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Conflicts of Climate Change Mitigation Actions with the Sustainable Development Goals

Creating a Systematic Overview by the Example of Renewable Energy Technologies

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Vorwort

2015 haben die Vereinten Nationen 17 Nachhaltigkeitsziele (Sustainable Development Goals, SDGs) vereinbart. Zwischen den 17 Zielen gibt es mannigfache Synergien. Es gibt jedoch auch Potenziale für Zielkonflikte. So erfordert die Bereitstellung einer klimafreundlichen und universellen Energieversorgung erhebliche Investitionen in neue Kraftwerke und Übertragungsnetze. Solche Energieprojekte stehen insbesondere in Ländern des globalen Südens immer wieder in Konflikt mit der lokalen Landwirtschaft und damit mit der Lebensgrundlage der lokalen Bevölkerungen.

Die bisherigen Diskussionen und Veröffentlichungen zum Verhältnis von Klima und SDGs fokussieren sehr häufig auf die synergistischen Effekte einer nachhaltigen Herangehensweise an Treibhausgasminderungen und Anpassung. Für eine effektive und langfristig positive Umsetzung der Ziele von Paris und einem größtmöglichen Nutzen für Staaten und ihre Bevölkerungen sollten die potenziellen Zielkonflikte aber keinesfalls vergessen werden.

Die Master-Arbeit von Jan-Hendrik Scheyl entwirft einen Ansatz, wie mögliche Zielkonflikte kartiert werden können. Auf dieser Grundlage erstellt die Arbeit einen systematischen Überblick über mögliche Konflikte zwischen drei Erneuerbare-Energien-Technologien (Solar-, Wind- und Wasserkraft) und den SDGs. Der Überblick beruht auf einer systematischen Auswertung der einschlägigen wissenschaftlichen Literatur. Die Zusammenstellung zeigt, dass einerseits jede Technologie verschiedene Konflikte hervorrufen kann, andererseits aber auch gemeinsame Probleme bestehen, insbesondere im Bereich Erhaltung der Biodiversität, Degradierung natürlicher Habitate und Verschärfung lokaler sozialer Ungleichheiten. Entsprechend sind die Auswahl der Flächen für Energieprojekte sowie die Ausgestaltung der lokalen Entscheidungsprozesse wichtige Elemente bei der Vermeidung oder Minimierung von Konflikten.

Der in der Arbeit entwickelte Ansatz zur Kartierung von Konflikten könnte für weitere Forschung sowie von politischen EntscheidungsträgerInnen aufgenommen und auch auf andere Arten von Klimaschutzmaßnahmen übertragen werden. Die Arbeit leistet damit einen wichtigen Beitrag zu der Debatte, wie mögliche Zielkonflikte zwischen Klimaschutz und anderen Nachhaltigkeitszielen identifiziert und vermieden werden können.

Wuppertal, im Februar 2020

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Zusammenfassung

Trotz eines engen Zusammenhangs zwischen dem Pariser Abkommen und der 2030 Agenda, sind Ziele des Klimaschutzes und Ziele der nachhaltigen Entwicklung oft nicht effizient aufeinander abgestimmt. Dies kann zu Konflikten zwischen den Zielen führen.

Diese Arbeit erstellt einen systematischen Überblick über Konflikte von drei Technologien erneuerbarer Energien mit den Zielen nachhaltiger Entwicklung (SDGs) durch eine Literaturrecherche im Web of Science. Die Technologien Solarenergie, Windenergie und Wasserkraft dienen als Beispiele für Ziele des Klimaschutzes. Von 530 überprüften Artikeln zeigten 63 Konflikte. Der systematische Überblick zeigt, dass Konflikte für jede der Technologien unterschiedlich sind. Besonders stechen jedoch Konflikte im Hinblick auf den Verlust der biologischen Vielfalt und die Zerstörung natürlicher Lebensräume (SDG 15) und Ungleichheiten (SDG 10) auf.

Die Ergebnisse des systematischen Überblicks deuten darauf hin, dass die Standortwahl und der Entscheidungsprozess über den Bau von Projekten im Bereich der erneuerbaren Energien entscheidende Schritte sind, um Konflikte mit den SDGs zu vermeiden.

Abstract

Despite a strong connection between the Paris Agreement and the 2030 Agenda for Sustainable Development, climate change mitigation actions and sustainable development objectives are oftentimes not aligned efficiently, causing conflicts between the objectives.

This thesis creates a systematic overview of conflicts of three renewable energy technologies with the Sustainable Development Goals (SDGs) by a literature review in Web of Science. The technologies solar energy, wind energy and hydropower function as examples for climate change mitigation actions. Out of 530 screened articles, 63 demonstrated conflicts. The systematic overview reveals that conflicts are different for each technology, but conflicts in regard to biodiversity loss and the degradation of natural habitats (SDG 15) and inequalities (SDG 10) were frequently identified for all technologies.

The results of the systematic overview suggest that the site selection and the decision-making process on the construction of renewable energy projects are crucial stages to avoid conflicts with the SDGs.

Content

List of abbreviations

BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
CO_2	Carbon dioxide
COP	Conference of the Parties
CSP	Concentrated solar power
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
MDG	Millennium Development Goal
NDC	Nationally Determined Contribution
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PV	Photovoltaic
SCAN	SDG Climate Action Nexus
SDG	Sustainable Development Goal
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USSE	Utility-scale solar energy
WCED	World Commission on Environment and Development

List of tables

List of figures

1 Introduction

Jan-Hendrik Scheyl

In the beginning of 2019, the World Economic Forum published their annual Global Risks Report. It broadly states that "the world is facing a growing number of complex and interconnected challenges [...]" (World Economic Forum 2019: 5) and that for solving these challenges "there has never been a more pressing need for a collaborative and multistakeholder approach [...]" (World Economic Forum 2019: 5). The report contains the result of a survey conducted in order to identify the top ten global risks in terms of likelihood and impact (World Economic Forum 2019: 100). In the report, a global risk is defined as an "an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years" (World Economic Forum 2019: 96). In 2019 primarily environmental risks appear in high-ranked positions of the survey (World Economic Forum 2019: 3). The risks are listed as following in table 1 (World Economic Forum 2019: 3):

Table 1: Global risks in terms of likelihood and impact (World Economic Forum 2019: 3)

Top 10 global risks in terms of likelihood	Top 10 global risks in terms of impact
1) Extreme weather events	1) Weapons of mass destruction
2) Failure of climate-change mitigation and adaptation	2) Failure of climate-change mitigation and adaptation
3) Natural disasters	3) Extreme weather events
4) Data fraud or theft	4) Water crisis
5) Cyber-attacks	5) Natural disasters
6) Man-made environmental disasters	6) Biodiversity loss and ecosystem collapse
7) Large-scale involuntary migration	7) Cyber-attacks
8) Biodiversity loss and ecosystem collapse	8) Critical information and infrastructure breakdown
9) Water crisis	9) Man-made environmental disasters
10) Asset bubbles in a major economy	10) Spread of infectious diseases

The listed risks are highly interconnected. For example, a failure of climate change mitigation and adaptation could lead to more extreme weather events. A water crisis could lead to an ecosystem collapse and natural disasters could lead to large-scale involuntary migration. The connectedness between the risks illustrates that they need to be tackled collectively and on a global level as many countries are likely to be affected, directly or indirectly. Therefore, the list provides an essential overview of areas where urgent action is needed, especially in the form of international agreements and policies.

The year 2015 can be seen as a historic year in regard to tackling many of the risks mentioned on a global level because of two main events. In December 2015 the Paris Agreement was adopted during the 21st Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) (see chapter 2.1). The Paris Agreement is a global treaty that has been ratified by 185 parties to the convention and that aims at "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (UNFCCC 2015: Art. 2 (1a)). Three months earlier, the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development were adopted (see chapter 2.2) and came into effect at the beginning of the following year (UN n.d.b). Achieving the 17 goals, including their 169 specific targets and their indicators, is not legally binding, but "governments are expected to take ownership and establish national frameworks" (UN n.d.b) that lead to their fulfillment. The overall aim is that "over the next fifteen years, with these new Goals that universally apply to all, countries will mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind" (UN n.d.b). The adoption of these two international policy instruments in 2015 is described as "important milestones" (Von Stechow et al. 2016: 2), "a watershed for international sustainability governance" (Obergassel et al. 2017: 249) and as "landmark" (Van Tilburg et al. 2018: 2).

The Paris Agreement and the SDGs are two policy instruments that are intertwined. The Paris Agreement constitutes that its aims are to be achieved "on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty" (UNFCCC 2015: Art. 4 (1)), while SDG 13 is about climate change and reducing greenhouse gas (GHG) emissions (UN n.d.a). The United Nations (UN) describe the relationship between climate change and sustainable development as following (UN n.d.b):

- "Climate change is already impacting public health, food and water security, migration, peace and security. Climate change, left unchecked, will roll back the development gains we have made over the last decades and will make further gains impossible.
- Investments in sustainable development will help address climate change by reducing greenhouse gas emissions and building climate resilience.
- Conversely, action on climate change will drive sustainable development.
- Tackling climate change and fostering sustainable development are two mutually reinforcing sides of the same coin; sustainable development cannot be achieved without climate action. Conversely, many of the SDGs are addressing the core drivers of climate change."

The relationship between climate change and sustainable development is highly relevant as they are interdependent. The UN focuses in their description on synergies and the need to address the two together. Highlighting synergies is important, but conflicts may arise as well. In regard to the SDGs, Nilsson et al. (2016) point out that "if countries ignore the overlaps and simply start trying to tick off targets one by one, they risk perverse outcomes." Pradhan et al. (2017) demonstrate that even within one SDG conflicts may arise: the indicator for SDG 7 "proportion of population with access to electricity" may interfere with the indicator "renewable energy share in the total final energy consumption" for the same goal (Pradhan et al. 2017: 1171).
Van Tilburg et al. (2018: 3) provide an example of how climate change mitigation actions interfere with the SDGs: "[...] [D]eployment of some renewable technologies requires significant amounts of land which, depending on the context, can conflict with ecosystem conservation objectives."

Although the connection between climate change and sustainable development is clear, "in practice, climate change and sustainable development have so far been siloed issues" (Obergassel et al. 2017: 249). This is why Obergassel et al. (2017: 252) call for a better integration of climate change and sustainable development in order to create policies that are more effective. Therefore, a precise understanding of possible conflicts is necessary. The Intergovernmental Panel on Climate Change (IPCC) also identifies the need for "expanded treatment of co-benefits and risks of mitigation pathways" (IPCC 2014a: 489). In the literature, categorizations and overviews of conflicts and synergies among the SDGs and between climate actions and the SDGs exist. However, they are very broad and lack a specific relation to concrete climate change mitigation actions or do not present them in great detail. Analyzing these concrete actions is expected to reveal different conflicts for each climate change mitigation action. Creating a systematic overview for these different conflicts not only adds value to the academic discourse but can also be a useful tool for governments and policy makers to be aware of possible negative aspects of a chosen mitigation action in regard to the SDGs.

This thesis outlines and discusses conflicts of renewable energy technologies, as examples for specific climate change mitigation actions, with the SDGs. The aim is to create a systematic overview that showcases how the renewable energy technologies solar energy, wind energy and hydropower harm sustainable development objectives, specifically the 17 SGDs and their 169 targets. The method used is a literature review in Web of Science. With the help of the overview, a landscape of conflicts of each of the three technologies with the SDGs will be identified. In this context, the conflicts between the mentioned technologies and each of the 169 SDG targets will be illustrated. In addition, if possible, they will be tied to a geographic area and potential causes for the conflict will be noted. Due to the difficulty of predicting results of a comprehensive literature review, it can only be hypothesized that the landscape looks different for each technology and that some SDGs are connected to more conflicts than others. Patterns in regard to the geographic area and the cause of the conflict would add special value to the results.

In order to put the systematic overview into context, the second chapter details climate change and sustainable development and their history as well as the development of the most recent international policy instruments, namely the Paris Agreement and the 2030 Agenda. In this chapter the terminology related to climate change and sustainable development is clarified and the connection between the two is further elaborated upon. Chapter three explains what climate change mitigation actions are and shows how they can be categorized. It also describes why renewable energy technologies were chosen as examples for climate change mitigation actions. The fourth chapter outlines the methodology of the development of the systematic overview. Beginning with an assessment of existing overviews, it then presents how relevant articles in Web of Science are selected and how the systematic overview is structured. Following this, the fifth chapter applies the overview to the three renewable energy technologies and summarizes the main results of each technology. Finally, an analysis of the results is followed by a conclusion.

2 Climate change and sustainable development

Climate change and sustainable development gained worldwide attention in 2015 as the Paris Agreement and the 2030 Agenda were adopted. These two policy instruments can be seen as flagships on the international policy level of climate change and sustainable development. It is important to illustrate the historic and political development of the two areas in order to understand the relevance of the assessment of conflicts between them. It is also necessary to briefly highlight the distinction between climate change and sustainable development before covering each topic in greater detail.

Climate change is, in general, a natural phenomenon that is caused by a variety of complex factors on earth (Bundeszentrale für politische Bildung 2013). Defining factors are variations in geoastrophysical parameters, changes on the earth's surface and the composition of the earth's atmospheric gases (Umweltbundesamt 2014). In contrast, sustainable development is a principle that "calls for society to strive to become environmentally sound, socially just and economically productive", while "people living in one part of the world today should not live at the cost of people in other regions of the world nor at the cost of future generations" (BMU n.d.).

2.1 Climate change and the Paris Agreement

In the following chapter, the scientific background of climate change is outlined before illustrating the historic and political development of climate policy. This is necessary in order to demonstrate that although climate change is a natural phenomenon, recent developments pose various threats for natural and human systems.

2.1.1 Scientific background of climate change

At first glance, the meaning of the term climate change seems straightforward: it describes a changing climate. However, there is a need for a more detailed description in order to understand why the topic has gained public attention in recent years. The following definitions by the IPCC are drawn from the glossary of the Fifth Assessment Report on mitigation of climate change and are presented shortened: climate is the average weather over a period of 30 years (IPCC 2014a: 1255). Indicators used to describe the climate are variables like temperature, precipitation and wind (IPCC 2014a: 1255). If by using statistical tests a significant change in these variables over a certain time period is observed, this is called climate change (IPCC 2014a: 1255). It is crucial to mention that the climate has been consistently changing over all geological eras (Bundeszentrale für politische Bildung 2013). In this sense, climate change is a natural phenomenon, as reasons for this change may be due to natural processes on earth as mentioned in the beginning of chapter two.

Anthropogenic effects also contribute to a changing climate. Human-induced changes in the composition of the atmosphere or in land use are examples of anthropogenic effects (IPCC 2014a: 1255). This is why the UNFCCC defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is addition to natural climate variability observed over comparable time periods" (UNFCCC 1992: Art. 1 (2)).

With the beginning of industrialization in the 18th century, these anthropogenic effects became more and more pronounced due to the increased use of fossil fuels and changes in land use (Umweltbundesamt 2014). Figure 1 (Lindsey 2017) illustrates the concentration of carbon dioxide (CO_2) over the last 800,000 years.[1] CO_2 is a GHG that is released by burning fossil fuels and contributes to climate change (IPCC 2014a: 1254). CO_2 is one of many GHGs. Besides CO_2 the most important anthropogenic GHGs include methane, nitrous oxide and fluorinated gases (Environmental Protection Agency n.d). CO_2 is the most relevant anthropogenic GHG as it has biggest share of all anthropogenic GHGs.[2] Except for fluorinated gases, all other three main anthropogenic GHGs are not only released by human activities but also exist naturally in the earth's atmosphere. The concentration of CO_2 over the last 800,000 years demonstrates that there were variabilities in the concentration. Nonetheless recent decades have been unprecedented.

