# Producing wind energy at the cost of biodiversity: A stakeholder view on a green-green dilemma

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## ABSTRACT

Although renewable energy production is widely accepted as clean, it is not necessarily environmental neutral since, for example, wind turbines kill large numbers of airborne animals such as bats. Consequently, stakeholders involved in the planning and operation of wind turbines are often in conflict when trying to reconcile both goals, namely, promoting wind energy production and protecting bats. We report the responses to an online questionnaire sent out to stakeholders to assess this conflict. More than 80% of stakeholders acknowledged the conflict between bat conservation and wind energy production; yet, the majority was confident about solutions and all desired an ecologically sustainable energy transition. All groups, except members of the wind energy sector, disagreed with the statements that wind energy production is of higher priority than biodiversity protection and that global warming is more critical than the biodiversity crisis. All groups agreed that more measures have to be taken to make wind energy production ecologically sustainable and that the society should be included to pay for the implementation of these measures. All stakeholders except for members of the wind energy sector agreed on that revenue losses from wind energy production and delays in the transition process should be acceptable to resolve the green–green dilemma. Among offered choices, most stakeholders suggested engaging in more research, improving the efficiency of energy use and implementing context dependent cut-in speed during wind turbine operation. The suggestion to weaken the legal protection of wildlife species was dismissed by all, underlining the consensus to protect biodiversity.



## I. INTRODUCTION

More than 20 years ago, Germany decided on a complete transition from conventional energy production from both fossil and nuclear sources to energy production from renewable sources, a political decision which has been called "Energiewende" (EEG17). These efforts align with international treaties, such as the 2016 Paris agreement, among others, to reduce global $CO_2$ emission and as a consequence to limit the increase in the global average temperature to a maximum of 2 °C above preindustrial levels. To this end, energy production from renewable energy sources has reached a significant proportion (33%) of the total energy production in Germany. Wind energy production (16%) forms the largest sector of renewable energy production followed by energy production from biomass (7%), photovoltaic sources (6%), and hydropower (3%; Rohrig, 2018). In December 2018, Germany hosted about 30.000 onshore wind turbines and numbers will likely increase in the future (Deutsche WindGuard, 2019). From a global perspective, Germany ranks third after China and USA with respect to the national total energy production from wind power (GWEC, 2019), pointing toward the large-scale energy production from wind in a densely populated country in the center of Europe.

While wind energy production is considered a clean energy source, recent studies have revealed that it is not environmentally neutral (Arnett *et al.*, 2016 and May *et al.*, 2019). For example, wind energy production requires relatively large areas for the installation and operation of wind turbines, mostly in regions with favorable wind conditions such as coastlines (Arnett *et al.*, 2016). This has caused increasing problems in Germany because the availability of areas suitable for wind energy production has declined over time (Blankenhorn and Resch, 2014). Therefore, wind parks have recently encroached into areas that are less favorable in terms of wind speed and also in areas which were largely considered to be too valuable to be used for wind energy production, such as forests (Sudhaus, 2017 and Hurst *et al.*, 2015). Over the past few years, evidence has been also accumulated that wind energy production is associated with direct and indirect detrimental effects for wildlife species, particularly for bats (Voigt *et al.*, 2015; Arnett *et al.*, 2016, and O'Shea *et al.*, 2016). First, areas used for wind parks may turn unsuitable for bat species, e.g., when forests are cut down to establish roads and platforms for the erection and operation of wind turbines (Hurst *et al.*, 2015 and Arnett *et al.*, 2016). Second, bats may die at wind turbines (Dürr, 2002 and Dürr and Bach, 2004; Rydell *et al.*, 2010), either when colliding with

the rotors of wind turbines or when being exposed to the vortices in the tailwind of turbines, which seem to cause a fatal barotrauma (Baerwald *et al.*, 2008 and Voigt *et al.*, 2015). Indeed, recently, wind turbines have been identified as one of the major anthropogenic causes of mortality for bats worldwide (O'Shea *et al.*, 2016). Cumulative effects of bat fatalities at wind turbines may cause population declines, particularly in species with a high collision risk (Ingersoll *et al.*, 2013; Zahn *et al.*, 2014; and Frick *et al.*, 2016). This is particularly worrisome from a conservation viewpoint since collisions at wind turbines involve mostly migratory species and, as a consequence, fatalities at wind turbines impact bat populations over a much larger geographical area than the area used for wind energy production (Voigt *et al.*, 2012 and Lehnert *et al.*, 2014).

