social Psychology, Advances in Experimental Social Psychology. Academic Press, New York, pp. 221–279. https://doi.org/http://dx.doi.org/10.1016/S0065-2601(08)60358-5

Schwartz, S.H., Bilsky, W., 1987. Toward a universal psychological structure of human values. J. Pers. Soc. Psychol. 53, 550–562. https://doi.org/10.1037//0022-3514.53.3.550

Schwartz, S.H., Howard, J.A., 1981. A normative decision-making model of altruism, in: Rushton, J.P., Sorrentino, R.M. (Eds.), Altruism and Helping Behavior: Social, Personality and Developmental Perspective. Hillsdale, NJ: Lawrence Erlbaum, pp. 198–211.

Schweitzer, F., Van den Ende, E., 2016. To Be or Not to Be in Thrall to the March of Smart Products. Psychol. Mark. 33, 830–842. https://doi.org/10.1002/mar.20920

Shah, K.U., Niles, K., 2016. Energy policy in the Caribbean green economy context and the Institutional Analysis and Design (IAD) framework as a proposed tool for its development. Energy Policy 98, 768–777. https://doi.org/10.1016/j.enpol.2016.07.045

Shilton, K., Koepfler, J.A., Fleischmann, K.R., 2013. Charting Sociotechnical Dimensions of Values for Design Research. Inf. Soc. 29, 259–271. https://doi.org/10.1080/01972243.2013.825357

Shove, E., 2003. Converging Conventions of Comfort, Cleanliness and Convenience. J. Consum. Policy 26, 395–418. https://doi.org/10.1023/A:1026362829781

Shrader-Frechette, K.S., 1997. Technology and Ethical Issues, in: Shrader-Frechette, K.S., Westra, L. (Eds.), Technology and Values. Rowman & Littlefield Publishers, Lanham, Md., pp. 25–34.

Shrader-Frechette, K.S., Westra, L., 1997a. Technology and Values. Rowman & Littlefield Publishers, Lanham, Md.

Shrader-Frechette, K.S., Westra, L., 1997b. Overview: Ethical Studies about Technology, in: Shrader-Frechette, K.S., Westra, L. (Eds.), Technology and Values. Rowman & Littlefield Publishers, Lanham, Md., pp. 3–10.

Shrouf, F., Miragliotta, G., 2015. Energy management based on Internet of Things: Practices and framework for adoption in production management. J. Clean. Prod. 100, 235–246. https://doi.org/10.1016/j.jclepro.2015.03.055

Siciliano, G., Urban, F., 2017. Equity-based Natural Resource Allocation for Infrastructure Development: Evidence From Large Hydropower Dams in Africa and Asia. Ecol. Econ. 134, 130–139. https://doi.org/10.1016/j.ecolecon.2016.12.034

Siebenhüner, B., Rodela, R., Ecker, F., 2016. Social learning research in ecological economics: A survey. Environ. Sci. Policy 55, 116–126. https://doi.org/10.1016/j.envsci.2015.09.010

Sierra, L.A., Yepes, V., Pellicer, E., 2018. A review of multi-criteria assessment of the social sustainability of infrastructures. J. Clean. Prod. 187, 496–513. https://doi.org/10.1016/j.jclepro.2018.03.022

Sintov, N.D., Schultz, P.W., 2017. Adjustable green defaults can help make smart homes more sustainable. Sustain. 9, 1–12. https://doi.org/10.3390/su9040622

Skjølsvold, T.M., Ryghaug, M., Berker, T., 2015. A traveler's guide to smart grids and the social sciences. Energy Res. Soc. Sci. 9, 1–8. https://doi.org/10.1016/j.erss.2015.08.017

Sovacool, B.K., 2014. What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. Energy Res. Soc. Sci. 1, 1–29. https://doi.org/10.1016/j.erss.2014.02.003

Sovacool, B.K., Burke, M., Baker, L., Kotikalapudi, C.K., Wlokas, H., 2017a. New frontiers and conceptual frameworks for energy justice. Energy Policy 105, 677–691. https://doi.org/10.1016/j.enpol.2017.03.005