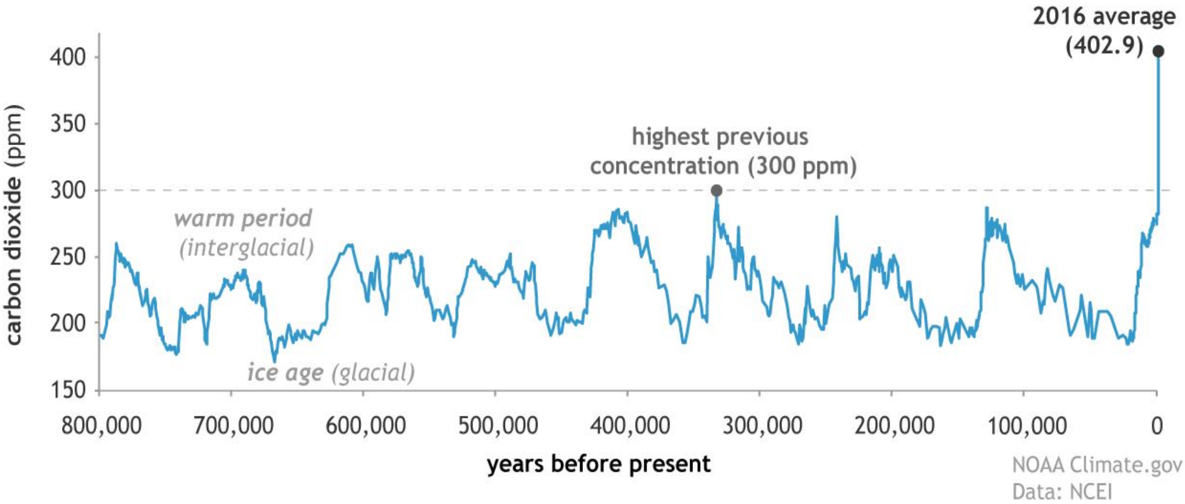

Figure 1: CO_2 during ages and warm periods for the past 800,000 years (Lindsey 2017)

It is scientifically agreed upon that recent changes in climate and global temperature are caused by humans (Cook et al. 2013). These recent and drastic changes result in various negative impacts for natural and human systems all over the world. Examples for these negative impacts include effects on water resources, coastal erosion, species migration, wildfires or effects on food production and human health (IPCC 2014b: 7). Because of these negative impacts, global action is urgent.

In anticipation of chapter three, there are two main approaches of combating climate change. The first is adaptation, meaning "the process of adjustment to actual or expected climate and its effects" (IPCC 2014a: 1251). Climate change adaptation mainly deals with avoiding negative impacts of climate change. Adaptation measures are important as vulnerable natural and human systems need immediate protection. Considering future negative impacts of climate change, it would be best if they could

[1] In figure 1 the global average atmospheric carbon dioxide level is 402.9 parts per million. This number is dated from 2016. More current measures demonstrate an increase to 411 parts per million measured in July 2019 (NASA 2019).

[2] In general the most important GHG is water vapor.

be avoided completely or, at very least lessened. This is why the second approach, climate change mitigation, is also highly relevant and the main topic of this thesis. Climate change mitigation is defined as “a human intervention to reduce the sources or enhance the sinks of GHGs” (IPCC 2014a: 1266). Considering this, climate change refers to a natural phenomenon per se that because of human activities was altered during last decades. This alteration causes significant negative impacts on natural and human systems and therefore, global action is needed to cope with and prevent further negative impacts. This understanding is similar to the definition by UNFCCC.

2.1.2 Political and historic development of climate change

Politically, climate change was hardly on the global agenda before the 1990s (Bodansky 2001: 224), but, scientifically, the discussion started in the 19th century. Agrawala (1998: 606) traces the first scientific contributions in regard to the greater topic of climate change back to Fourier, Tyndall and Arrhenius in the respective years 1827, 1863 and 1896. In 1965, the Science Advisory Committee of the President of the United States of America published one of the first official documents that recognized that a changing climate caused by humans could entail negative consequences (Kellogg 1987: 117). As mentioned before, this recognition is crucial in order to understand the full impact of climate change and hence the need to take global action.

The First World Climate Conference in 1979 can be seen as a starting point for political action concerning climate change. This was the first time experts from around the world and from various disciplines met to discuss the world’s climate (Zillmann 2009: 143). During the Conference a “World Climate Conference Declaration as an appeal to nations […]” was produced and “suggested immediate strategies to assist countries to make better use of climate information in planning for social and economic development” (Zillmann 2009: 143). However, a subsequent workshop in 1985 in Villach, Austria, gained more attention as a group of international scientists pointed out that due to the negative consequences of climate change, the topic should become politically more relevant (Agrawala 1998: 608). Agrawala (1998: 608) argues that after Villach 1985 “[…] climate change had truly ‘arrived’ both in the news media and on the international policy agenda.”

Two milestones on the road to the Paris Agreement are the establishment of the IPCC in 1988 and UNFCCC in 1992. The IPCC describes itself as “the international body for assessing the science related to climate change” (IPCC 2013b). The overall task of the IPCC is providing scientific information about climate change for governments (IPCC 2013b). The information provided is also relevant to the more political based processes at UNFCCC (IPCC 2013b). At the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro “[…] countries joined an international treaty, the United Nations Framework Convention on Climate Change, as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable” (UNFCCC n.d.a).

The objective of UNFCCC stated in Article 2 (UNFCCC 1992) is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." It follows the principle of "common but differentiated responsibilities" (UNFCCC 1992: Art. 3 (1)) distinguishing between Annex I and non-Annex I parties. Annex I parties include in general "industrialized countries" (UNFCCC n.d.b), whereas non-Annex I parties include parties that "are mostly developing countries" (UNFCCC n.d.b). This differentiation makes Annex I parties taking "the lead in combating climate change" (UNFCCC 1992: Art. 3 (1)) and therefore tries to "represent the philosophical notions of fairness and equity in international (climate) policy" (Pauw et al. 2014: 6) based on the differences in "economic welfare" (Pauw et al. 2014: 1) and "historical responsibilities" (Eckersley 2009: 23) of the parties. The principle of common but differentiated responsibilities contributed to the successful adoption of UNFCCC. However, it also created obstacles in later negotiations (Pauw et al. 2014: 1), especially in the form of conflicts between developed and developing countries (Beer 2014: 85).

Since 1995, UNFCCC held annual COPs. These meetings have had different ramifications in terms of climate change as a relevant topic of the international political arena. Most notably are COP 3 in Kyoto, 1997, and COP 21 in Paris, 2015, because the Kyoto Protocol and the Paris Agreement were adopted at the respective conferences. The Kyoto Protocol, which entered into force in 2005 (UNFCCC n.d.a), is "[…] the first legally binding international agreement on climate protection […]" (Böhringer 2003: 463). It clearly defines which parties have to reduce emissions, what these emissions are, how much each country has to reduce and until when this is supposed to happen. It is differentiating between Annex I and non-Annex I parties, since only Annex I parties have these obligations (UNFCCC 1998). Hence, one of the largest emitters of GHG emissions and an Annex I party, the United States of America, refrained from participating in the Kyoto Protocol as they demanded binding emissions targets also for developing countries (Pauw et al. 2014: 27). Although the effectiveness of the Kyoto Protocol is debatable, it still marks "a valuable starting point for efficient climate policies in the future" (Böhringer 2003: 464). Since the Kyoto Protocol international climate negotiations have continued. COP 15 in Copenhagen, 2009, had the intention of creating a new climate agreement with obligations for Annex I and non-Annex I parties but in the end failed to deliver the expected results (Falkner 2016: 1110).[3]

With the Paris Agreement a "new logic" (Falkner 2016) came into international climate politics. In the Paris Agreement there is no differentiation between Annex I and non-Annex I parties, but the concept of common but differentiated responsibilities is still present as "most provisions establish common obligations for all countries but require developed countries to continue taking the lead while expecting developing countries to step up over time" (Obergassel et al. 2016: 6). This is reflected in the key to the Paris Agreement: the nationally determined contributions (NDCs). In their NDC, each party individually pledges to aims and actions that will benefit the overall

[3] For further assessments of COP 15 in Copenhagen see for example Bodansky (2010), Christoff (2010) or Dubash (2009).

goal stated in Article 2 (UNFCCC 2015: Art. 3). This constitutes a new approach that moves away from binding emission targets for developed countries to a focus on individual NDCs in the context of common but differentiated responsibilities (UNFCCC 2015: Art. 4). In December 2018 the Rulebook of the Paris Agreement was adopted at COP 24 in Katowice. The Rulebook's purpose is to provide guidance on how countries implement and report on their NDCs so that the mechanisms of the Paris Agreement function effectively (World Resource Institute 2018: 3).

The Paris Agreement "creates a framework for making voluntary pledges that can be compared and reviewed internationally, in the hope that global ambition can be increased through a process of 'naming and shaming'" (Falkner 2016: 1107). With this new bottom-up element, the agreement represents a landmark in the history of climate negotiations. The devastating consequences of a failure to combat climate change is the reason for the high ranking in the list of global risks by the World Economic Forum. The Paris Agreement also highlights the need for a global, inclusive and sustainable approach in combating climate change.

2.2 Sustainable Development and the SDGs

The SDGs evolved out of several international conferences that started decades ago, and are based on a principle that is even older. The principle of sustainable development is often traced back to the Brundtland report by the World Commission on Environment and Development (WCED) in 1987. This was the first time the term "sustainable development" gained worldwide public attention (Dusseldorp 2016: 12, Redclift 2005: 212). The Brundtland report states the most common definition of sustainable development: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). The definition by the WCED is also used by the UN explaining sustainable development in the context of the recent 2030 Agenda (UN n.d.b). Although the Brundtland report can be seen as a starting point for sustainable development to become an important principle in the international policy arena (Du Pisani 2006: 92), related ideas and concepts predate 1987.

The term sustainable development was first used in the World Conservation Strategy of the International Union for the Conservation of Nature in 1980 (Dusseldorp 2016: 13). However, outside of this context it did not gain wider public attention. A crucial distinction is that before the 1980s, sustainability and development were two separate concepts (Robinson 2004: 370). Sustainability was connected to the notion of environmental protection (Robinson 2004: 371) and development was connected to economic growth and progress (Du Pisani 2006: 89). The positive notion of the latter was challenged in the 1970s due to a worldwide recession and an oil crisis (Du Pisani 2006: 89). The critique of unlimited growth and progress was summarized in the report by the Club of Rome titled 'The Limits to Growth' in 1972 (Du Pisani 2006: 89). These events set the stage for the emergence of the principle of sustainable development. The Brundtland report manifests the principle as it can be seen as "[…] the first overview of the globe, which considered the environmental aspects of development from an economic, social and political perspective […]" (Redclift 2005: 212).

An in-depth historical analysis of the concepts sustainability and development would go back into pre-modern times. Du Pisani (2006: 84) argues that the idea of progress as a form of development can be traced back to the ancient Greek and Romans: “The ancient Egyptian, Mesopotamian, Greek and Roman civilizations environmental problems such as deforestation and the salinization and loss of fertility of soil [...]” are problems that would now fall under the category of sustainability (Du Pisani 2006: 84). Making a great leap in time but still situated long before the Brundtland report, Grober (2007: 7) pinpoints the first usage of the term sustainability to a German book published in 1713 in which the author Hanns Carl von Carlowitz is concerned about sustainable forest management. The examples by Du Pisani (2006) and Grober (2007) illustrate that the principle of sustainable development has deep historical roots, especially concerning the differentiation of sustainability and development, two concepts which have been brought together only recently.

After 1987 the discussion of the Brundtland report led to the United Nations Conference on Environment and Development in 1992, where the principle of sustainable development was reinforced (Dusseldorp 2016: 14). During this conference three agreements related to sustainable development were produced[4]:

> “Agenda 21 – a comprehensive programme of action for global action in all areas of sustainable development; The Rio Declaration on Environment and Development – a series of principles defining the rights and responsibilities of States; The Statement of Forest Principles – a set of principles to underlie the sustainable management of forests worldwide” (UN 1997).

These agreements led the way to another important milestone on the road towards the SDGs, namely the UN Millennium Summit in 2000 and its main document the Millennium Declaration.

The Millennium Declaration states that “the collective responsibility of the governments of the world to uphold human dignity, equality and equity is recognized, as is the duty of world leaders to all people, and especially children and the most vulnerable” (UN n.d.c). From the Millennium Declaration eight goals were derived, which needed to be achieved by 2015. These goals, known as Millennium Development Goals (MDGs), are illustrated in figure 2 (MDG Monitor 2015).[5] The MDGs are the direct predecessor of the SDGs, which are shown in figure 3 (UN n.d.b). They were adopted in 2015 during the UN Sustainable Development Summit from September 25-27 in New York.

The MDGs are historic in the sense that for the first time the global political community agreed on a specific set of goals, including measureable indicators that need to be tackled in the next fifteen years. Therefore, “[...] the MDGs help to promote global awareness, political accountability, improved metrics, social feedback, and public pressures” (Sachs 2012: 2206). Sustainable development is mentioned in the MDGs

[4] The United Nations Conference on Environment and Development in 1992 also led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC), mentioned in chapter 2.1.2 and the Convention on Biological Diversity, which are also related to sustainable development objectives.

[5] The specific targets of the MDGs (UN 2006) and the SDGs (UN n.d.a) are presented in the respective references.

and their targets twice: Within Goal 7 "ensure environmental sustainability" the first target calls for "integrat[ing] the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources." Within Goal 8 "develop a global partnership for development", the third target aims at "address[ing] the special needs of [...] small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States [...]" (UN 2006). The two direct references demonstrate that firstly, sustainable development in the MDGs makes up only a small part that is related to environmental concerns. Secondly, the two references demonstrate that sustainable development is something needed by developing countries and provided for by developed countries. This reflects an understanding of the improvement the SDGs present in comparison to the MDGs.

Figure 2: Illustration of the MDGs (MDG Monitor 2015)

Figure 3: Illustration of the SDGs (UN n.d.b)

The naming of the SDGs already suggests that all of the 17 goals and their 169 targets are about sustainable development. Sustainable development is the main theme of the goals. In addition, the SGDs apply to all countries and are not a “North-South aid agenda” (Fukuda-Parr 2016: 44) like the MDGs. The SDGs are not only more universal but also more comprehensive addressing a wider area of problems (Coonrod 2014). These differences are likely linked to the way in which the SDGs were developed. Whereas the MDGs were drafted by technical experts (Fukuda-Parr 2016: 44) through a top-down process (Coonrod 2014), the SDGs were created “in one of the most inclusive participatory processes the world has ever seen” (Coonrod 2014). The SDGs are part of the 2030 Agenda, which is based on the five core aspects “people, planet, prosperity, peace and partnership" (UN n.d.a) and illustrates the linkages between them. However, the list of the 17 SDGs stands out due to their high recognition value, as they are formulated succinctly and precisely and due to their measureable indicators. This and their up-to-datedness are the reasons why they are a suitable indicator of sustainable development objectives in this thesis.