Within all E.U. countries, bats are protected by the Habitat Directive (92/32/CEE, Annexes II and IV). Also, most E.U. countries have signed the UN convention for the protection of migratory species under which bats are covered as migrants (UNEP/EUROBATS, Bonn 1979, London 1981). Additionally, all bat species are legally protected in Germany by national legislation (§7 Bundesnaturschutzgesetz, 2015). These high levels of legal protection are consistent with the general public interest in protecting endangered wildlife species, which make the consideration of bat conservation mandatory during the planning, development, and operation of wind turbines. In Germany and many other E.U. countries, it is mandatory to monitor the presence and activity of bats prior to the installation and during the initial phase of wind turbine operation. These monitoring schemes follow recommendations and guidelines on the international (Rodrigues *et al.*, 2016) and national level (e.g., Dietz *et al.*, 2015; MKULNV NRW, 2016; and MULE, 2018). Additionally, major research programs have investigated the impact of wind turbines on bats and how to mitigate the potential conflict between bat conservation and wind turbine operation (Brinkmann, 2011 and Behr *et al.*, 2018). Besides formulating recommendations about how to monitor bats during wind turbine projects, the aforementioned studies also aimed at establishing a set of explanatory variables, such as the time of day, season, ambient temperature, and wind speed, which help to predict the number of bat fatalities based on the acoustic activity of bats at the height of wind turbine nacelles. Threshold criteria of these explanatory variables are then used to define elevated cut-in speeds when wind turbines should operate without causing large numbers of bat fatalities (Voigt *et al.*, 2015), a measure that is known to reduce substantially the rate of bat fatalities at wind turbines (Brinkmann *et al.*, 2011 and Arnett *et al.*, 2011). Yet, even though mitigation schemes have been widely implemented over the past decade in Germany, it is estimated that less than 25% of onshore wind turbines in Germany may operate under any mitigation scheme (Fritze *et al.*, 2015). Furthermore, the efficacy of these mitigation schemes, particularly when being extrapolated from small to large wind turbines, has been recently criticized (Lindemann *et al.*, 2018). Accordingly, it is widely assumed that large numbers of bats are still getting killed at wind turbines in Germany and other countries (Voigt *et al.*, 2015 and Fritze *et al.*, 2019). Thus, the national goal for a complete shift to energy production from renewable sources (EEG17) as practiced in Germany may be in conflict with the national and international efforts to protect biodiversity. This so-called green–green dilemma appears to be an unsolved issue in the planning process and operation of wind turbines in Germany and likely also in other countries (Voigt, 2016).

Irrespective of legislations, climate protection, or biodiversity conservation goals, people have different views on the promotion of wind energy and on bat conservation, particularly of people who "hold a stake" in this green–green dilemma. Stakeholders may pursue different interest and come from different backgrounds; yet, they have to make decisions that impact the green–green dilemma. For some, the efforts in fighting climatic change or purely economic gains might be a worth-while goal; for others, it may be exclusively biodiversity conservation. Understanding the different views of stakeholders, which are involved in the management of nature related issues, is crucial for successful outcomes in societal conflict scenarios (Teel and Manfredo, 2010). Hence, surveys may help to identify different or similar viewpoints and details of a conflict. Further, they provide a starting point for discussions and negotiations that can lead in solutions. Twenty years after the start of the Energiewende, we considered it timely to see where stakeholders who are participating in the planning process of wind turbines stand in relation to environmental and biodiversity goals. Additionally, we aimed at fostering a discussion to better align conservation goals with climate goals. To achieve this, we conducted a self-administrated online survey to shed light on the opinions of stakeholders, specifically on members of nongovernmental organizations (NGO), members of the wind energy sector, members of conservation agencies, consultants, and researchers. We were particularly interested to investigate the stakeholder perspective on the (i) Importance of wind energy during the energy transition process in relation to protecting biodiversity, (ii) political measures to reconcile wind energy production and biodiversity conservation, and, specifically, (iii) practical steps to reconcile wind energy production and bat conservation. While we acknowledge that the wildlife-wind energy conflict involves all kinds of animal taxa, such as birds of prey, among others, we included nonetheless only bats in our survey and analysis. We used bats as a model because they profit from a high level of legal protection and they play a major role in the planning and development process of wind turbine projects, but they are still killed at large numbers at wind turbines. Hence, with this survey, we would like to present and discuss expert views on this situation. Finally, focusing on a single taxon helped us to deal with consistent stakeholder groups and thus consistent responses.

## II. MATERIALS AND METHODS

*Survey instrument:* We developed a self-administered questionnaire with 25 closed questions in relation to wind turbines and bat conservation (based on concepts such as value orientations, attitudes, and beliefs) and demographic data. Here, we report the results on questions related to (i) beliefs about the benefits of wind energy production as part of the Energiewende, i.e., the full transition from conventional energy production to energy production from renewable sources, (ii) beliefs about the economic and ecologically sustainable operation of wind turbines, and (iii) beliefs about the existence of a conflict between energy production from renewable sources, specifically wind energy production, and the protection of biodiversity, specifically bat conservation. Finally, we asked if this conflict is solvable and, if yes, what measures should be practiced to mitigate or solve it. We sent out the questionnaire via the online survey tool Lamapoll (https://app.lamapoll.de) to more than 1200 email-addresses, focusing on groups of stakeholders that participate in the environmental impact assessment during the planning process of wind turbines. We