Sovacool, B.K., Dworkin, M.H., 2015. Energy justice: Conceptual insights and practical applications. Appl. Energy 142, 435–444. https://doi.org/10.1016/j.apenergy.2015.01.002

Sovacool, B.K., Heffron, R.J., McCauley, D., Goldthau, A., Pozzer, A., 2016. Energy decisions reframed as justice and ethical concerns. Nat. Energy 1, 16024. https://doi.org/10.1038/nenergy.2016.24

Sovacool, B.K., Kivimaa, P., Hielscher, S., Jenkins, K., 2017b. Vulnerability and resistance in the United Kingdom's smart meter transition. Energy Policy 109, 767–781. https://doi.org/10.1016/j.enpol.2017.07.037

Spence, A., Demski, C., Butler, C., Parkhill, K., Pidgeon, N., 2015. Public perceptions of demand-side management and a smarter energy future. Nat. Clim. Chang. 5, 550–554. https://doi.org/10.1038/nclimate2610

Stedin, 2019. Hoog Dalem [WWW Document]. URL https://www.stedin.net/over-stedin/projecten/hoog-dalem (accessed 9.24.19).

Steg, L., Dreijerink, L., Abrahamse, W., 2005. Factors influencing the acceptability of energy policies: A test of VBN theory. J. Environ. Psychol. 25, 415–425. https://doi.org/10.1016/j.jenvp.2005.08.003

Stern, P.C., 2000. Toward a Coherent Theory of Environmentally Significant Behavior. J. Soc. Issues 56, 407–424. https://doi.org/10.1111/0022-4537.00175

Strengers, Y., 2012. Peak electricity demand and social practice theories: Reframing the role of change

R

agents in the energy sector. Energy Policy 44, 226–234. https://doi.org/10.1016/j.enpol.2012.01.046

Suarez, F.F., 2004. Battles for technological dominance: An integrative framework. Res. Policy 33, 271–286. https://doi.org/10.1016/j.respol.2003.07.001

Suarez, F.F., Utterback, J.M., 1995. Dominant designs and the survival of firms. Strateg. Manag. J. 16, 415–430. https://doi.org/10.1002/smj.4250160602

Szulecki, K., 2018. Conceptualizing energy democracy. Env. Polit. 27, 21–41. https://doi.org/10.1080/09644016.2017.1387294

Taebi, B., 2016. Bridging the Gap between Social Acceptance and Ethical Acceptability. Risk Anal. forthcomin, 1–21. https://doi.org/10.1111/risa.12734

Taebi, B., Kadak, A.C., 2010. Intergenerational considerations affecting the future of nuclear power: equity as a framework for assessing fuel cycles. Risk Anal. 30, 1341–1362. https://doi.org/10.1111/j.1539-6924.2010.01434.x

Teece, D.J., 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Res. Policy 15, 285–305. https://doi.org/10.1016/0048-7333(86)90027-2

Thomas, S.D., 2012. Not Too Smart an Innovation: Britain's Plans to Switch Consumers to Smart Electricity and Gas Meters. Energy Environ. 23, 1057–1074. https://doi.org/10.1260/0958-305X.23.6-7.1057

Thomson, H., Bouzarovski, S., Snell, C., 2017. Rethinking the measurement of energy poverty in Europe: A critical analysis of indicators and data. Indoor Built Environ. 26, 879–901. https://doi.org/10.1177/1420326X17699260

Timmermans, J., Zhao, Y., 2011. Ethics and Nanopharmacy: Value Sensitive Design of New Drugs. Nanoethics 5, 269–283. https://doi.org/10.1007/s11569-011-0135-x

Tuballa, M.L., Abundo, M.L., 2016. A review of the development of Smart Grid technologies. Renew. Sustain. Energy Rev. 59, 710–725. https://doi.org/10.1016/j.rser.2016.01.011

Tweede Kamer der Staten-Generaal, 2006. Liberalisering energiemarkten, Kamerstuk TK 2005-2006, 28982, nr. 51.