Especially in comparison with the MDGs, the SDGs are often considered as progress and advancement (Coonrod 2014, Fukuda-Parr 2016), but certain critiques are still relevant. The SDGs have been called "stupid development goals" (The Economist 2015) or "senseless, dreamy, garbled" (Easterly 2015). The two articles illustrate that the SDGs can be criticized as too numerous, too vague, too ambitious or too expensive. In addition to this, the SDGs interact with each other. These interactions can result in synergies, but trade-offs or conflicts are also possible (Nilsson et al. 2016, Pradhan et al. 2017). This demonstrates a problem of the SDGs that is rooted in the history of the principle of sustainable development: promoting development while ensuring sustainability.

The example of a conflict described by Pradhan et al. (2017) mentioned in chapter one reflects this problem: from a development perspective, it is desirable that the whole population of a country has access to electricity. From a sustainability perspective, it is desirable that there is a high amount of renewable energy in the energy mix of a country. If renewable energy were more expensive than energy from fossil fuels, it would limit people's access to electricity not being able to pay for the renewable share. This is an example why sustainable development has been dubbed an "oxymoron" (Redclift 2005: 66). In spite of this, striving for sustainable development is not about deciding between development and sustainability but about bringing the two roots of the principle together. The SDGs provide a well-constructed overview of areas that need to be considered in regard to sustainable development. They are neither perfect, nor all-encompassing but constitute a useful tool to work with. In this thesis climate mitigation actions are checked against the SDGs to see where sustainable development objectives might be violated.

2.3 Connection between climate change and sustainable development

The previous two chapters gave an overview of how the concepts of sustainable development and climate policy evolved historically and politically. They are united in the sense that combating climate change and striving for sustainable development are two objectives that call for inclusive global action. This is illustrated by the manner in which two areas have from a political perspective. As detailed in the respective chapters, both areas became more politically significant during the 1990s and early 2000s. Neither the MDGs, adopted in 2000, nor the Kyoto Protocol, adopted in 1997 and enforced in 2005, were developed and designed in a fully inclusive way. The distinction between developed and developing countries, north and south (Fukuda-Parr 2016: 44) or Annex I and non-Annex I countries reflects this structure. The SDGs and the Paris Agreement as subsequent policy instruments are both different in design. They use a far less distinctive differentiation between the role of developed and developing countries. This is why the SDGs and the Paris Agreement represent a development towards a more inclusive policy approach.[6]

As the Paris Agreement and the SDGs allow countries to create their own policies to strive for sustainable development and to combat climate change, an effective integration of the two policy instruments is crucial. This need for integration is embedded within the two policy instruments. In the Paris Agreement the "intrinsic relationship that climate change actions, responses and impacts have with equitable access to sustainable development and eradication of poverty" (UNFCCC 2015) is emphasized. Moreover, the overall goals in Article 1 are to be achieved "in the context of sustainable development" (UNFCCC 2015: Art. 1). Sustainable development is mentioned eight times in the document. It is exclusively used in a similar way as in Article 1: effectively combating climate change requires the need to integrate and consider sustainable development objectives.

In the SDGs Goal 13, "climate action", addresses combating climate change (UN n.d.a). Although the SDGs contain a goal specifically related to climate change, the topic is also mentioned in three targets: Target 1.5 calls for reducing the exposure and vulnerability of the poor to climate-related extreme events (UN n.d.a). Target 2.4 calls for ensuring sustainable food production systems that strengthen capacity for adaptation to climate change (UN n.d.a). Target 11.B calls for substantially increasing the number of cities and human settlements adopting and implementing integrated policies and plans towards mitigation and adaptation to climate change (UN n.d.a). The cross-referencing of climate change and sustainable development in the Paris Agreement and the SDGs demonstrates the connectedness between the two areas. Figure 4 summarizes the main milestones on the road to the Paris Agreement and the 2030 Agenda.

[6] The question in how far this is a more effective approach is up to debate and not part of this thesis

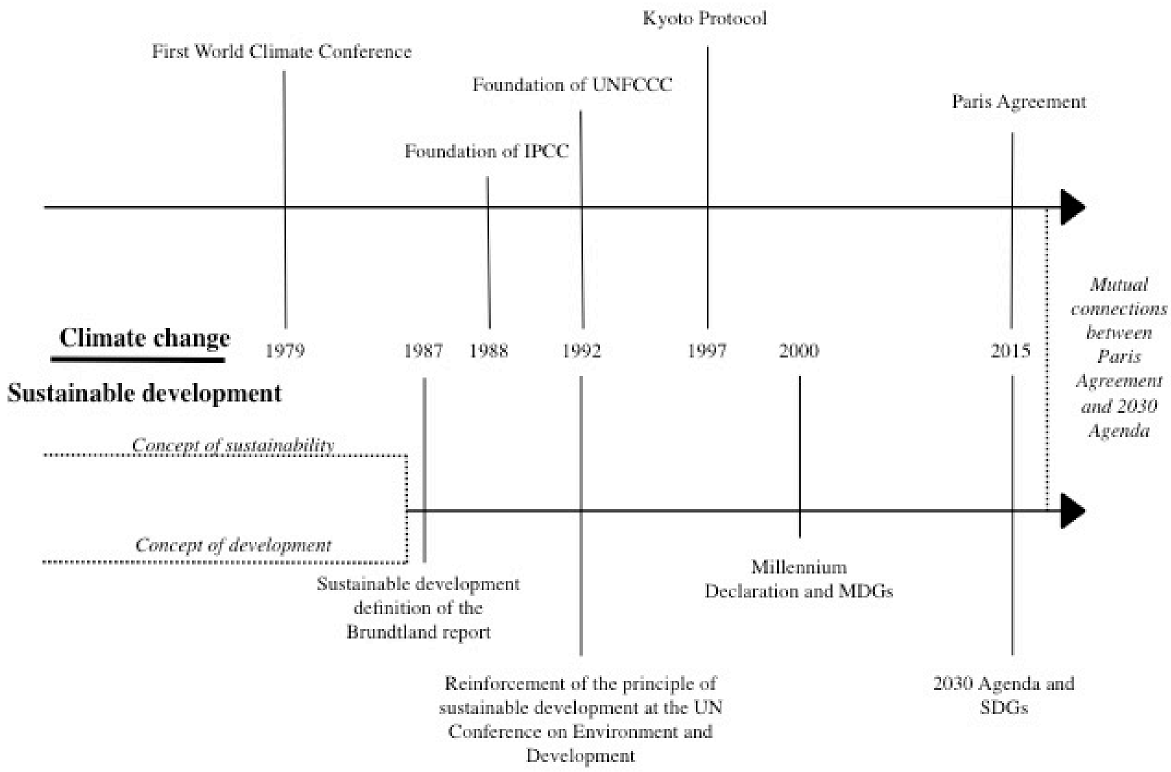

Figure 4: Milestones on the road to the Paris Agreement and the 2030 Agenda (own illustration)

The IPCC states "high confidence" (IPCC 2014a: 287) in the close connection of climate change and sustainable development. It is also recognized that there are synergies and conflicts of climate actions with sustainable development objectives (IPCC 2014a: 293). Therefore, "[...] an effective climate response is necessarily an integral objective of an SD [sustainable development] strategy" (IPCC 2014a: 293). The connection between climate change and sustainable development is largely represented in scientific literature (IPCC 2014a, Jakob and Steckel 2016, Kok et al. 2008, Obergassel et al. 2017, Van Tilburg et al. 2018, Von Stechow et al. 2016). A lack of integration between the two areas is highlighted by Van Tilburg et al. (2018: 2) and Obergassel et al. (2017: 249).

Putting climate change and sustainable development in perspective to each other, combating climate change is a part of striving for sustainable development and not vice versa. The SDGs show that there are many other areas crucial for sustainable development like human health (SDG 3), education (SDG 4), infrastructure (SDG 9) or ecological aspects (SDG 14 and 15). Although these areas can be influenced by climate change as well, combating climate change is one goal out of 17. The general approach of this thesis could be transferred to areas other than climate change mitigation. Actions to reduce poverty (SDG 1), promote human health (SDG 3) or foster responsible consumption (SDG 12) could be analyzed as well because the SDGs and their targets provide a well-structured overview of sustainable development objectives. The connection between climate change and sustainable development is embedded in the Paris Agreement and the SDGs and, as demonstrated, there is also strong evidence in the literature that the two areas depend on each other.

3 Climate change mitigation actions

The previous chapters illustrated the strong link between climate change and sustainable development. It was shown that combating climate change requires adaptation and mitigation approaches. Both approaches are important and complementary (IPCC 2014b: 17). Climate change mitigation is especially relevant in regard to future scenarios of, for example, atmospheric CO_2 concentration. Figure 5 (IPCC 2013a: 1103) demonstrates that even in the most optimistic scenario (Representative Concentration Pathway (RCP) 2.6), the atmospheric CO_2 concentration will most likely stagnate and not decrease under levels before the year 2000.

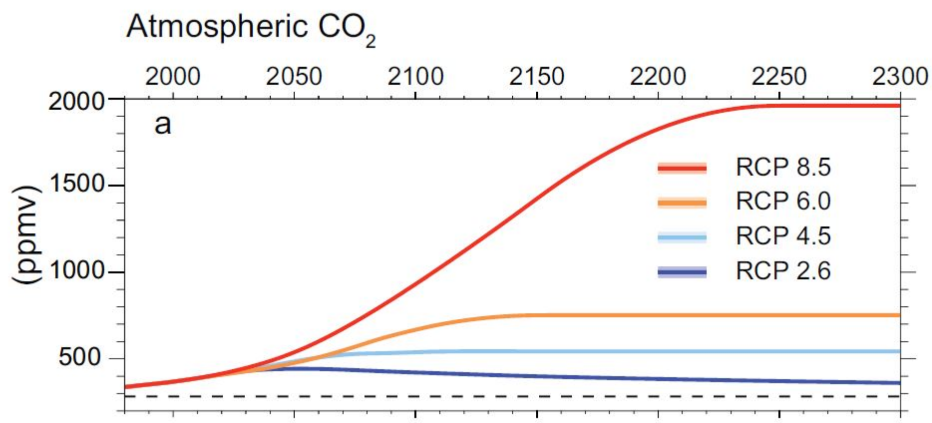

Figure 5: Scenarios of future atmospheric CO_2 concentrations (IPCC 2013a: 1103)

Therefore, only if climate change mitigation is carried out effectively, climate change adaption can become obsolete eventually. This is why this thesis focusses on mitigation. In the first part of this chapter it is clarified what climate change mitigation actions are and how they can be categorized by sectors. The second part of this chapter explains the focus on renewable energy technologies.

3.1 Categorization of climate change mitigation actions

Climate change mitigation "[...] can substantially reduce climate change impacts in the latter decades of the 21st century and beyond" (IPCC 2014b: 17) and represents therefore a long-term approach in comparison to adaptation. The nature of human intervention or action in regard to climate change mitigation can vary:

"Mitigation can mean using new technologies and renewable energies, making older equipment more energy efficient, or changing management practices or consumer behavior. It can be as complex as a plan for a new city, or as a simple as improvements to a cook stove design. Efforts underway around the world range from high-tech subway systems to bicycling paths and walkways" (UN Environment n.d.).

This demonstrates the need to explain what climate change mitigation actions are in the context of this thesis and how they can be categorized.

As the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) explains on their website, "everyone can play a role in climate action" (BMU 2017). It is without doubt that actions of individuals and their everyday life decisions matter in regard to combating climate change. Using a bicycle instead of a car is a simple example for an action that helps mitigating climate change. Also national and international policies are mentioned on the same website of the BMU (2017) as examples for climate change mitigation actions. However, policies and changing consumer behavior are different sets of mitigation actions. This is why the term climate change mitigation action can be misleading. Considering the definition by IPCC, policies do not directly reduce the sources of GHGs emissions. In contrast, using a bicycle instead of a car does reduce the sources of GHGs emissions. Policies can only promote, subsidize or regulate actions that directly reduce GHGs emissions. A similar differentiation can made with regard to the explanation of mitigation actions by UN Environment: a plan for a new city does not directly reduce GHGs emissions, only the integration of renewable energy sources within this plan would do so. It is important to critically question the usage of the term climate change mitigation as defined by the IPCC. The following categorization of mitigation actions suggests a usage of the term that is related to concrete actions that reduce GHG emissions.

The IPCC categorizes climate change mitigation actions by sectors (IPCC 2014a: 469). Given the amount of possible actions, a categorization is important to structure work in this area. The categorization by the IPCC is also used as a basis for other overviews (Iacobuta et al. 2018: 105, Roeser et al. 2018: 8). The following categorization in table 2 is adjusted to the aim of this thesis and based on the work of the IPCC (2014a: 469) and Roeser et al. (2018: 6). It uses the term of mitigation actions in the stricter sense of describing concrete actions that lead to the direct reduction of GHGs. Table 2 does not aim at providing an all-encompassing overview but rather at illustrating relevant sectors and suitable examples within the sectors.

Table 2: Sectorial categorization of climate change mitigation actions (own illustration; based on IPCC (2014a: 469) and Roeser et al. (2018: 6))

Sector	Measures	Examples for mitigation actions
Energy supply		
	Renewable energy in power generation	E.g. solar energy, wind energy, hydropower
	Nuclear or CO_2 capture and storage power generation	Nuclear power and fossil plants fitted with CO_2 capture and storage
Transport		
	Reducing transport demand	Sustainable urban planning to reduce the need to travel; behavior change to avoid travel
	Modal share shift	Improved public transport (metro, bus rapid transit, etc.); cycling infrastructure
	Fuel switch to low carbon vehicles	Electric vehicles; fuel cell vehicles; hydrogen; biofuels
Buildings		
	Fuel switch away from fossil fuels	Moving from gas/ oil boiler to biomass boiler; solar; thermal
	Energy efficient building/ community design	Community scale heating/ cooling; green roofs; cool roofs; improved building fabric
Waste		
	Reduce, reuse, recycle	Behavior change to reduce, reuse and recycle waste
	Sustainable waste management systems	Landfill gas capture and utilization
Industries		
	Material efficiency	Material efficiency in design and production; longer lasting products; recycling
	Fuel switch away from fossil fuels	Moving from gas to biomass for process heat
	Reducing process and fugitive emissions	Reducing process and fugitive emissions e.g. reduced coolant leakage
Agriculture, forestry and other land use		
	Sustainable consumption practices	Reducing demand for agricultural products: less consumer wastage; reduced meat consumption
	Climate smart agriculture	Reduced fertilizer use; better irrigation; soil conservation; manure management
	Smart cities and green urban planning	Creation of green spaces; vertical gardens; green roofs; green-blue corridors
	Sustainable forest management	Agroforestry; reforestation

Table 2 adopts in general the sectors of the IPCC (2014a) categorization. Waste was added as an individual sector as done by Roeser et al. (2018) because in the IPCC (2014a) categorization, waste is sorted into the industry sector, but it can be relevant in other areas as well. The sector “human settlements and infrastructure” was left out because many of the corresponding actions are already mentioned in the transport and agriculture, forestry and other land use sector. For reasons of conciseness, the columns “category” in Roeser et al. (2018) and “integrated model results for stringent mitigation scenarios” in IPCC (2014a) were omitted. Information in both columns is not relevant for this thesis’ approach. The column “effect on additional objectives/concerns” in IPCC (2014a) was also omitted. This column names positive and negative effects of climate change mitigation and classifies them into economic, social, environmental and other effects. This is a similar approach to the upcoming systematic overview and therefore not relevant in this chapter. Crucial differences between existing overviews and the overview in this thesis are illustrated in chapter 4.1.