identified the following stakeholders to be particularly relevant for the practical aspects in this green–green conflict: Consultants (with an expert focus on bat monitoring), members of conservation agencies, representatives of environmental NGO (mostly employees), volunteers of NGO, members or affiliates of the wind energy sector, and, finally, researchers working in the area of wind energy production or bat ecology. We were interested in those stakeholders because they are involved in conflict situations during the planning process of wind turbine projects. For example, members of wind energy sectors approach the local conservation agency to receive permits for constructing a wind park. The conservation agency is usually requesting the monitoring of bat activity at wind turbine sites (pre- and post-construction), which is then realized by consultants who are paid by the wind turbine industry. NGO may survey the process and might interfere via legal actions with the planning process when they consider that monitoring and implementation of mitigation schemes are insufficient. Accordingly, we also distinguished between those stakeholders who deal with the conflict issue as part of their profession (consultants, members, or affiliates of the wind energy sector, members of conservation agencies, or representatives of environmental NGO) or leisure time activity (volunteers of NGO). In particular, we were interested in, for example, how consistent responses were from employees and volunteers from NGO. While we did not ask the volunteers in our questionnaire to specify the NGO they are involved with, we assume that most volunteers are part of an environmental NGO. Respondents who did not fall into any of the aforementioned categories could self-report their category and were grouped as "diverse." Yet owing to the inherent problem of lumping across a large variety of self-reported categories, we excluded these respondents from the survey. Following the snowball sampling method (Bryman, 2008), we asked all recipients of our initial call to fill out the questionnaire and to forward the call to other potentially interested people.

Almost all the statements could be rated on a 7-point scale, where 1 corresponds to "completely disagree," 4 is related to "partly/partly," and 7 is related to "completely agree." For the reason of simplicity, we have subsumed response points 1 to 3 to one category "disagreement" and points 5 to 7 to one category "agreement." Besides the 7-point scale, we also offered dual choice options where appropriate. In our analyses, we only included respondents who finished the questionnaire from the first to the last question. However, since a response toward a specific question was not always mandatory, we did not receive responses to all questions from all participants. In these cases, we reported the number of respondents who answered a specific question by stating $n$ in brackets. Two sections included a set of statements from which participants could select. These sections focused on (i) beliefs about the benefits of wind energy production as part of the Energiewende and (ii) beliefs about the economic and ecologically sustainable operation of wind turbines. For the results of these sections, we calculated Cronbach's Alpha estimates. Cronbach's Alpha estimates show the internal consistency of responses on multi-item scales (Vaske *et al.*, 2017). Although we did not use an overall score for these sections of this manuscript, we still present Cronbach's Alpha here to get an understanding about the coherence of statements among each other (i.e., whether statements are related to each other or not). Since the questionnaire was in German, we will use the following translation of two terms widely used in German but without an adequate translation in English. First, we refer to the Energiewende, the full transition of energy production from conventional (fossil and nuclear sources) to renewable energy sources, to "energy transition." Second, we refer to the "naturverträgliche Energiewende" as the "ecologically sustainable energy transition," an energy transition that succeeds in reconciling the two environmental goals of fighting biodiversity loss and climate change. Finally, we used only descriptive statistics and not hypothesis-testing statistics, because the goal of our research was to present stakeholders' responses to our questions rather than drawing conclusions from statistical significance.

## III. RESULTS

In total, we received 537 responses (44.8% response rate), i.e., 537 participants filled out the questionnaire from the first to the last question and a larger number started the questionnaire but then discontinued at some stage. Nineteen per cent of respondents listed themselves as members of conservation authorities (n = 99), 16% as consultants (82), 15% as volunteers of an NGO (81), 11% as researchers (58), 10% as representatives of an NGO (53), and 4% as representatives of the wind energy sector (21). Twenty-five per cent of participants categorized themselves as "other" (129), and 14 participants did not respond to this question. Additionally, we asked about the geographical background in which participants were mostly active. Almost half of the respondents came from four federal countries in Germany: 13% (n = 65) from Brandenburg, 12% each from Baden-Wurttemberg (64) and Lower Saxony (60), and 11% (54) from Hesse. The other federal countries contributed as follows: North Rhine-Westphalia (40, 8%), Mecklenburg-West Pomerania (38, 7%), Bavaria (31, 6%), Thuringia (25, 5%), Rhineland-Palatinate (22, 4%), Schleswig-Holstein (21, 4%), Berlin (20, 4%), Saxony (17, 3%), Saxony-Anhalt (17, 3%), Hamburg (6, 1%), Bremen (2, 0.4%), and Saarland (2, 0.4%). Eight respondents were active in Austria (2%), 5 in Switzerland (1%), and 2 in the Netherlands (0.4%). Fourteen participants categorized themselves as having some other geographical background (3%).