UNFCCC, 2018. Solidarity and Just Transition. Silesia Declaration, COP24, Katowice.

United Nations Development Programme, 2004. World Energy Assessment: Overview. 2004 Update. United Nations Development Programme, New York, USA.

United Nations Development Programme, 2000. World Energy Assessment. Energy and the challenge of Sustainability, World Energy Assessment. United Nations Development Programme, New York, USA.

Vagropoulos, S.I., Balaskas, G.A., Bakirtzis, A.G., 2017. An Investigation of Plug-In Electric Vehicle Charging Impact on Power Systems Scheduling and Energy Costs. IEEE Trans. Power Syst. 32, 1902–1912. https://doi.org/10.1109/TPWRS.2016.2609933

Van de Kaa, G., De Vries, H.J., 2015. Factors for winning format battles: A comparative case study. Technol. Forecast. Soc. Change 91, 222–235. https://doi.org/10.1016/j.techfore.2014.02.019

Van de Kaa, G., De Vries, H.J., Rezaei, J., 2014. Platform selection for complex systems: Building automation systems. J. Syst. Sci. Syst. Eng. 23, 415–438. https://doi.org/10.1007/s11518-014-5258-5

Van de Kaa, G., De Vries, H.J., Van den Ende, J., 2015. Strategies in network industries: the importance of inter-organisational networks, complementary goods, and commitment. Technol. Anal. Strateg. Manag. 27, 73–86. https://doi.org/10.1080/09537325.2014.951320

Van de Kaa, G., Van den Ende, J., de Vries, H.J., Van Heck, E., 2011. Factors for winning interface format battles: A review and synthesis of the literature. Technol. Forecast. Soc. Change 78, 1397–1411. https://doi.org/10.1016/j.techfore.2011.03.011

van de Poel, I., 2018. Design for value change. Ethics Inf. Technol. 0, 1–5. https://doi.org/10.1007/s10676-018-9461-9

Van de Poel, I., 2016. A coherentist view on social acceptance and moral acceptability of technology, in: Franssen, M., Vermaas, P., Kroes, P. (Eds.), Philosophy of Technology after the Empirical Turn. Springer International Publishing, pp. 1–14. https://doi.org/10.1007/978-3-319-33717-3_11

Van de Poel, I., 2013. Translating Values into Design Requirements, in: Michelfelder, D.P., McCarthy, N., Goldberg, D.E. (Eds.), Philosophy and Engineering: Reflections on Practice, Principles and Process. Springer Netherlands, pp. 253–266. https://doi.org/10.1007/978-94-007-7762-0_20

Van de Poel, I., 2009. Values in engineering design, in: Meijers, A.W.M. (Ed.), Handbook of the Philosophy of Science. pp. 973–1006.

Van de Poel, I., Royakkers, L., 2011. Ethics, Technology and Engineering: An Introduction. Wiley-Blackwell, Chichester, West Sussex.

Van den Hoven, J., Vermaas, P.E., Van de Poel, I., 2015. Design for Values: An Introduction, in: van den Hoven, J., Vermaas, P.E., van de Poel, I. (Eds.), Handbook of Ethics, Values, and Technological Design: Sources, Theory, Values and Application Domains. Springer Netherlands, Dordrecht, pp. 1–87. https://doi.org/10.1007/978-94-007-6970-0

van der Kam, M.J., Meelen, A.A.H., van Sark, W.G.J.H.M., Alkemade, F., 2018. Diffusion of solar photovoltaic systems and electric vehicles among Dutch consumers: Implications for the energy transition. Energy Res. Soc. Sci. 46, 68–85. https://doi.org/10.1016/j.erss.2018.06.003

van der Werff, E., Steg, L., 2016. The psychology of participation and interest in smart energy systems: Comparing the value-belief-norm theory and the value-identity-personal norm model. Energy Res. Soc. Sci. 22, 107–114. https://doi.org/10.1016/j.erss.2016.08.022

van Mierlo, B., 2019. Users Empowered in Smart Grid Development? Assumptions and Up-To-Date Knowledge. Appl. Sci. 9, 815. https://doi.org/10.3390/app9050815

Van Santen, H., 2017. Je stroom bewaren in de buurtbatterij. NRC Handel. 11.24.19.