The columns “measures” and “examples for mitigation actions” in table 2 were, for the most parts, derived from the columns “mitigation actions” and “examples” in Roeser et al. (2018). The naming was changed deliberately in order to avoid a misleading usage of the term mitigation action. For example, Roeser et al. (2018) name “sustainable waste management systems” mitigation actions. In table 2 these are referred to as “measures” which is a broader description. Hence, “landfill gas capture and utilisation” (Roeser et al. 2018) is referred to as “examples of mitigation actions” because the implementation of this system is what contributes to mitigating climate change. In anticipation of chapter four, these examples for mitigation actions address different effects on sustainable development objectives and therefore need to be analyzed individually. Almost all categories in Roeser et al. (2018) include measures in regard to increasing energy efficiency. In respect to redundancy and conciseness, this aspect is not included here, but it is still relevant. All other information in table 2 was drawn from Roeser et al. (2018) and IPCC (2014a). Small changes and rephrasing were done to fit the approach and the scope of this thesis.

It is important to note that the examination of concrete climate change mitigation measures does not encompass all aspects of how climate mitigation potentially results in conflicts with the SDGs. There are two aspects that are not analyzed in this thesis which are worth mentioning. First, striving for sustainable development does not only require new technologies or concepts but also abandoning of old technologies or concepts. In the context of policies for sustainable transitions this is discussed by Kivimaa and Kern (2014). They state that “the urgency of sustainability transitions requires explicit analyses of active destabilisation, because solely relying on the emergence and growth of a variety of alternatives to replace incumbent systems will be too slow” (Kivimaa and Kern 2014: 206). Transferring this approach to, for example, the measure of renewable energy in power generation, it is also important to decrease the share of fossil energy in power generation for effective climate change mitigation. This could result in conflicts, for example, workers employed in the fossil energy sector could become unemployed (SDG 8). Second, policy measures could also create conflicts with the SDGs, albeit indirectly. For example, a taxation of CO_2 could result in higher energy prices, which would make energy services more expensive for people with lower income (SDG 7) (Vera and Sauma 2015: 479).

Table 2 puts the upcoming focus on the energy supply sector into perspective. The table illustrates six sectors with at least two different measures. The number of mitigation actions for each measure can hardly be quantified. The IPCC (2014a: 472) and Roeser et al. (2018: 4) also state that their categorizations do not cover every single mitigation action possible. In order to successfully reveal conflicts of climate change mitigation actions with the SDGs in this thesis, it is necessary to narrow down the examined mitigation actions.

3.2 Focus on renewable energy technologies

The focus of this thesis will be the energy supply sector and more specifically renewable energy in power generation as the energy supply sector is highly relevant in the context of both climate change and sustainable development. Based on robust evidence, the IPCC (2014a: 516) states that “the energy supply sector[7] is the largest contributor to global greenhouse gas emissions” with “35% of total anthropogenic GHG emissions.” SDG 7, “affordable and clean energy”, specifically aims at providing access to energy services, increasing the use of renewable energy sources and improving energy efficiency (UN n.d.a). Analyzing linkages between NDCs and SDGs, Van Tilburg et al. (2018) highlight the need to examine the conflicts of climate change mitigation actions in the energy supply sector with the SDGs in greater detail: among all analyzed sectors the energy supply sector revealed the most negative linkages and “accounts for almost half of the potential negative linkages identified” (Van Tilburg et al. 2018: 6).

Among the various possibilities that are available to limit GHG emissions in the energy supply sector, “low-GHG energy supply technologies such as renewable energy” (IPCC 2014a: 516) is one of them. Renewable energy is defined as “any form of energy from solar, geophysical, or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use” (IPCC 2014a: 1261). Technologies that belong in this category include solar energy, wind energy and hydropower (IPCC 2014a: 519) as illustrated in table 2. They are considered to have a positive impact on climate change mitigation. They do not cover all existing technologies in this category (see Roeser et al. 2018 and IPCC 2014a) but are the ones with the biggest share of global capacities as illustrated in figure 6 (International Renewable Energy Agency 2019: 1) and therefore the most relevant (Gibson et al. 2017: 923). These three technologies are used for the systematic overview.

[7] In the report the energy supply sector “[…] comprises all energy extraction, conversion, storage, transmission, and distribution processes that deliver final energy to the end-use sectors (industry, transport, and building, as well as agriculture and forestry)” (IPCC 2014a: 516).

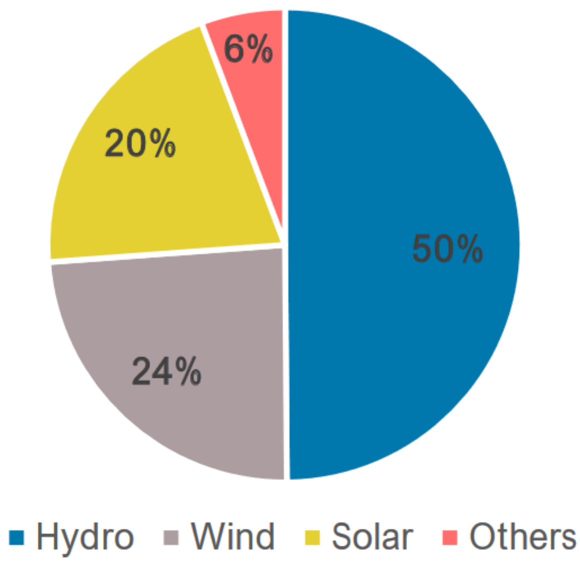

Figure 6: Global share of renewable energy capacity in 2018
(International Renewable Energy Agency 2019: 1)

4 Development of the systematic overview

The systematic overview is created by reviewing relevant literature. The chosen methodology guarantees that results are reproducible and transparent. As the systematic overview is narrowed down to renewable energy technologies, the methodology also provides a guideline of how other sectors or measures could be analyzed. Similar approaches to the one of this thesis exist. Chapter 4.1 briefly discusses them and presents in how far the systematic overview adds value to the existing discourse. Chapter 4.2 then outlines the methodology before it is applied in chapter five and states limitations of the methodology.

4.1 Assessment of existing overviews

Existing overviews in regard to interactions between climate change and sustainable development can be broadly summarized in two groups: the ones examining SDG interactions and the ones dealing with interactions of climate change mitigation actions and sustainable development. For the first group the works by Griggs et al. (2017)[8] and Pradhan et al. (2017) and for the second group the works by the IPCC (2014a) and Van Tilburg et al. (2018)[9] are relevant. After briefly discussing the four works, a summary follows.

The works on interactions among the SDGs are related to this thesis as any interactions with SDG 13, "climate action", could theoretically fall under the category of climate change mitigation action. Griggs et al. (2017) examine the positive and negative interactions of four SDGs (1, 3, 7 and 14) with other SDGs. Therefore, SDG 13 receives only little attention. The interactions are described very generally: "Integrating climate measures into national policies will support improvements in air quality" (Griggs et al. 2017: 113). In this example the synergy between SDG 13 and SDG 3 is relevant, but it does not explain which exact climate measures would improve air quality. Moreover, Griggs et al. (2017) consider the interactions in both ways: they not only examine, for example, how measures of combating climate change (SDG 13) affect striving for zero hunger (SDG 2) but also how striving for zero hunger affects combating climate change (Griggs et al. 2017: 63). Although the later approach is not part of this thesis' systematic overview, its relevance should not be neglected.

Pradhan et al. (2017) conduct a statistical analysis of how the SDGs interact among each other based on data sets of the SDG indicators. The results of their comprehensive analysis mainly describe a quantitative angle. Pradhan et al. (2017) are able to quantify the share of synergies and trade-offs within an SDG and between the SDGs. They can also pinpoint these synergies and trade-offs geographically as the used data refers to "122 [of 230 overall] indicators for a total of 227 countries between the years 1983 and 2016" (Pradhan et al. 2017: 1170). Because this quantitative approach is based on the SDG indicators, it does not directly refer to actions that contribute to combating climate change. Therefore, the work of Pradhan et al. (2017) differs sub-

[8] The work by Griggs et al. (2017) is related to the article by Nilsson et al. (2016) cited earlier.

[9] The work by Van Tilburg et al. (2018) and Roeser et al. (2018) both refer to the SCAN (SDG & Climate Action Nexus) tool. While Van Tilburg et al. (2018) describe some results, Roeser et al. (2018) explain the methodology of the tool.

stantially from the approach of this thesis, although the notion of illustrating conflicts with the SDGs is similar.

The works of the IPCC (2014a) and Van Tilburg et al. (2018)[10] were, in part, discussed in chapter three in order to categorize climate change mitigation actions. The IPCC (2014a) presents conflicts of climate change mitigation measures similarly to the approach of this thesis. However, the IPCC (2014a: 469) considers "effects on additional objectives/concerns" and does not refer to the SDGs. The categories "economic, social, environmental and other" (IPCC 2014a: 469) include a sustainable development angle but do not specifically use the SDGs as indicators. In addition, there is no differentiation between the "sectoral mitigation measures" (IPCC 2014a: 469). For example, the section on renewable energy contains multiple technologies like wind energy or hydropower without differentiating between them.

Van Tilburg et al. (2018) specifically present conflicts of climate change mitigation actions with the SDGs using the SCAN-tool. The SCAN-tool "[...] uses a taxonomy of mitigation actions and explores potential linkages between these actions and the SDGs at the target level" (Van Tilburg et al. 2018: 5). The tool is also based on a literature analysis (Roeser et al. 2018: 5). However, the SCAN-tool names 93 references for all sectors and does not indicate which reference belongs to which mitigation action. In addition, there is no information about whether an SDG interaction is related to a geographic area or not and whether potential causes for a negative interaction can be drawn from the respective reference.

All of the discussed overviews contribute important work to the discussion of synergies and trade-offs between climate change and sustainable development. While this thesis deals with conflicts of climate change mitigation actions with the SDGs, most other overviews use slightly different approaches. In this thesis, the specific analysis of renewable energy technologies as a measure to mitigate climate change provides very detailed results. Value to the existing discourse is also added by the unique systematic overview which includes information on the geographic area and the potential cause for a conflict making further use of the results easily possible.

4.2 Methodology

The method of this thesis is a literature review, which selects articles in Web of Science that deal with negative side effects of three renewable energy technologies. Relevant information retrieved from these articles is then grouped into a systematic overview of how these side effects relate to the SDGs. In the following, the selection of articles is explained as well as the overview itself capturing the results of the literature review. In respect to the scope of this thesis and the magnitude of the topic of climate change and sustainable development, limitations of the methodology are inevitable. These limitations are also discussed in the following.

[10] This includes the work of Roeser et al. (2018).

4.2.1 Selection of articles

The selection of articles follows a hybrid approach that is based on literature in the Web of Science Core Collection. For reasons of reproducibility a flow diagram adopted from the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) Statement (Moher et al. 2009) for each of the three technologies is included in order to illustrate the number of articles selected and excluded. The search terms are the same for each technology so that results are comparable. The keywords 'environmental', 'social' and 'economic' in combination with 'impact', 'problem' and 'conflict' aim at covering a preferably wide range of potential negative effects. In total, 530 articles were analyzed using the following search query in Web of Science:

- TS=(X[11] AND environmental-impact* OR X AND environmental-problem* OR X AND environmental-conflict*) OR
  TS=(X AND social-impact* OR X AND social-problem* OR X AND social-conflict*) OR
  TS=(X AND economic-impact* OR X AND economic-problem* OR X AND economic-conflict*)

The only criterion for an article to be included is that it clearly states a negative effect of the respective technology that can be attributed to an SDG.[12] The hybrid approach has two search components and three selection steps in order to identify relevant literature:

- Component 1: Articles and proceeding papers published in English in the years 2016, 2017 and 2018
  In order to analyze the most recent literature, the year 2016 represents a border as at the end of the previous year the Paris Agreement and the 2030 Agenda were adopted. Articles from 2019 are not included because more articles will be added throughout the year so the assessment of 2019 will not be complete. Hence, the years 2016, 2017 and 2018 represent three recent years where the body of literature can be analyzed completely.
  In Web of Science a refinement by document type is possible. With only a few exceptions the most common document types that come up using the search query are articles, reviews and proceeding papers. Reviews are excluded because they might reference articles already identified in the search. Proceeding papers are included because it was shown that their relevance is not inherently different compared to regular articles (González-Albo and Bordons 2011: 379). Therefore, 'article' refers also to proceedings papers in the context of this thesis' literature review. Additionally, the search components only consider articles in English.

[11] X stands for the respective technology. At the beginning of the respective chapters the exact search term for each technology is mentioned in a footnote.

[12] Some authors may cite other articles to emphasize their statement. In the systematic overview the page number is illustrated to easily check the respective paragraph in the source for other articles that contributed to the statement. For a clear arrangement of the overview, this information is not displayed and can be retrieved individually.

- Component 2: 20 most cited articles in the selection not considering the year
  This component makes sure that relevant articles in terms of citations are not missed out by component 1. In regard to the refinement by article type and the language no further changes are made in comparison to component 1.

- Step 1: Identification of records using the two components and removing duplicates
- Step 2: Screening of records by title and/or abstract
- Step 3: Assessment of full-text articles for eligibility

Other combinations of search terms could lead to relevant results as well. However, the used search query determines a suitable number of articles in step 1 for this thesis' scope and objective. Additionally, disadvantages of other approaches outweigh the advantages. A short summary is shown in table 3:

Table 3: Summary of disadvantages using other search terms (own illustration)

Other possible approaches in regard to the selection of search terms	Disadvantages and/or challenges
Including search terms that directly link to the SDGs like 'SDGs' or 'sustainable development'	Leads to significantly less results and assumes that all negative effects are already connected to sustainable development by the author
Including a specific key word for each SDG	Difficult to identify these key words; rather obvious for SDG 1 'poverty' or SDG 3 'health' but hard to determine for SDG 9 or SDG 15
Excluding the terms 'environmental', 'social' and 'economic' for a wider range of results	Leads to too many results as it can be assumed that almost all articles deal with an impact, problem or conflict in some regard
Adding additional, related terms to 'environmental', 'social' and 'economic' e.g. adding cultural to social or natural to environmental	Leads to too many results
Replacing the specific technology with 'renewable energy' for a wider range of results	Violates the thesis' approach to specifically analyze the three example technologies
Adding additional, related terms to the specific technology e.g. adding solar-power or photovoltaic to solar-energy or water-power to hydropower	Leads to too many results

4.2.2 Structure of the systematic overview

The systematic overview aims at presenting relevant information clearly and concisely. Therefore, a table format with five columns is used. The first column lists the respective SDG and its target. The SDG icons are used for visualization purposes as they ensure a quick orientation within the table. The next column summarizes the conflict. Detailed descriptions are excluded here because these can be retrieved individually by using the author's name in column three in combination with the references at the end of this thesis.

The geographic area in column four and the potential cause in column five add crucial information to the systematic overview. Being able to quickly identify that a conflict is directly related to the area of interest of policy makers, governments or researchers is highly useful in order to effectively and efficiently find relevant information. Moving from identifying problems to searching for solutions, listing, if included in the article, a potential cause is a first step in overcoming the conflict. Columns four and five are not a stand-alone solution to the issue described by Roeser et al. (2018: 5) that “in reality, the linkages are highly context-specific; national circumstances and other factors will greatly influence the magnitude and direction of any linkage.” However, the information in the systematic overview further support any in-depth research for a context-specific problem at hand.