### A. Evaluating the importance of wind energy in relation to biodiversity conservation

More than 95% of all participants (n = 519) responded to the question if an ecologically sustainable energy transition is important. The majority (90%, n = 493) considered this to be very or highly important. We further asked stakeholders to specify the level of priority that they would assign to wind energy production in relation to other sources of renewable energy. Volunteers (58%) and representatives of NGO (38%) were mostly disagreeing on the statement that wind energy production is key for the energy transition compared to the other stakeholder groups [all other < 23%; Fig. 1(a)]. All representatives of the wind energy sector strongly agreed with this statement (100%), whereas researchers and members of conservation authorities remained between the two extremes [Fig. 1(a)].

We observed similar patterns for answers regarding statements whether energy production from wind has to be more promoted than energy production from other renewable sources (solar, water, biogas, and geothermy). The majority of respondents from the wind energy sector (67%) agreed with this statement with only a small number disagreeing [14%, Fig. 1(b)]. The majority of participants from other stakeholder groups disagreed with the statement, with volunteers disagreeing the most (85%), followed by conservation authorities (76%) and employees of NGO [75%, Fig. 1(b)]. All stakeholder groups,

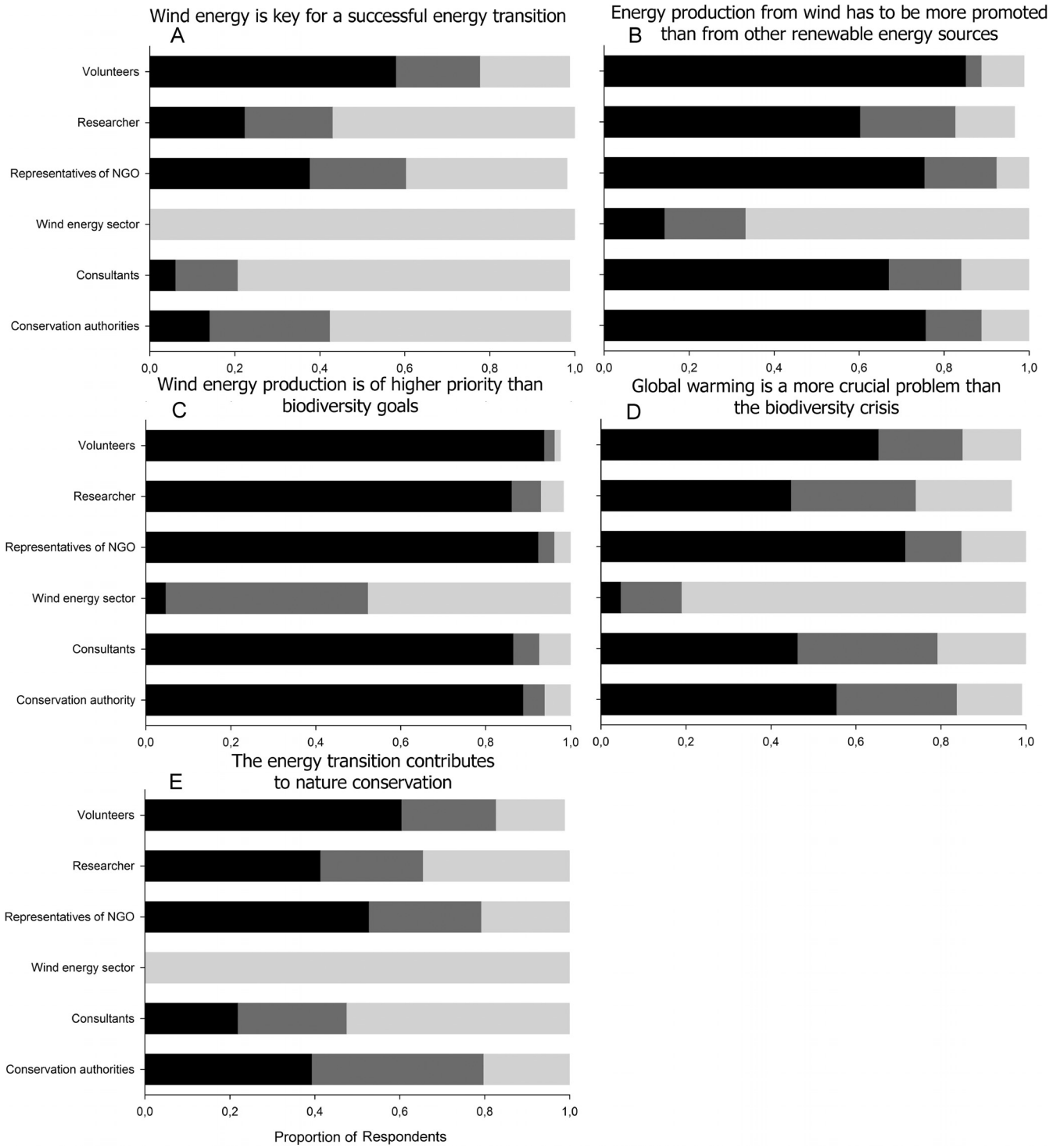


**FIG. 1.** Stakeholder specific evaluation of the statement: **(a)** "Wind energy production is key for a successful energy transition," **(b)** "energy production from wind has to be more promoted than from other renewable energy sources (solar, water, biogas, and geothermy)," **(c)** "Wind energy production is of higher priority than biodiversity goals," **(d)** "Global warming is a more crucial problem than the biodiversity crisis," and **(e)** statement "The energy transition contributes to nature conservation." Black bars indicate "No," dark gray bars "Undecided," and light gray bars "Yes." Note that in some stakeholder groups, not all participants responded, causing a deviation from 1.0 with respect to the proportion of respondents. All statements within this section showed a high internal reliability (Cronbach's Alpha.89), indicating that items were related to each other.