Van Wynsberghe, A., 2013. Designing Robots for Care: Care Centered Value-Sensitive Design. Sci. Eng. Ethics 19, 407–433. https://doi.org/10.1007/s11948-011-9343-6

Vassileva, I., Dahlquist, E., Wallin, F., Campillo, J., 2013. Energy consumption feedback devices' impact evaluation on domestic energy use. Appl. Energy 106, 314–320. https://doi.org/10.1016/j.apenergy.2013.01.059

Venkatesh, V., Davis, F.D., 2000. A theoretical extension of the technology acceptance model: Four longitudinal Studies. Manage. Sci. 46, 186–205. https://doi.org/10.1287/mnsc.46.2.186.11926

Venkatesh, V., Thong, J., Xu, X., 2012. Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. MIS Q. 36, 157–178. https://doi.org/10.1111/j.1540-4560.1981.tb02627.x

Verbeek, P.P., 2008. Obstetric ultrasound and the technological mediation of morality: A postphenomenological analysis. Hum. Stud. 31, 11–26. https://doi.org/10.1007/s10746-007-9079-0

Verbong, G.P.J., Beemsterboer, S., Sengers, F., 2013. Smart grids or smart users? Involving users in developing a low carbon electricity economy. Energy Policy 52, 117–125. https://doi.org/10.1016/j.enpol.2012.05.003

Verein Deutscher Ingenieure, 2000. VDI 3780: Technology Assessment Concepts and Foundations, Technology. Verein Deutscher Ingenieure.

Villamayor-Tomas, S., 2017. The Water-Energy Nexus in Europe and Spain: An Institutional Analysis From the Perspective of the Spanish Irrigation Sector, in: Ziolkowska, J.R., Peterson, J.M. (Eds.), Competition for Water Resources: Experiences and Management Approaches in the US and Europe. Elsevier Inc., Amsterdam, NL; Oxford, UK; Cambridge, USA, pp. 105–122. https://doi.org/10.1016/B978-0-12-803237-4.00006-9

Vringer, K., Dassen, T., 2016. De Slimme Meter , Uitgelezen Energie(k)?, Den Haag: PBL.

Walker, G., 2009. Beyond distribution and proximity: Exploring the multiple spatialities of environmental justice. Antipode 41, 614–636. https://doi.org/10.1111/j.1467-8330.2009.00691.x

Walker, G., Day, R., 2012. Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. Energy Policy 49, 69–75. https://doi.org/10.1016/j.enpol.2012.01.044

Warren, P., 2014. A review of demand-side management policy in the UK. Renew. Sustain. Energy Rev. 29, 941–951. https://doi.org/10.1016/j.rser.2013.09.009

Will, C., Schuller, A., 2016. Understanding user acceptance factors of electric vehicle smart charging. Transp. Res. Part C Emerg. Technol. 71, 198–214. https://doi.org/10.1016/j.trc.2016.07.006

Williamson, O.E., 1998. Transaction Cost Economics: How It Works; Where It is Headed. Economist (Leiden). 146, 23–58. https://doi.org/10.1023/a:1003263908567

Wilson, C., Hargreaves, T., Hauxwell-Baldwin, R., 2017. Benefits and risks of smart home technologies. Energy Policy 103, 72–83. https://doi.org/10.1016/j.enpol.2016.12.047

Wilson, C., Hargreaves, T., Hauxwell-Baldwin, R., 2015. Smart homes and their users: a systematic analysis and key challenges. Pers. Ubiquitous Comput. 19, 463–476. https://doi.org/10.1007/s00779-014-0813-0

Winner, L., 1980. Do Artifacts Have Politics? Daedalus 109, 121–136.