4.2.3 Limitations

Limitations result from the restriction of the number of analyzed articles by the chosen search terms and by choosing Web of Science as the only search engine. The focus on the years 2016 – 2018 and most relevant articles in terms of citations constitutes another limitation. At the same time, it reduces the number of articles strategically. Still, the article selection cannot be completely free of personal bias especially in step 2 and 3 when articles are selected.

Within one mitigation action, differences are likely to appear: for example, there are different forms of solar energy technologies (Tsoutsos et al. 2005: 289 and chapter 5.1) and therefore, further subdivisions could be appropriate. In addition, the geographic area of a conflict depicts a special challenge as in one country or region a mitigation action could have different conflicts with the SDGs than in another country or region. In the scope of this thesis it is not possible to avoid these aspects completely, but a careful examination of the selected articles and the reference to the geographic area in the systematic overview help to minimize these challenges.

The systematic overview reveals limitations in terms of relevance. The used approach neglects qualitative and quantitative aspects of a conflict with the SDGs as it only presents the landscape of conflicts. Evaluating the robustness of evidence or the magnitude of a conflict is beyond the scope of this thesis. In addition, the conflicts found in the literature are most likely not fully representing actual conflicts on the ground as it can be assumed that there are conflicts that are not yet discussed in scientific research. Despite the described limitations, the used methodology is able to map and analyze conflicts of mitigation actions in regard to the SDGs and to provide useful information for actors working on climate change and sustainable development.

5 Application of the systematic overview

The application of the systematic overview follows the same pattern for each of the three technologies. First, the basic concept of the respective technology is introduced very briefly. Then the article selection is described using a flow diagram adapted from the PRISMA Statement. Reasons for the exclusion of articles are included in this part as they contribute to the assessment of the body of literature. In the last step, the systematic overview in the table format summarizes the main findings of the literature review comprehensively. Due to the scope of this thesis, not every conflict identified will be critically analyzed. Therefore, the systematic overview is supported by further explanations and observations only of the main themes of conflict. A collective analysis for all technologies follows in chapter six.

5.1 Solar energy

Solar energy technologies use the energy from the sun and can convert it into, for example, heat, natural light, fuel or electricity (IPCC 2011: 337). Therefore, many technologies exist using solar energy for different purposes from flat-plate collectors for water and space heating (IPCC 2011: 346) to solar refrigeration (IPCC 2011: 350).[13] In regard to producing electricity, the most relevant technologies are photovoltaics (PVs) and concentrated solar power (CSP). Whereas PVs are "electronic devices that convert sunlight directly into electricity", CSP "uses mirrors to concentrate solar rays" for driving a turbine with the steam of a fluid that was heated up by the concentrated solar rays (International Renewable Energy Agency n.d.). Figure 7 (IPCC 2011: 351) and 8 (IPCC 2011: 265) illustrate schemes of these two technologies.

[13] Section 3.3 of the IPCC Report "Renewable Energy Sources and Climate Change Mitigation" provides an overview of solar technologies.

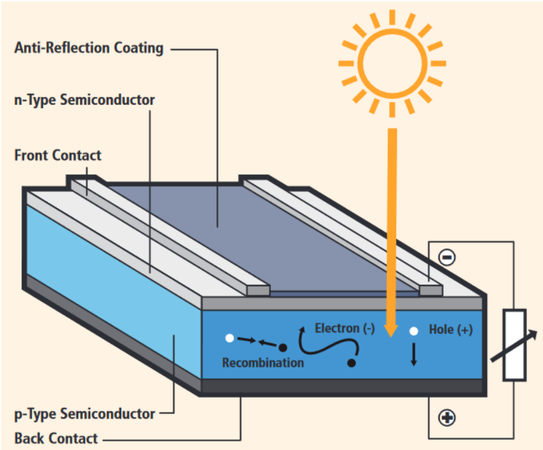

Figure 7: Example of a PV cell (IPCC 2011: 351)

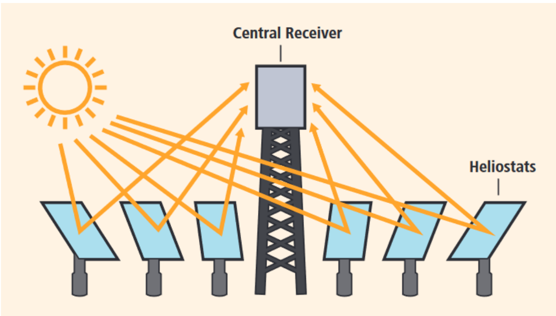

Figure 8: Example of CSP (IPCC 2011: 265)

5.1.1 Number of articles included and reasons for exclusion (solar energy)

By using the search query for solar energy[14], 190 articles were identified and 17 were included in the systematic overview (see figure 9):

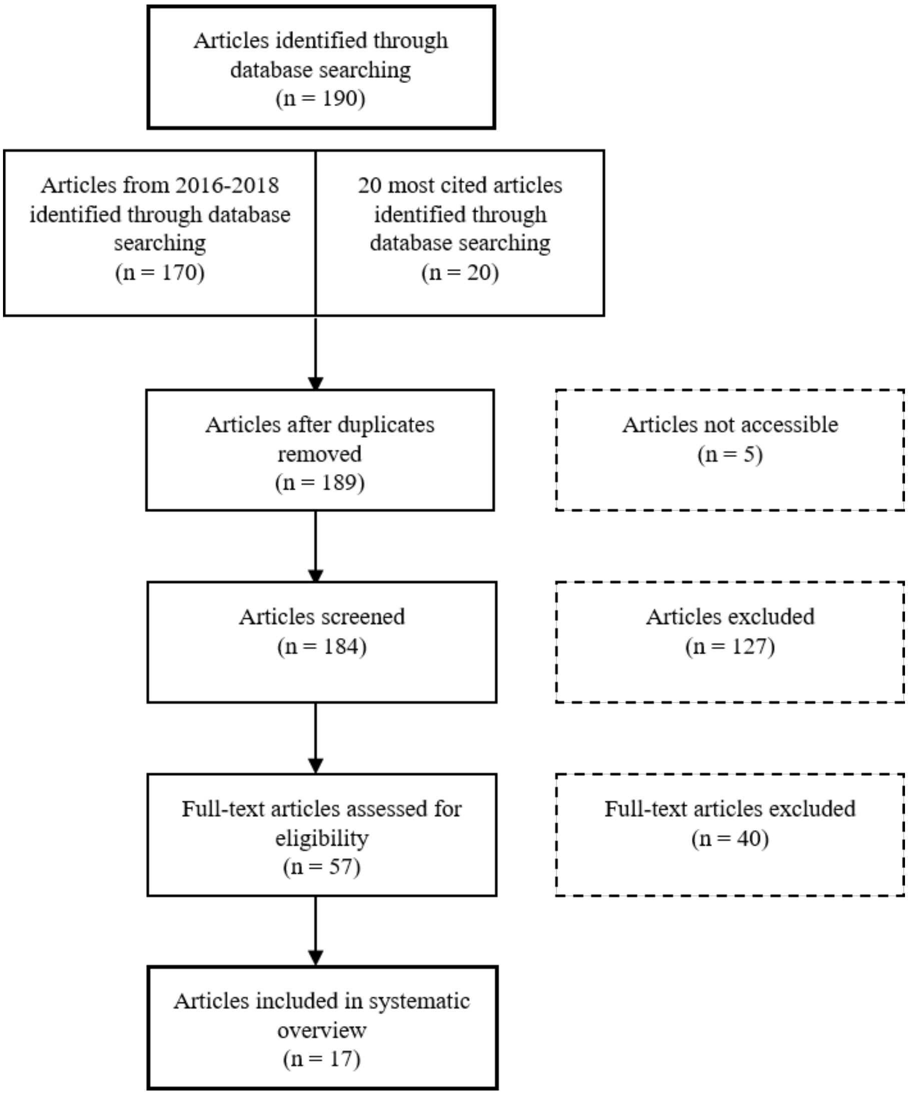

Figure 9: Flow diagram of solar energy (own illustration)

The limited number of articles included in the systematic overview demonstrates the difficulty of finding literature that clearly states a negative effect of solar energy tech-

[14] TS=(solar-energy AND environmental-impact* OR solar-energy AND environmental-problem* OR solar-energy AND environmental-conflict*) OR

TS=(solar-energy AND social-impact* OR solar-energy AND social-problem* OR solar-energy AND social-conflict*) OR

TS=(solar-energy AND economic-impact* OR solar-energy AND economic-problem* OR solar-energy AND economic-conflict*). The search query was used on May 6, 2019.

nologies. The main reasons why articles were excluded in the screening process (step 2) can be summarized as following:

- Articles assess the efficiency/ performance/ functionality of very specific kind of technologies/ materials/ systems (for example Aldali and Morad 2016 or Gong et al. 2018)
- Solar energy technologies are not the main theme of the article (for example Hossain 2016 or Rivera et al. 2018)
- General statements about the environmental, social or economic impacts of solar energy are made in the first sentences of the abstract and these are not further elaborated upon (for example Omarov et al. 2017 or Qi et al. 2017)
- A life-cycle analysis or the assessment of environmental impacts does not present relevant results for this thesis (for example Mahmud et al. 2018 or Ozlu and Dincer 2018)

In addition to the reasons above, especially the assessment of full-text articles for eligibility (step 3) revealed that many articles are not relevant for the systematic overview because they do not mention negative impacts (for example Doljak and Stanojevic 2017 or Guiller et al. 2017). The reasons for exclusion demonstrate that even though mostly negative connoted search terms were used, many positive effects of solar energy technologies were found. General as well as site-specific assessments of negative effects are rare as many articles present very technical assessments as demonstrated in the first reason for exclusion that cannot be mapped in regard to the SDGs.

5.1.2 Conflicts identified (solar energy)

Table 4 shows the systematic overview for solar energy:

Table 4: Systematic overview for solar energy (own illustration)

SDG target	Problem	Author	Geographic area	Potential cause
2.1	PV facilities take up land that could be used for agriculture	Botelho et al. 2017: 192	General	/
2.1	Competition of land used for PV installations with land used for agricultural production	Sacchelli et al. 2016: 91	General	/
6.3	Environmental categories affected by concentrated solar power are associated to marine and freshwater toxicity	Corona et al. 2016: 9	General	Use of biomethane in this technology

SDG target	Problem	Author	Geographic area	Potential cause
6.3	Floating PV systems may release toxic elements into the water body	Liu et al. 2018: 966	General	Material degradation
6.3	Depending on the site and the specific solar technology negative effects on water resources such as pollution can originate from solar energy systems	Tsoutsos et al. 2005: 291	General	/
6.5	Cleaning of PV installations requires water that in arid regions in northwestern India may conflict with small-scale substance agriculture or domestic consumption	Ravi et al. 2016: 384	Northwestern India	/
8.8	The usage of critical materials such as lithium in PV technology and research may be linked to human rights abuses and poor labor standards among others (p. 486)	Hancock et al. 2018: 486	General	/
10.2	Negative effects of PV facilities are only experienced by local people living close to it, while larger parts of the population benefit	Botelho et al. 2017: 191	General	/
10.2	Utility-scale solar energy systems take up cultural resources of Native American groups	Mulvaney 2017: 16	Southwest of the USA	/
11.4	PV farms cause landscape alterations	Botelho et al. 2017: 192	General	/
11.4	Visual impact of utility-scale PV systems in regions that depend on attractive landscapes for tourism	Calvert 2018: 198	General	/
11.4	Visual disturbance of relevant landscapes for visitors or landowners by utility-scale solar energy systems	Mulvaney 2017: 17	Southwest of the USA	/
12.4	Batteries used in PV technologies can be harmful in regard to human-toxicity, eco-toxicity or metal depletion	Bazan et al. 2018: 1457	General	/

SDG target	Problem	Author	Geographic area	Potential cause
12.4	With an increase of solar power plants comes an increase of waste from these plants	Bogacka et al. 2017: 198	General	/
12.4	Depending on the site and the specific solar technology chemicals can be released from solar energy systems	Tsoutsos et al. 2005: 291	General	/
14.2	Floating PV systems block sunlight that would go into the water body securing good water quality, for example by supporting the growth of algae	Pimentel Da Silva and Branco 2018: 8	General	/
15	Utility-scale PV systems take up low-quality agricultural land in Ontario, Canada	Calvert 2018: 196	Ontario, Canada	In general land use is not taken into account when assessing site location
15	Depending on the site and the specific solar technology negative effects on land use can originate from solar energy systems	Tsoutsos et al. 2005: 291	General	/
15.5	Alterations in the countryside because of PV facilities may affect biodiversity by changing local animal and plant species	Botelho et al. 2017: 192	General	/
15.5	PV systems impact biodiversity and natural ecosystems depending on local circumstances	Castillo et al. 2016: 88	General	/
15.5	The two types of solar cells studied both have the most significant impacts on ecosystem quality	Khaenson et al. 2017: 117	Thailand	/
15.5	Utility-scale solar energy systems can negatively affect wildlife, for example, during the construction phase in the form of habitat fragmentation	Moore-O'Leary et al. 2017: 388	General	/
15.5	Utility-scale solar energy have negative impacts on wildlife as area of natural habitats is taken up	Mulvaney 2017: 10	Southwest of the USA	/

SDG target	Problem	Author	Geographic area	Potential cause
15.5	Utility-scale PV systems cause bird mortality	Walston et al. 2016: 411	California, USA	Birds collide with the system or suffer from burning injuries
15.5	Depending on the site and the specific solar technology ecosystems can be harmed by solar energy systems, for example, if they are placed too close to ecological sensitive sites	Tsoutsos et al. 2005: 291	General	/
15.5	Utility-scale solar energy systems have various negative effects on wildlife in the desert of the Southwest of the USA	Lovich and Ennen 2011: 984	Southwest of the USA	/

There were conflicts with eight SDGs identified. The main themes of conflict are land use and waste, chemicals and materials. For land use, conflicts result from the site selection of utility-scale solar energy (USSE) systems as these systems require large areas of land: If placed on arable land, USSE competes with agricultural production (SDG target 2.1; Botelho et al. 2017, Mulvaney 2017). If placed on land of value for specific communities, it is likely that these communities were not involved in the decision-making process (SDG target 10.2; Botelho et al. 2017, Mulvaney 2017). The visual impact of the systems can also restrict the attractiveness of certain landscapes (SDG target 11.4; Botelho et al. 2017, Calvert 2018, Mulvaney 2017). General impacts on land use are summarized under SDG 15 (Calvert 2018 and Tsoutsos et al. 2005). Moreover, USSE systems affect biodiversity in most cases regardless of the land they are placed on (SDG target 15.5; Botelho et al. 2017, Castillo et al. 2016, Khaenson et al. 2017, Moore-O'Leary et al. 2017, Mulvaney 2017, Tsoutsos et al. 2005, Lovich and Ennen 2011). A specific case of biodiversity loss is bird mortality (SDG target 15.5; Mulvaney 2017, Walston et al. 2016).