except for members of the wind energy sector, disagreed with the statement that "wind energy production is of higher priority than biodiversity goals" (at least >86% disagreement in 5 out of 6 stakeholder groups). While only a small fraction of the members of the wind energy sector objected this statement (4%), approximately half were undecided (48%) or agreed with that wind energy production is of higher priority than biodiversity goals [48%, Fig. 1(c)]. Additionally, we asked stakeholders if they would consider global warming to be a more crucial problem than the global biodiversity crisis. Here, we found similar patterns. Five out of 6 stakeholder groups, i.e., except members of the wind energy sector, disagreed with this statement [at least >45% disagreement in 5 out of 6 stakeholder groups, Fig. 1(d)]. The largest fraction of disagreeing respondents was observed in the groups of representatives (72%) and volunteers of NGO [65%, Fig. 1(d)]. Finally, we asked stakeholder groups whether they concur on the statement that the "Energy transition contributes to nature conservation." This statement was fully supported by members of the wind energy sector [100%, Fig. 1(e)]. However, other stakeholder groups showed a more diverse response to this statement. Again, employees of NGO (53%) and volunteers of NGO (60%) disagreed largely with this statement, whereas most consultants (52%) agreed with it. Researchers and members of conservation authorities ranked between the before mentioned groups [Fig. 1(e)].

### B. Evaluating political measures to reconcile wind energy production and biodiversity conservation

With the following statements, we targeted the political measures that may seem to be acceptable for stakeholders to reconcile the conflict between wind energy production and biodiversity conservation, with a particular focus on monetary aspects. The vast majority of all stakeholder groups agreed on the statement that more has to be invested into the development of measures to reconcile wind energy protection and biodiversity goals [>62% agreement in all stakeholder groups, Fig. 2(a)]. However, a third more of respondents in the group of volunteers of NGO (37%) and members of the wind energy sector (33%) disagreed on or were undecided about this statement [Fig. 2(a)].

Additionally, we asked if the society has to be included in paying for the implementation of conservation measures, specifically if tax money should be used for this purpose. We observed in almost all stakeholder groups that most participants agreed on this statement [Fig. 2(b)]. This statement received the strongest support from volunteers of NGO (63%) and researchers (66%) and the least from representatives of NGO (53%), member of the wind energy sector (52%), and members of conservation authorities [47%, Fig. 2(b)]. Additionally, we asked if economic losses from wind energy production have to be accepted to better consider biodiversity goals during wind energy production. All stakeholder groups, except for members of the wind energy sector agreed on this statement largely, with at least 88% support for the statement [Fig. 2(c)]. In contrast, about one third of the members of the wind energy sector disagreed on this statement (29%) and the majority (62%) was undecided [Fig. 2(c)]. As the last statement in this section, we asked if stakeholders would accept a delay in the development of wind energy production to account better for biodiversity goals. Most stakeholder groups, except for members of the wind energy sector, were in favor of this scenario [>79% agreement in all stakeholder groups, Fig. 2(d)]. Eighty-one per cent of members of the wind energy sector refuted this scenario, and the remaining 19% were undecided [Fig. 2(d)].

### C. Evaluating practical steps to reconcile wind energy production and bat conservation

Eighty-two per cent of responding participants (433 out of 527) acknowledged a conflict between bat conservation and the environmental goal to protect our climate. The majority of these respondents (89%, n = 418) considered this conflict solvable. Out of the offered predefined answers, the following three received most support across all respondents, irrespective of the stakeholder membership: (1) more research to reconcile wind energy production and conservation goals (67.5% of respondents), (2) improved energy efficiency (61.4%), and (3) context dependent cut-in speeds in the operation of wind turbines (61.4%; Table I). Stakeholders offered least support (<10% of respondents) for the suggestion to weaken the legal protection of biodiversity (1.9%; Table I).