Wissner, M., 2011. The Smart Grid – A saucerful of secrets? Appl. Energy 88, 2509–2518. https://doi.org/10.1016/j.apenergy.2011.01.042

Wolsink, M., 2013. Fair distribution of power-generating capacity: justice, microgrids and utilizing the common pool of renewable energy, in: Bickerstaff, K., Walker, G., Bulkeley, H. (Eds.), Energy Justice in a Changing Climate: Social Equity and Low Carbon Energy. Zed Books, London, pp. 116–138.

Wolsink, M., 2007. Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. Energy Policy 35, 2692–2704. https://doi.org/10.1016/j.enpol.2006.12.002

World Bank, 2013. Toward a Sustainable Energy Future for All [WWW Document]. World Bank Group's Energy Sect. URL http://documents.worldbank.org/curated/en/745601468160524040/pdf/795970SST0SecM00box377380B00PUBLIC0.pdf (accessed 3.20.18).

Wüstenhagen, R., Wolsink, M., Bürer, M.J., 2007. Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy 35, 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Xenias, D., Axon, C.J., Whitmarsh, L., Connor, P.M., Balta-Ozkan, N., Spence, A., 2015. UK smart grid development: An expert assessment of the benefits, pitfalls and functions. Renew. Energy 81, 89–102. https://doi.org/10.1016/j.renene.2015.03.016

Yang, H., Lee, H., Zo, H., 2017. User acceptance of smart home services: an extension of the theory of planned behavior. Ind. Manag. Data Syst. 117, 68–89. https://doi.org/10.1108/IMDS-01-2016-0017

Yin, R.K., 2014. Case Study Research, Design and Methods, 5th ed. Sage Publications, Thousand Oaks, CA.

Yin, R.K., 2009. Case Study Research. SAGE Publications, Inc.

Young, I.M., 1990. Justice and the Politics of Difference. Princeton University Press, Princeton, New Jersey.

Zhou, B., Li, W., Chan, K.W., Cao, Y., Kuang, Y., Liu, X., Wang, X., 2016. Smart home energy management systems: Concept, configurations, and scheduling strategies. Renew. Sustain. Energy Rev. 61, 30–40. https://doi.org/10.1016/j.rser.2016.03.047

Zhou, S., Brown, M.A., 2017. Smart meter deployment in Europe: A comparative case study on the impacts of national policy schemes. J. Clean. Prod. 144, 22–32. https://doi.org/10.1016/j.jclepro.2016.12.031

Zipperer, A., Aloise-Young, P.A., Suryanarayanan, S., Roche, R., Earle, L., Christensen, D., Bauleo, P., Zimmerle, D., 2013. Electric energy management in the smart home: Perspectives on enabling technologies and consumer behavior. Proc. IEEE 101, 2397–2408. https://doi.org/10.1109/JPROC.2013.2270172

# About the author

Christine Milchram has a background in international management and corporate sustainability. She is driven by the need to create more sustainable societies, with particular interest in social justice, renewable energy, and urban mobility systems.

Born and raised in Austria, Christine holds a BA in International Business Relations from the University of Applied Sciences Burgenland in Eisenstadt and an MSc in International Business Administration from the University of Vienna. During her studies, she spent one semester each in Waterford (Ireland), Mladá Boleslav (Czech Republic), and Montréal (Canada). Additionally, she completed an extracurricular education program in sustainable development. In 2012, Christine started working as sustainability consultant for Accenture Strategy & Sustainability in Berlin (Germany). She worked mainly with automotive manufacturers and electric utilities, implementing projects for electric mobility and business process management as well as conducting analyses for corporate sustainability strategies and reporting.