The land use of solar energy technologies, especially USSE systems, results in a variety of conflicts depending on the previous land use of the respective area and the surrounding area. In regard to the geographic focus, Mulvaney 2017, Lovich and Ennen 2011 and Walston et al. 2016 refer to the southern parts of the USA. However, except for the specific conflict with Native American groups, the conflicts could in theory apply to all areas where large areas of land are used for USSE systems. The focus on the southern parts of the USA is therefore more of a case-specific example than an indication that the conflicts are only relevant in this geographic area.

Although only few potential causes for land use conflicts of solar energy technologies are mentioned in the articles, they summarize the main problem. The crucial factor is a sensitive site selection with an in-depth assessment of the current land use and the participation of local communities in the decision-making process. Suuronen et al.

2017 present a possible assessment including physical, environmental and social factors. The technology inherent factor that USSE systems use large areas of land cannot be completely avoided, but alternative proposals suggesting the usage of degraded or contaminated land (Castillo 2016: 96) or water bodies (Liu et al. 2018: 957, Pimentel Da Silva and Branco 2018: 4) exist in the literature.

The theme of waste, chemicals and materials of solar energy technologies demonstrates different conflicts: Released chemicals can negatively affect water bodies (SDG target 6.3; Corona et al. 2016, Liu et al. 2018, Tsoutsos et al. 2005). Hazardous waste and chemicals need to be recycled appropriately (SDG target 12.4; Bazan et al. 2018, Bogacka et al. 2017, Tsoutsos et al. 2005) and critical materials needed for construction and research purposes may be obtained under poor labor standards (SDG target 8.8; Hancock et al. 2018). There were no indications about the geographic area of these conflicts in the articles, most likely because they are independent of site location. Potential causes of these conflicts can be directly linked to the respective chemicals and materials. Approaches for replacement, sustainable and fair production and sound recycling are needed to overcome these conflicts.

The conflicts of solar energy demonstrate a focus on the SDGs 6, 12 and 15 with the two main themes land use and waste, chemicals and materials. Most of the articles name conflicts generally and do not refer to specific cases. The analyzed literature points to a lack of case studies evaluating conflicts of solar energy technologies in the context of sustainable development. Hence, the articles do not provide great insights into a geographic area that is specifically relevant for these conflicts. The site selection and the production process represent crucial stages where conflicts with the SDGs appear. Although hardly mentioned in the articles, many of the potential causes are determined by the technologies in the sense that it cannot be avoided that USSE take up large areas of land.

5.2 Wind energy

Wind energy technologies use the kinetic energy of wind and turn it into electricity (Nascimento and de Souza 2017: 40). Wind moves the blades of a wind turbine. The rotating blades move a shaft connected to a generator that produces electricity (International Renewable Energy Agency n.d.). The technology is illustrated in figure 10 (IPCC 2011: 552). It can be differentiated between two types depending on the location of the wind turbine: on-shore, meaning on land, and off-shore, meaning on water bodies. The term wind farm indicates an allocation of many wind turbines in the same area.

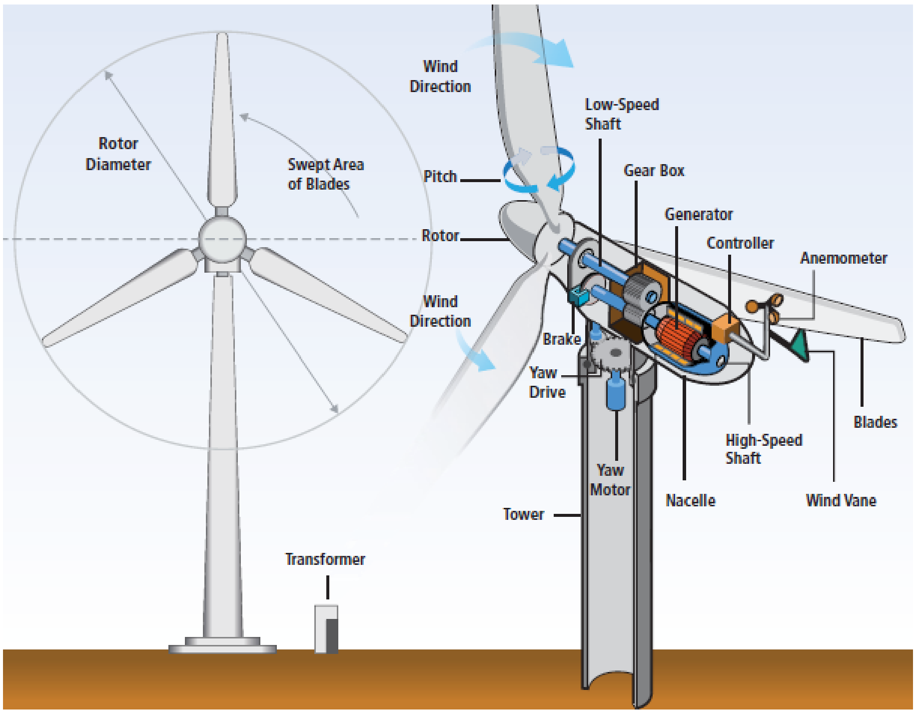

Figure 10: Example of a wind turbine (IPCC 2011: 552)

5.2.1 Number of articles included and reason for exclusion (wind energy)

By using the search query for wind energy[15], 154 articles were identified and 20 were included in the systematic overview (see figure 11)[16]:

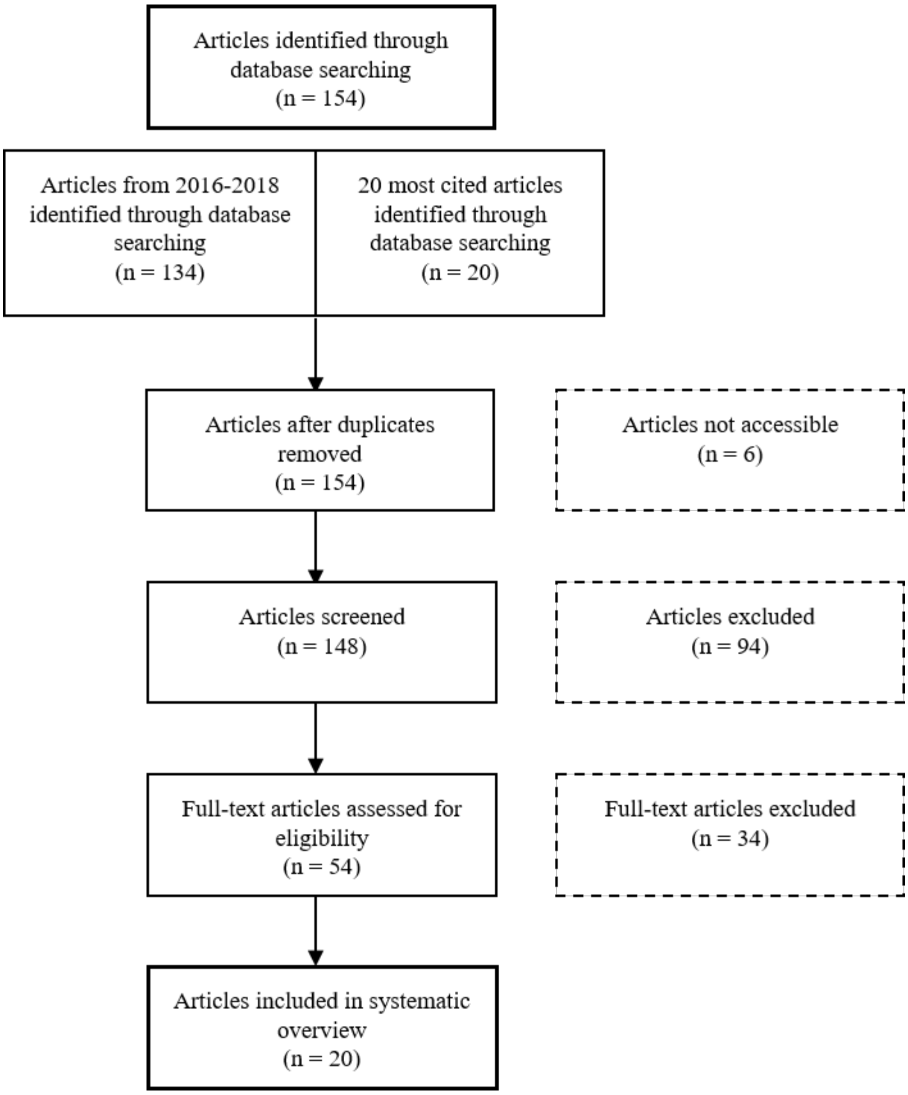

Figure 11: Flow diagram of wind energy (own illustration)

[15] TS=(wind-energy AND environmental-impact* OR wind-energy AND environmental-problem* OR wind-energy AND environmental-conflict*) OR

TS=(wind-energy AND social-impact* OR wind-energy AND social-problem* OR wind-energy AND social-conflict*) OR

TS=(wind-energy AND economic-impact* OR wind-energy AND economic-problem* OR wind-energy AND economic-conflict*). The search query was used on June 6, 2019.

[16] 14 articles were also identified in the solar energy search. All of them were either not accessible or excluded in step 2.

Similar to the article selection of solar energy, also in regard to wind energy many articles had to be excluded in step 2. The most prominent reasons for exclusion are the same as for solar energy:

- Articles assess the efficiency/ performance/ functionality of very specific kind of technologies/ materials/ systems (for example Amine et al. 2016 or Reddy and Manohar 2017)
- Wind energy technologies are not the main theme of the article (for example Frew et al. 2018 or Benham 2017)
- General statements about the environmental, social or economic impacts of wind energy are made in the first sentences of the abstract and these are not further elaborated upon (for example Fateh et al. 2016 or Hassanzadeh et al. 2017)
- A life-cycle analysis or the assessment of environmental impacts does not present relevant results for this thesis (for example Weinzettel et al. 2009 or Tsai et al. 2016)

In comparison to solar energy, the articles for wind energy presented to a much lesser degree technical assessments and there were more articles found that refer to electricity generation. This can be attributed to the diverse applications for solar energy technologies mentioned at the beginning of chapter 5.1. In addition to the exclusion of articles due to no indication of negative aspects of wind energy in step 3, this step also revealed that some articles assessed a potential problem but could not confirm any negative aspects (for example Lopucki and Perzanowski 2018 or Hooper et al. 2017).

5.2.2 Conflicts identified (wind energy)

Table 5 shows the systematic overview for wind energy:

Table 5: Systematic overview for wind energy (own illustration)

SDG target	Problem	Author	Geographic area	Potential cause
2.1	Lakes that were used for fishing by the Xavier community were destroyed due to the creation of roads to wind turbines	Gorayeb et al. 2016: 385	Western Ceara, Brazil	/
3	The noise of wind turbines may cause annoyance and sleep problems and therefore affect human health	Songsore and Buzzelli 2016: 2	General	/
3	Wind farms may have a negative impact on human health because of noise	Sorkhabi et al. 2016: 359	General	/

SDG target	Problem	Author	Geographic area	Potential cause
8.9	If implemented, offshore wind farms in Catalonia would negatively impact coastal tourism	Voltaire et al. 2017: 122	Catalonia	Because of the visual impact, visitors would come less often to the beaches
10.2	Positive effects of wind farms are experienced on a national and global level, while negative effects are only experienced by communities located close to the site	Adagha et al. 2017: 81	General	/
10.2	Indigenous groups oppose wind projects on a narrow land bridge in Mexico as the projects impact their livelihoods	Avila-Calero 2017: 993	The Isthmus of Tehuantepec, a narrow land bridge in Mexico	Lack of consultation and uneven power relations. Conflict of private and local interests
10.2	Although not implemented, the decision-making process of a wind project on Kings Island, Australia, caused conflicts within the community	Colvin et al. 2018: 1	Kings Island, Australia	Community involvement in the decision-making process was characterized by a problematic voting process
10.2	Local governments can hardly influence the development of wind farms in Inner Mongolia	Han et al. 2009: 2949	Inner Mongolia	/
10.2	Contrasting attitudes towards off-shore wind projects: nationally a positive perception, locally a mixed perception by communities of the Bay of Saint-Brieuc, France	Kermagoret et al. 2016: 21	Bay of Saint-Brieuc, France	/
11.4	Wind energy causes unaesthetic landscape alterations and lights cause disturbances	Botelho et al. 2018: 148	General	/
12.4	Concrete and composite materials are materials used in wind turbines that do not have an established recycling process	Liu and Barlow 2017: 229	General	/

SDG target	Problem	Author	Geographic area	Potential cause
14.2	Despite diverse negative impacts, many wind farms were established in coastal areas of Australia causing significant land use change	Harvey et al. 2017: 377	Coasts of Australia	Uncoordinated national approach of site selection for wind farms for over 20 years
15.5	Wind energy impacts flora and fauna	Botelho et al. 2018: 148	General	/
15.5	Bats and birds collide with wind turbines	Kleyheeg-Hartman et al. 2018: 145	General	/
15.5	Some vertebrates are negatively affected by wind turbines	Lopucki et al. 2017: 343	Southeastern Poland	/
15.5	Some small mammals show stress responses in the vicinity of wind turbines	Lopucki et al. 2018: 169	Southeastern Poland	/
15.5	Wind technologies can have negative effects on wildlife, for example habitat fragmentation due to wind energy infrastructure	Roddis 2018: 46	General	/
15.5	Wind power affects marine and terrestrial animals in various ways	Rodriguez-Rodriguez et al. 2016: 9	General	/
15.5	Soaring birds are particular effected by wind turbines as many species fly low to the ground with their heads pointing down looking for prey	Santangeli et al. 2018: 2	General	/
15.5	Wind farms interfere with natural habitats	Sorkhabi et al. 2016: 359	General	/

SDG target	Problem	Author	Geographic area	Potential cause
15.5	Wind farms located near to large groups of Anseriformes and Charadriiformes have a negative impact on these birds primarily in terms of abundance	Stewart et al. 2007: 9	General	/
15.5	Wind farms in the Eastern Rhodopes mountains in Greece and Bulgaria may contribute to decreasing numbers of the Balkan cinereous vulture	Vasilakis et al. 2016: 15	Eastern Rhodopes mountains in Greece and Bulgaria	/

Conflicts with eight SDGs were identified for wind energy. The main themes of conflict are land use and impacts on local communities. Wind turbines often impact land use due to the fact that the turbines are often deployed in large numbers on a large area of land. In the context of land use, the analyzed articles especially highlight the impact on natural habitats and biodiversity (SDG target 15.5; Botelho et al. 2018, Kleyheeg-Hartman et al. 2018, Lopucki et al. 2017, Lopucki et al. 2018, Roddis 2018, Rodriguez-Rodriguez et al. 2016, Santangeli et al. 2018, Sorkhabi et al. 2016, Stewart et al. 2007, Vasilakis et al. 2016). This is relevant for on-shore and off-shore wind turbines as, for example, birds are affected by both types. The establishment of wind farms also results in changes of coastal areas (SDG target 14.2; Harvey et al. 2017) which can lead to a decrease in tourism (SDG target 8.9; Voltaire et al. 2017) because the wind farms can be perceived as aesthetically unpleasing (SDG target 11.4; Botelho et al. 2018).

The few geographic areas that are listed in regard to land use conflicts only represent examples. It is likely that animals are affected by wind turbines not only in Southeastern Poland (Lopucki et al. 2017, Lopucki et al. 2018), but in other areas as well. However, each case is specific and therefore needs to be examined individually. The conflict itself is inherent to the technology as wind turbines deployed in large numbers require large areas of land. When it comes to landscape alterations that are perceived as aesthetically unpleasing, the potential cause of uncoordinated national approaches of site selection described by Harvey et al. 2017 points to way of mitigating this conflict.