A more detailed view on the stakeholder specific responses reveals that all stakeholder groups gave strong support to more research in the area of wind energy production and conservation and an improved energy efficiency, i.e., measures to reduce the consumption of energy (e.g., via improved insulation). The affiliates and members of the wind energy sector did not support more energy production from solar power and other renewable sources, a full stop in the further development of the wind energy sector and a stronger legal protection of biodiversity, contrasting with all other stakeholder groups. Also, affiliates and members of the wind energy sector did not support an improved involvement of stakeholders during the development of wind turbine projects. All stakeholder groups did not support the suggestion to weaken the legal protection of biodiversity; instead, many favored a stronger legal protection of biodiversity. Context dependent cut-in speeds in the operation of wind turbines combined with a continuous monitoring scheme was strongly supported by stakeholder groups, similar to an increased use of energy production from solar power and other renewable energy sources, except for affiliates and members of the wind energy sectors that did not support the idea to look into other renewable energy sources besides wind energy.

## IV. DISCUSSION

Conflicts arise from contrasting interest, perspectives, and evaluations of issues. Understanding the diversity of views on a highly disputed topic is a starting point for an improved discussion aiming at mitigating or even solving the conflict. We used an online based survey to compare the stakeholder views on wind energy production in relation to biodiversity goals, specifically bat conservation. In Germany and other countries, the spread of wind turbines over recent decades has caused manifold conflicts, particularly in relation to needs formulated by humans, e.g., landscape changes, and complaints about nuisance associated with the construction and operation of wind turbines (van den Berg, 2004 and van Grieken and Dower 2017), in relation to wildlife fatalities (Voigt *et al.*, 2015). To solve the green–green dilemma, the conflict between the environmental goal of fighting global climatic changes (e.g., via the promotion of wind energy production) and conservation goals to combat the biodiversity crisis (e.g., via the protection of endangered and legally protected bats) is of central importance to achieve a full transition from conventional to