In February 2016, Christine joined the faculty of Technology, Policy and Management at Delft University of Technology as a PhD researcher. In her work, she addressed the ethical acceptability of renewable energy systems by analyzing moral implications of smart electricity grids. Her research was interdisciplinary and contributed to value-sensitive design, energy justice, and institutional economics. The results were presented at international conferences and have been published in peer-reviewed journals. Christine was a visiting researcher at the Institute for Technology Assessment and Systems Analysis in Karlsruhe (Germany) and the Forschungszentrum Jülich (Germany). She also presented her results to policymakers and industry practitioners at events organized for example by the Green European Foundation. Next to her research, Christine reviewed papers for journals such as 'Nature Energy', 'Energy Research and Social Science', and 'Applied Energy'. She supervised master students, gave lectures on energy justice in BSc and MSc courses, and co-organized two international conferences on infrastructure economics and sustainable urban energy systems in Delft.

## List of publications

**Milchram, C.**, Künneke, R., Doorn, N., Van de Kaa, G., Hillerbrand, R., 2020. Designing for justice in electricity systems: A comparison of smart grid experiments in the Netherlands. Energy Policy (in press). https://doi.org/10.1016/j.enpol.2020.111720

Jenkins, K.E.H., Spruit, S., **Milchram, C.**, Höffken, J., Taebi, B., 2020. Synthesizing value sensitive design, responsible research and innovation, and energy justice: A conceptual review. Energy Res. Soc. Sci. 69, 101727. https://doi.org/10.1016/j.erss.2020.101727

**Milchram, C.**, Märker, C., Schlör, H., Künneke, R., van de Kaa, G., 2019. Understanding the role of values in institutional change: the case of the energy transition. Energy. Sustain. Soc. 9, 1–14. https://doi.org/10.1186/s13705-019-0235-y

**Milchram, C.**, Märker, C., Hake, J.-F., 2019. The role of values in analyzing energy systems: Insights from moral philosophy, institutional economics, and sociology. Energy Procedia 158, 3741–3747. https://doi.org/10.1016/j.egypro.2019.01.882

Hillerbrand, R., **Milchram, C.**, Schippl, J., 2019. The Capability Approach as a normative framework for technology assessment. TATuP 28, 52–57. https://doi.org/10.14512/tatup.28.1.52

**Milchram, C.**, Hillerbrand, R., van de Kaa, G., Doorn, N., Künneke, R., 2018. Energy Justice and Smart Grid Systems: Evidence from the Netherlands and the United Kingdom. Appl. Energy 229, 1244–1259. https://doi.org/10.1016/j.apenergy.2018.08.053

Märker, C., **Milchram, C.**, 2018. The role of values in analysing energy systems: Insights from moral philosophy, institutional economics and sociology, in: CONTROL, CHANGE AND CAPACITY-BUILDING IN ENERGY SYSTEMS RESEARCH DESIGN CHALLENGE. Cambridge, pp. 77–84.

**Milchram, C.**, van de Kaa, G., Doorn, N., Künneke, R., 2018. Moral Values as Factors for Social Acceptance of Smart Grid Technologies. Sustainability 10, 2703. https://doi.org/10.3390/su10082703

Hillerbrand, R., **Milchram, C.**, Schippl, J., 2017. Digitalization to realize our energy future. In: Otto, P., Gräf, E. (eds.), 3TH1CS: A reinvention of ethics in the digital age? Berlin: iRIGHTS media.

Van De Kaa, G., Scholten, D., Rezaei, J., **Milchram, C.**, 2017. The battle between battery and fuel cell powered electric vehicles: A BWM approach. Energies 10, 1707. https://doi.org/10.3390/en10111707

**Milchram, C.**, Hillerbrand, R., 2017. Values at stake for smart grid systems: The case of the Netherlands, in: Proceedings of the 12th Conference on Sustainable Development of Energy, Water, and Environment Systems, October 2017.

**Milchram, C.**, Van De Kaa, G., 2017. Moral values as factors for social acceptance: The case of smart energy systems, in: Proceedings of the 26th International Association for Management of Technology Conference, May 2017.

Halkias, G., Micevski, M., Diamantopoulos, A., **Milchram, C.**, 2016. Exploring the effectiveness of foreign brand communication: Consumer culture ad imagery and brand schema incongruity. J. Bus. Res. 80, 210–217. https://doi.org/10.1016/j.jbusres.2017.04.018