The main theme of impacts on local communities refer to a lack of or ineffective community involvement (SDG target 10.2; Adagha et al. 2017, Avila-Calero 2017, Colvin et al. 2018, Han et al. 2009, Kermagoret et al. 2016: 21). This theme highlights the conflict between global or national and local priorities. The positive impacts of wind energy especially in comparison with fossil fuels are experienced on a global and national level, while the negative impacts of the actual wind turbines are only experienced by the communities living close to the site. The listed geographic areas represent specific case studies.

Avila-Calero 2017 addresses potential causes for conflicts in great depth and many points are applicable to this theme in general: the conflict of national vs. local, or private vs. local interests manifests itself in uneven power relations. In the case of indigenous communities this also has a historic component as uneven power relations have been existed before the construction of wind farms. However, the example of Kings Island, Australia (Colvin et al. 2018) demonstrates that even if the community is actively involved, the involvement itself could cause social conflict. Therefore, better and case-specific tools for community involvement still need to be developed.

The SDGs 10 and 15 are the most relevant SDGs in regard to conflicts with wind energy. They represent the main themes of land use and impacts on local communities. Especially the later theme demonstrates some relevant case studies, but in total only a few concrete references to geographic areas and potential causes could be made. Both themes indicate that the site selection for wind turbines is a crucial step to avoid possible conflicts with the SDGs.

5.3 Hydropower

Hydropower plants use water flow to produce electricity. The plants convert "the energy of water moving from higher to lower elevations on its way back to the ocean, driven by the force of gravity" (IPCC 2011: 443) to electricity by turbines (International Renewable Energy Agency n.d.). Technologies are differentiated mainly by size and by flow type (IPCC 2011: 451). Regarding size, hydropower plants are distinguished between small and large plants depending on the installed capacity (IPCC 2011: 450). There is no universal definition for this distinction, but national references exist (IPCC 2011: 450). Common flow types are run-of-river, storage, pumped storage and in-stream technology (IPCC 2011: 450).[17] As an example, figure 12 (IPCC 2011: 451) shows a storage hydropower plant with a typical water reservoir separated by a dam.

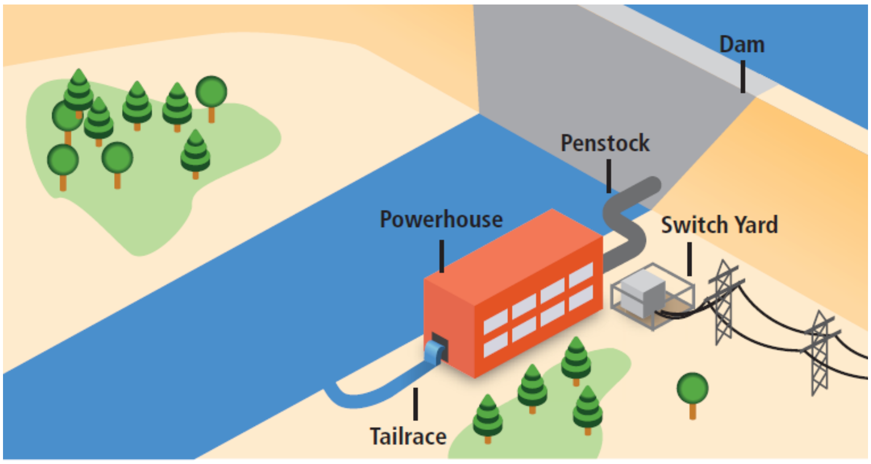

Figure 12: Example of storage hydropower (IPCC 2011: 451)

[17] Section 5.3 of the IPCC Report "Renewable Energy Sources and Climate Change Mitigation" provides an overview of these technologies.

5.3.1 Number of articles included and reasons for exclusion (hydropower)

By using the search query[18] for hydropower, 205 articles were identified and 26 were included in the systematic overview (see figure 13)[19]:

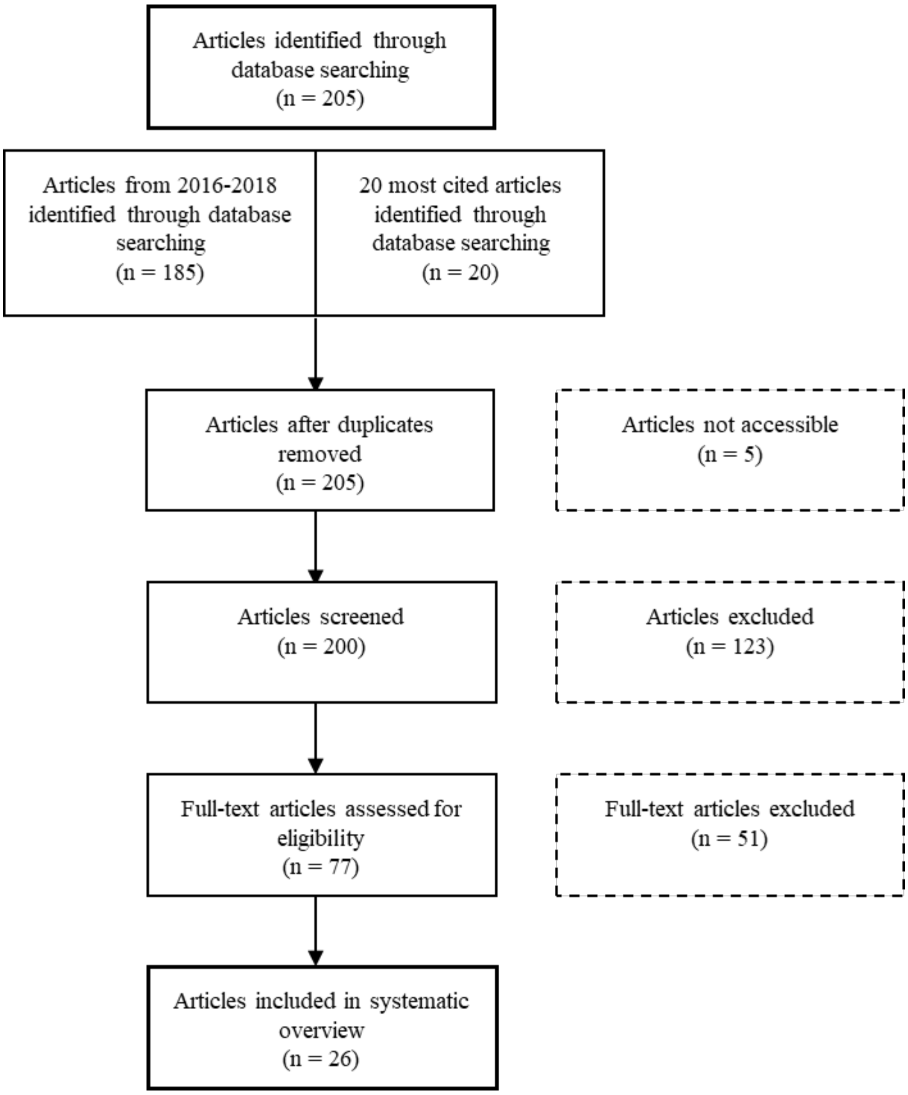

Figure 13: Flow diagram of hydropower (own illustration)

[18] TS=(hydropower AND environmental-impact* OR hydropower AND environmental-problem* OR hydropower AND environmental-conflict*) OR

TS=(hydropower AND social-impact* OR hydropower AND social-problem* OR hydropower AND social-conflict*) OR

TS=(hydropower AND economic-impact* OR hydropower AND economic-problem* OR hydropower AND economic-conflict*). This search query was used on June 26, 2019.

[19] One article was also found in the solar and wind energy search and here for the third time excluded. Three articles were found in the wind energy search and only one of these was included.

The identification of articles for hydropower revealed that negative impacts of hydropower plants appear more frequently in the literature in comparison to solar and wind energy. Many articles mentioned only on a general level negative aspects of hydropower plants. Therefore, the selection of articles needed to be slightly stricter in a sense that mainly new findings from the assessed articles are included. This was necessary in order to provide a concise overview.

Many articles were excluded in step 2. The main reasons for exclusion are the following:

- Hydropower is not the main theme of the article (for example Camargo 2017 or Liikanen et al. 2018)
- Effects mentioned are not clearly negative (for example Brignoli et al. 2017 or Keto et al. 2018)

This demonstrates that technical assessments of hydropower plants including analyzing the performance or functionality of specific elements or materials was not as common in the literature as it was the case for wind and especially for solar energy. In step 3 the difficulty of assessing whether a reported effect is negative reoccurred. Oftentimes changes were observed without a clear indication that this change is negative (for example Hirsch et al. 2017 and Orr et al. 2012).

5.3.2 Conflicts identified (hydropower)

Table 6 shows the systematic overview for hydropower:

Table 6: Systematic overview for hydropower (own illustration)

SDG target	Problem	Author	Geographic area	Potential cause
2 ZERO HUNGER 2.1	Among other negative aspects, the resettlement because of the construction of the Kelau Dam caused a reduction of food resources for the Orang Asli, a Malaysian indigenous community	Nor-Hisham and Ho 2016: 1194	Kelau Dam, Malaysia	Unequal power relations between the indigenous group and the Malaysian state
3 GOOD HEALTH AND WELL-BEING 3	Although not implemented and planned for 36 years, the expectation of eventually being relocated creates anxiety for people affected by the Kaeng Suea Ten Dam	Kirchherr et al. 2018: 487	Kaeng Suea Ten Dam, Thailand	/

SDG target	Problem	Author	Geographic area	Potential cause
5	The Belo Monte Hydroelectric dam on the Xingu River in Brazil made women of the Vila Nova community fully dependent on men's income	Castro-Diaz et al. 2018: 419	Xingu River, Brazil	As fish became less abundant, women can no longer sell additional fish to earn extra income
5	Among many other impacts, especially indigenous Brou women experience severe negative effects from the Nam Theun 2 Hydropower Project in Laos	Manorom et al. 2017: 293	Laos	Development actors did not account for the presence of indigenous groups
6.4	Due to small hydropower plants there is water stress for farmers in Yunnan, China	Hennig and Harlan 2018: 123	Yunnan, China	Project assessment did not evaluate impacts on the whole watershed
6.4	There is less water available in natural sources in the Beas River basin due to hydropower projects	Kumar and Katoch 2016: 606	Beas River, India	/
6.6	The Belo Monte Hydroelectric dam on the Xingu River in Brazil decreased the water quality of the river	Castro-Diaz et al. 2018: 419	Xingu River, Brazil	/
6.6	Hydropower plants in Vietnam cause river segments to dry out	Luu et al. 2017: 31	Vietnam	/
8.3	After resettlement, affected communities in China and Vietnam are not compensated effectively, especially in regard to land	Rousseau et al. 2017: 2416	China, Vietnam	Unequal power relations between the communities affected and governance regimes contribute to the problem

SDG target	Problem	Author	Geographic area	Potential cause
8.5	The San Antonio and Jirau dam caused resettlement without providing adequate compensation especially in regard to jobs	Fearnside 2014: 169	San Antonio and Jirau dam, Madeira River, Brazil	The decision of building the dams were made before the impacts were adequately assessed
8.5	Among other positive and negative aspects, the construction of the Bui Hydroelectric Project led to decline of fishing opportunities for affected communities which caused unemployment for fishermen	Obour et al. 2016: 292	Bui Hydroelectric Project, Ghana	/
8.5	Because of the Kamchay dam, local communities have lost access to land, fish and bamboo which caused unemployment for bamboo collectors	Siciliano et al. 2016: 9	Kamchay dam, Cambodia	Planning and management of the dam was not effectively conducted
10.2	Impacts of hydropower plants are felt by communities living close to the plant, while benefits occur on national or global levels	Fearnside 2014: 164	General	/
10.2	Economic and cultural resources of the Munduruku community are endangered by the hydropower project Sao Luiz do Tapajos in the Tapajos River	Hess and Fenrich 2017: 28	Tapajos River, Brazil	/
10.2	While local communities have lost access to resources, the developers of the Kamchay dam will gain long-term financial benefit	Siciliano et al. 2016: 15	Kamchay dam, Cambodia	/
10.3	Advantages from small hydro power projects in the Gundia River basin that were guaranteed to local communities did not become effective	Jumani et al. 2017: 507	Gundia River, India	/
11.4	Some hydropower projects impact natural heritage	Botelho et al. 2018: 148	General	/
15.1	The dam of the Balbina hydropower plant causes downstream disturbances that are likely to be the reason for trees dying	Assahira et al. 2017: 121	Uatuma River, Brazil	Downstream impacts of dams are not assessed sufficiently

SDG target	Problem	Author	Geographic area	Potential cause
15.1	The San Antonio and Jirau dam cause a loss of natural ecosystems	Fearnside 2014: 166	San Antonio and Jirau dam, Madeira River, Brazil	The decision of building the dams were made before the impacts were adequately assessed
15.1	Forests are negatively impacted by the transmission lines of hydropower projects in the Amazon Legal region	Hyde et al. 2018: 347	Amazon Legal region, Brazil	Powerlines are usually not assessed when evaluating environmental impacts of hydropower projects
15.1	Hydropower plants in Vietnam cause deforestation	Luu et al. 2017: 32	Vietnam	/
15.1	The Kasilian Reservoir Dam causes a loss of agricultural and forest lands	Khodarahmi et al. 2018: 113	Kasilian Reservoir Dam, Iran	/
15.5	Storage type hydropower plants are obstacles for migratory fish species and may injure them	Bilotta et al. 2015: 2	General	/
15.5	Some hydropower projects impact biodiversity	Botelho et al. 2018: 148	General	/
15.5	The San Antonio and Jirau dam negatively impact fish species	Fearnside 2014: 167	San Antonio and Jirau dam, Madeira River, Brazil	The decision of building the dams were made before the impacts were adequately assessed
15.5	The flushing of a reservoir on the Rhone River caused a decline of fish density in the reservoir	Grimardias et al. 2017: 247	Rhone River, France	/

SDG target	Problem	Author	Geographic area	Potential cause
15.5	A hydropower station on the Jinggu River negatively affects phytoplankton	Li et al. 2018: 50	Jinggu River, China	/
15.5	Hydropower plants in Vietnam harm fish species	Luu et al. 2017: 31	Vietnam	/
15.5	Elevated levels of total dissolved gas caused by hydropower plants on the Jinsha River harm fish species	Ma et al. 2018: 13546	Jinsha River, China	/
15.5	Hydropower plants in Austria negatively affects aquatic organisms in the studied rivers	Moog et al. 1993: 11	Austria	/
15.5	The Cachoeira Caldeirao Dam causes a decline in actual and potential nesting ares of the semi-aquatic yellow spotted river turtle	Norris et al. 2018: 12	Cachoeira Caldeirao Dam, Brazil	/
15.5	The San Antonio and the Jirau dam cause a decline of fish	Santos et al. 2018: 389	San Antonio and Jirau dam, Madeira River, Brazil	/
15.5	In China negative impacts of hydropower plants on fish outweigh the positive impacts	Zhong and Power 1996: 95	China	/
16.1	Some protests against dams of hydropower plants resulted in violence and repression	Del Bene et al. 2018: 631	General	/

Conflicts with nine SDGs were identified for hydropower. The main themes of conflict are ecological effects of hydropower plants and inequalities. The construction of hydropower plants inevitably alters the structure of a river. This can negatively impact fish and other organisms (SDG target 15.5; Bilotta et al. 2015, Botelho et al. 2018, Fearnside 2014, Grimardias et al. 2017, Li et al. 2018, Luu et al. 2017, Ma et al. 2018, Moog et al. 1993, Norris et al. 2018, Santos et al. 2018, Zhong and Power 1996). Also affected are trees, forests and ecosystems in general that are located downstream of the hydropower plant (SDG target 15.1; Assahira et al. 2017, Fearnside 2014, Hyde et al. 2018, Luu et al. 2017, Khodarahmi et al. 2018). In addition, the water quality and availability of the river and surrounding areas is impaired (SDG targets 6.4 and 6.6; Hennig and Harlan 2018, Kumar and Katoch, Castro-Diaz et al. 2018, Luu et al. 2017).