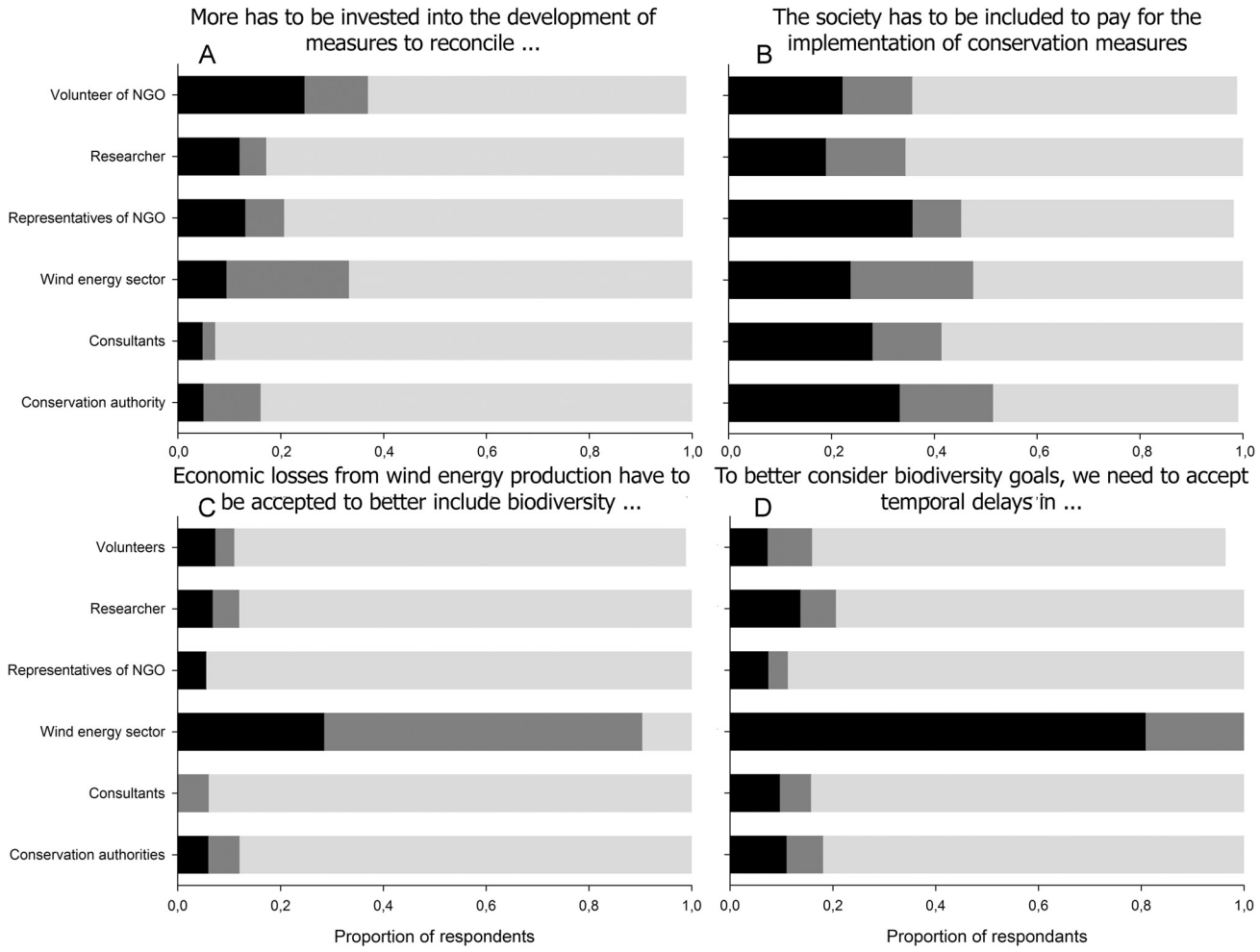


**FIG. 2.** Stakeholder specific evaluation of the statement **(a)** "More has to be invested into the development of measures to reconcile wind energy protection and biodiversity goals," **(b)** "The society has to be included to pay for the implementation of conservation measures, e.g., for supporting conservation projects by tax money," **(c)** "Economic losses from wind energy production have to be accepted in order to better include biodiversity goals," **(d)** "To better consider biodiversity goals, we need to accept temporal delays in the further development of wind energy production." Black bars indicate "No," dark gray bars "Undecided," and light gray bars "Yes." Note that in some stakeholder groups, not all participants responded, causing a deviation from 1.0 with respect to the proportion of respondents. All statements within this section showed a low internal reliability (Cronbach's Alpha.55), indicating that items were not strongly related to each other).

renewable energy sources under full consideration of conservation goals (Jackson, 2011 and Gasparatos *et al.*, 2017).

### A. Importance of wind energy for the energy transition in relation to biodiversity conservation

The majority of stakeholder groups, except for volunteers and representatives of NGO, recognized wind energy production as a key component of the transitional process toward a renewable energy production. We assume that disagreeing respondents see other renewable energy sources, such as energy production from solar power, disadvantage compared to wind energy production. This notion receives support from responses to the subsequent question in which we asked about the attitudes toward the statement "Energy production from wind has to be promoted more than from any other renewable energy source (solar, water, biogas, and geothermy)." A relatively high proportion of participants, except members of the wind energy sector, disagreed with this statement (Fig. 2). This contrast is not surprising since members of the wind energy sector may intrinsically favor wind energy production because of economic interest. Alternatively, they might consider wind energy production as the most efficient way to reduce global $CO_2$ emission. Currently wind energy production benefits strongest from governmental subsidies compared to other promoted sources of renewable energy in Germany, such as solar, water, biogas, and geothermy. Yet, promotion of renewable energy sources other than wind energy might be a way to mitigate the conflict between wind energy and bat conservation (Walter *et al.*, 2018).

Most stakeholder groups, with the exception of members of the wind energy sector, do not grant wind energy production a higher priority than the conservation of biodiversity or to judge global warming

**TABLE I.** Relative proportion of participants (%) within stakeholder groups and among all respondents in support of specific measures to reconcile the conflict between wind power production and bat conservation. The suggested measures were sorted according to the rank received from all respondents (left column). The highest and lowest ranks are highlighted for each stakeholder group in bold. Several options could be selected; hence, responses do not sum up to 100%.

| Suggested measure | Conservation authorities | Volunteers of NGO | Consultants | Wind energy sector | Representatives of NGO | Researcher | All respondents |
|---|---|---|---|---|---|---|---|
| More research in the area of wind energy production and conservation | **73** | 41 | **80** | **43** | 55 | **69** | **68** |
| Improved energy efficiency | 62 | **54** | 51 | 29 | **66** | 60 | 61 |
| Context dependent cut-in speeds in the operation of wind turbine | 71 | 47 | 74 | 29 | 45 | 64 | 61 |
| More energy production from solar power and other renewable energy sources | 59 | 49 | 41 | 0 | 60 | 45 | 53 |
| A stronger legal basis for biodiversity protection | 35 | 52 | 38 | 0 | 62 | 48 | 50 |
| More communication among stakeholder groups | 48 | 36 | 61 | 33 | 38 | 59 | 50 |
| More compensatory measures for bats | 46 | 30 | 40 | 33 | 36 | 41 | 43 |
| Improved inclusion of stakeholders | 21 | 37 | 43 | 5 | 40 | 45 | 37 |
| Improved financial approaches | 30 | 30 | 40 | 24 | 25 | 38 | 34 |
| Full stop in the further development of the wind energy sector | 15 | 51 | 2 | **0** | 26 | 29 | 32 |
| General implementation of cut-in speeds for the protection of bats | 41 | 20 | 38 | 5 | 28 | 29 | 31 |
| Repelling bats from wind turbines | 20 | 6 | 17 | 14 | 11 | 17 | 16 |
| More energy production from nuclear sources | 5 | 19 | 2 | **0** | 11 | 16 | 15 |
| More energy production from fossil fuels | **2** | 6 | **0** | **0** | 9 | **3** | 6 |
| Weakened legal protection of biodiversity | 3 | **1** | **0** | 5 | **0** | 5 | **2** |