In many cases the ecological effects are attributed not only to a geographic area but to a specific hydropower plant. The focus of the geographic aspect lies on Brazil and China. However, this focus does not mean that in these countries conflicts with the SDGs 6 and 15 occur because other countries perform better. It is crucial to point this out due to the fact that some countries have more potential for hydropower and therefore have more hydropower plants installed. Hence, Brazil and China are a geographic focus, but they are also the two countries with the highest installed capacity (International Hydropower Association 2018), so studies examining negative aspects of hydropower plants are likely to be conducted in China and Brazil. Although the alteration of rivers is to different degrees inherent to the technology of hydropower plants, the potential causes found in regard to SDGs 6 and 15 indicate, that in some cases an assessment of potential negative impacts was not conducted sufficiently. It implies that these negative effects could have possibly been avoided by a better and more comprehensive assessment before construction.

The theme of inequalities refers to the unequal distribution of benefits and burdens between local communities and private or national stakeholders (SDG targets 10.2 and 10.3; Fearnside 2014, Hess and Fenrich 2017, Siciliano et al. 2016, Jumani et al. 2017), the loss of jobs, land and food resources (SDG targets 8.3, 8.5 and 2.1; Rousseau et al. 2017, Fearnside 2014, Obour et al. 2016, Siciliano et al. 2016, Nor-Hisham and Ho 2016: 1194) and gender inequalities within affected communities (SDG 5; Castro-Diaz et al. 2018, Manorom et al. 2017). In many cases these inequalities are an effect of negative ecological impacts. Therefore, the two themes are connected in a sense that, for example, an ecological negative impact of a decline in fish can result in a social negative impact of women becoming financially dependent on men (Castro-Diaz et al. 2018). This demonstrates that one conflict can lead to others with different SDGs involved.

In regard to the geographic area, there is again a focus on China and Brazil. Smaller countries in Southeast Asia as well as Ghana are also mentioned but only in a few individual cases. If indicated, the potential causes are the same as for the theme of ecological effects: an insufficient assessment of potential negative impacts of the respective hydropower plant. In addition, unequal power relations also play a role in some cases.

The conflicts of hydropower and the SDGs focus on the SDGs 6, 8, 10 and 15. For the two themes ecological impacts and inequalities, the phase before the construction of hydropower plants is crucial as only then can many negative effects be prevented by detailed impacts assessments. Many case studies with references to geographic areas could be identified in contrast to the technologies of solar and wind energy.

6 Analysis

The following analysis first describes the article selection before evaluating the analyzed conflicts with the SDGs including the geographic area and the potential causes. This is done because the article selection itself presents relevant results. The results of the flow diagrams and the reasons for exclusion show that for solar and wind energy the literature identifies less conflicts than for hydropower. Although the number of included articles does not differ greatly (solar energy: 17, wind energy 20, hydropower 26), the selection process for hydropower had to be slightly stricter in order to provide concise results in the overview. This is shown in the systematic overview since for hydropower it was possible to make more connections to geographic areas. The results for hydropower are therefore more specific than those for solar and wind energy which could demonstrate that there are in principle more conflicts with hydropower. Another possible reason for this is that the perception of hydropower has shifted over the last 80 years from the "most clean" option to produce energy to "environmental activists go up in arms whenever a hydro-electric power project is planned" (Abbasi and Abbasi 2000: 135). As hydropower is sometimes not considered a "green energy" (King and Brown 2018: 2), negative impacts might have been studied more extensively over the years than in the case of wind and solar energy.

The low share of articles included in proportion to articles screened (solar energy 9%, wind energy 14%, hydropower 13%) and the limited number of relevant articles demonstrate that negative impacts are not discussed frequently. The argument that this result points to a research gap is only partly valid as many restrictions for the article selection were used. Using other search engines and no limitations in regard to the year of publication would lead to more results and therefore most likely to a larger body of relevant literature. The low share may also be explained by an unsuited search query. Although the number of articles identified is adequate for the scope of this thesis as the conflicts identified lead to relevant results, it cannot reliably be ruled out that other queries would lead to better results. Especially in the case of solar energy, a specific search query for USSE is relevant for further research. To a smaller extent this is also true for the different forms of technologies of wind energy and hydropower. A specification of forms of technologies could also minimize the reason for exclusion that the respective technology is not the main theme of the article.

The reason for exclusion that a life-cycle assessment did not provide relevant results in regard to conflicts with the SDGs can hardly be minimized by adjusting the search query. Instead, further research should investigate life-cycle assessments in general and how they can go beyond measuring indicators of performance. Conducting comprehensive life-cycle assessments is crucial to the construction of renewable energy technologies, but in the context of this thesis it was oftentimes not possible to map these assessments to the SDGs. The theme of inequalities within hydropower demonstrates that negative effects of renewable energy technologies are intertwined and that there is a need to assess indirect negative effects of a power plant comprehensively. This becomes especially difficult when negative effects cannot be measured like the financial dependency of women on their men due to less abundant fish (Castro-Diaz et al. 2018).

In regard to the analyzed conflicts with the SDGs, the conflicts for all three technologies are different. There are conflicts with different SDGs based on different themes. For example, SDG 12 appears only for solar and wind energy and the SDGs 5 and 16 only appear for hydropower. The theme of conflict waste, chemicals and materials is unique to solar energy, while the theme ecological effects is outstandingly relevant for hydropower. These differences demonstrates the complexity of conflicts of climate change mitigation actions with the SDGs. This thesis deals with one measure of one sector of the developed categorization of climate change mitigation actions. Within this measure, only the three most relevant renewable energy technologies were selected and still the conflicts are diverse. This emphasizes two things: first, the need to examine renewable energy technologies separately and not as one measure all together[20] and secondly, the urgency for more research on conflicts between climate change mitigation and sustainable development as this topic presents itself as highly comprehensive and detailed.

Although there are differences between the conflicts, there are also similarities. Conflicts with SDG 15 were found for all three technologies. Therefore, conflicts of solar energy, wind energy and hydropower center around biodiversity loss and the degradation of natural habitats and ecosystems. For solar and wind energy these conflicts are part of the theme of land use, while for hydropower these conflicts are specifically represented in the theme of ecological effects. The focus on SDG 15 can also be explained by the great variety of aspects that are covered within this SDG. All aspects are environmental but range from forests and land degradation to biodiversity loss and freshwater ecosystems. As SDG 15 covers many environmental aspects, it appears so prominently in the systematic overview. In addition, conflicts with SDG 15 represent the global risk of biodiversity loss and ecosystem collapse as outlined by the World Economic Forum, highlighting the strong linkage between this risk and the discussed risk of failure of climate change mitigation and adaptation.

A second predominant conflict is connected to inequalities. Although SDG 10 represents this conflict best, it is not only conflicts with SDG 10 that indicate inequalities. For all three technologies one conflict was identified that stresses the mismatch of burden and benefits (solar energy: Botelho et al. 2017: 191; wind energy: Adagha et al. 2017: 81; hydropower: Fearnside 2014: 164). Solar energy, wind energy and hydropower technologies are all bound to a specific place where the power plant is installed. Natural conditions like solar radiation, wind and rivers determine which places are suitable for an installation. Most of the conflicts identified result from the construction or operation phase of the power plant and therefore, only communities living close by are affected. While the main benefit of a power plant, namely the generation of renewable energy, is shared on national and global levels, the burden is to a large extent local. This mismatch becomes particularly problematic if affected local

[20] Note that an earlier version of this thesis highlighted the uniqueness of this thesis' approach to differentiate in detail between the different renewable energy technologies. In the course of writing the thesis, the discussed SCAN-tool was slightly revised so that the need for differentiation was more clearly visible in the tool. Therefore, the initially made claim of a unique approach was later omitted.

communities or indigenous groups are not included in decision-making processes led by governments or private companies.

Highlighting conflicts with SDG 15 and 10 does not imply that other identified conflicts are less relevant. As explained in the limitations section, the approach used in this thesis does not allow reaching conclusions concerning the robustness or magnitude of a conflict.

In respect to the geographic area, no general results can be drawn from the analyzed articles for all three technologies. For solar and wind energy there were hardly any connections to geographic areas so that an interpretation of results would not be adequate. The systematic overview for hydropower includes more references to countries, areas and sometimes to specific power plants. However, in most cases the countries referred to are Brazil and China, the countries with the most installed hydropower capacity worldwide and therefore the countries most likely to be studied. Other countries are only mentioned occasionally. As no geographic areas could be identified where conflicts of renewable energy technologies with the SDGs are particularly relevant, site-specific assessments are of exceptional importance.

Potential causes of conflicts were only identified in a few cases. However, most of these cases have in common that a comprehensive assessment of possible negative effects was not conducted prior to the construction of respective power plants. In addition, unequal power relations prevent local groups from having the opportunity to influence any decision-making processes. These results, although not numerous, indicate that the site selection and the decision-making process on the construction of renewable energy plants are crucial stages in order to avoid conflicts with the SDGs. Unless there are major technological advancements, it is a fact that large solar and wind energy installations take up extensive areas of land and that hydropower plants alter river flows. Currently, this cannot be changed, but it can be changed how especially large projects are developed. This means that local communities are involved as much as possible and environmental assessments cover a wide range of potential negative effects. These claims are certainly not new as they are implied by the identified potential causes. Exactly the fact that these are not new ideas for solutions demonstrates that there is still work to be done when it comes to aligning renewable energy technologies and sustainable development objectives.

The to some extent poor alignment of renewable energy technologies, or in a broader sense climate change mitigation actions, and sustainable development can be traced back to the historic development discussed in the first chapters. Only in 2015, with the Paris Agreement and the 2030 Agenda, global policy instruments were created that not only refer to each other and were developed inclusively but depend on each other for their fulfillment. Therefore, literature published after 2015 was analyzed in order to account for this new development. However, it is not possible that within a few years a global course of action, indicated by the Paris Agreement and the 2030 Agenda, can be implemented into national and local renewable energy projects. In the first chapters the need for an international course of action is highlighted in order to tackle the global risks compiled by the World Economic Forum. The systematic overview demonstrates that for a successful integration of sustainable development objectives, regional, local and site-specific assessments for renewable energy technologies are necessary. In order to successfully avoid conflicts of climate change mitigation actions and the SDGs, global policy objectives need to be implemented on the ground and they need to be made tangible for national, regional and local stakeholders so that their projects are in line, not only with climate change mitigation, but also with sustainable development.

7 Conclusion

This thesis aimed at illustrating a landscape of conflicts of the renewable energy technologies solar energy, wind energy and hydropower with the SDGs. This aim stems from the identified need to align climate change and sustainable development objectives. Although climate change and sustainable development are on a global policy level more connected than ever before by the Paris Agreement and the 2030 Agenda, an improved integration is crucial against the background of the interconnected and to a large extent environmental global risks listed by the World Economic Forum.

The chosen focus on climate change mitigation and three renewable energy technologies can only contextualize limited aspects of possible approaches to analyze the topics of climate change and sustainable development in combination. Possible bifurcations on the road to the created systematic overview are flagged and further suggestions for a more detailed approach are mentioned, for example a focus on specific forms of the three renewable energy technologies or expanding the literature review by using more search engines and no restriction by year. In order to account for breaking down the topic of climate change to solar energy, wind energy and hydropower, the methodology of creating a systematic overview by a literature review and using the SDGs as a mean of categorization is easily transferable. Hence, this thesis' approach can be used for other renewable energy technologies, other climate change mitigation actions and also for climate change adaption.

Despite the limitations of the methodology, especially in respect to the article selection, the systematic overview identified a landscape of conflicts with the SDGs. The used search query in Web of Science identified 530 relevant articles for all three technologies of which 63 revealed conflicts that were mapped to the SDGs. All conflicts are presented concisely and with references in the systematic overview so that a further analysis of each conflict is possible. A further analysis of the conflicts is especially relevant as in this thesis' scope it is only possible to lay a basis for necessary in-depth and case-specific assessments.

The conflicts identified are different for the three technologies confirming the hypothesis from chapter one. Therefore, it is necessary that for further assessments renewable energy technologies are analyzed separately and not grouped as one overall measure. However, similarities exist as well as demonstrated by two main aspects of conflict. First, conflicts with SDG 15, "life on land", were identified in many cases. Therefore, biodiversity loss and the degradation of natural habitats and ecosystems are important aspects where sustainable development objectives are harmed. Second, inequalities, mainly represented by SDG 10, "reduced inequalities", exist in the context of all three renewable energy technologies. These two main aspects are relevant for all three technologies and are therefore highlighted confirming the hypothesis that some SDGs are connected to more conflicts than others. However, this does not imply that further in-depth and case-specific assessments should center on these two aspects and SDGs. As this thesis' approach does not allow an evaluation of the robustness or the magnitude of a conflict, all the listed conflicts are relevant for aligning climate change mitigation actions with sustainable development objectives and demonstrate topics and themes for further research.

Moving from presenting a landscape of conflicts to overcoming conflicts, the geographic area and the potential causes in the systematic overview were included to further specify the conflicts. In regard to the geographic area, no relevant focus area of conflicts could be identified. This highlights that conflicts with solar energy, wind energy and hydropower technologies are case-specific. The results for the potential causes are also limited as in only a few cases the examined articles describe causes. This observation indicates that further research of conflicts should focus on the question of why conflicts emerge. Despite the limited number of potential causes, an insufficient assessment of the respective power plant prior to construction and a lack of the inclusion of local communities in decision-making processes were identified as reoccurring reasons of why negative effects unfold. Therefore, a starting point for overcoming conflicts of the three technologies with the SDGs is the site selection phase and inclusive decision-making processes.

Beyond the developed landscape of conflicts, the systematic overview demonstrates that the two global policy instruments, the Paris Agreement and the 2030 Agenda, need to be aligned in local contexts. On a policy level, the global basis for this alignment was created in 2015. The illustrated conflicts of solar energy, wind energy and hydropower with the SDGs are only a fraction of potential conflicts of the topics climate change and sustainable development. It is crucial to identify these conflicts in order to tackle them. This thesis contributes to the identification of conflicts for the limited area of three renewable energy technologies but with an approach that is suitable for other areas as well. Researchers, policy makers and governments can use the systematic overview as a starting point and a tool to identify relevant conflicts in detail. In order to tackle the global risks compiled by the World Economic Forum, it is crucial that global policy instruments are well aligned, but this alignment needs to trickle down to local projects in order to become truly effective. This task constitutes an immense challenge that will need the cooperation of all sorts of stakeholders, private and public as well as global and local.

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