as a more crucial problem than the biodiversity crisis. This overall support of biodiversity goals within this green–green dilemma may reflect the general opinion of stakeholders, and likely also of the German society, that biodiversity goals should not be overseen in the fight against climatic changes. This is echoed in a similar study from Switzerland, where experts formulate concerns about the production of wind energy in alpine regions (Grilli *et al.*, 2016). Indeed, consideration of both goals seems to be mandatory from a legal point of view since legislation, treaties, and conventions in both directions have been formulated, signed, and ratified. For example, Germany is committed to follow two UN conventions, the convention for the conservation of biodiversity (CBD), and the convention on climatic changes (UNFCCC), signed by 195 nations worldwide. However, recent political decision in Germany aimed at softening the legal protection of wildlife species in the national law (Lukas, 2017; Lütkes, 2018) to facilitate and fasten the planning process for erecting and operating wind turbines (BMU, 2017). From a scientific point of view, both environmental threats are urgent (Rockström *et al.*, 2005), and efforts have to be improved fundamentally both on the national and international scale. In our survey, the response patterns toward the statement if "Global warming is a more crucial problem than the biodiversity crisis" were similar to the previous questions. In contrast to the wind energy sector, all other stakeholders mostly disagreed with this statement, showing that the majority of stakeholder groups perceive the biodiversity crisis at least as important or even more important than the climate crisis. It is important to note here that the number of participants from the wind energy sector responding to this question was small and that the overall pattern might change after including more feedback from members of the wind energy sector. Possibly, the recognition of the biodiversity crisis in the German society may have arisen from the recent discussion about the dramatic, continuous decline of insect diversity in even protected areas in Germany (Hallmann *et al.*, 2017). The majority of stakeholders also agreed that "The energy transition contributes to biodiversity goals." Most likely, the majority of respondents acknowledge that global warming has a negative impact on biodiversity as well (Bellard *et al.*, 2012), that the extraction of fossil fuels devours entire landscapes (Donahue, 2018), and that nuclear energy harbors significant risks during the operation of nuclear power plants and also during the long-term storage of nuclear waste with unforeseen large-scale negative effects on biodiversity (Møller *et al.*, 2013; Mousseau and Møller, 2011).

### *1. Political Measures to reconcile wind energy production and biodiversity conservation*

Stakeholder groups agree on the importance of the transition process in achieving a complete shift to renewable energy production; yet, stakeholders also agree that more has to be invested into reconciling wind energy production and the protection of biodiversity. More than half of all respondents favored the idea that the society should be

included to pay to reconcile these two goals. Additionally, the majority of stakeholders (except members of the wind energy sectors) supported the idea that economic losses from wind energy production and time delays during the further development of wind energy production in Germany have to be accepted in order to account for an improved protection of biodiversity. The lack of support for these two suggested measures from members of the wind energy sectors is most likely related to the intrinsic monetary disadvantages associated with these measures. For example, curtailment measures such as shutdown algorithms or turbine speed reduction during periods of high bat activity are the most effective ways to avoid bat fatalities at wind turbines; yet, these measures reduce the output of generated electricity from wind turbines. These economic losses have been estimated to amount about 1%–2% of the total energy output of wind turbines per year (Arnett *et al.*, 2011). Further, slowing down the process of wind turbine installation in Germany might lead to financial problems for companies involved in the planning, installation, and operation phases of wind turbines. Particularly, economic losses may hit wind energy companies when more detailed and long-term environmental impact assessments may cause significant delays in the final operation of wind turbines. However, considering the fact that large numbers of bats are still getting killed each year in Germany, experts and conservationists insist on applying these mitigation schemes at all wind turbines, particularly since they have been documented to be effective (Fritze *et al.*, 2019 and Lindemann *et al.*, 2018). This attitude is also apparent in the overall support for the suggested solutions for reconciling the conflict between wind power production and biodiversity goals (Table I) in which "context dependent cut-in speeds in the operation of the wind turbine (continuous adjustment based on automated acoustic monitoring)" were in the top three ranks of the suggested practical steps.

## V. CONCLUSION

We observed both strong discrepancies and also close agreements across stakeholder groups with respect to questions about the relative importance of wind energy production in relation to biodiversity conservation, the political measures to reconcile wind energy production and biodiversity conservation, and, specifically, practical steps to reconcile wind energy production and bat conservation. Most noticeably, we observed contrasting evaluations of issues between members of the wind energy sector and all other groups, including consultants, members of authorities, researchers, and conservationists. Wind energy representatives strongly believe that the generation of energy from wind turbines is more important and more urgent compared to the protection of biodiversity. Other participants judged wind energy production as an important factor but are nevertheless more concerned about issues related to biodiversity losses. We consider the results of our questionnaire as a call for more promotion of biodiversity protection, particularly for more bat conservation during the further expansion of wind energy production in Germany and also in other countries. The vast majority of participants favored an ecologically sustainable energy transition that puts equal weight on the conservation of wildlife and on the promotion of renewable energy production. Hence, ignoring these concerns may hinder effective collaborations and agreements among stakeholders who are participating in the environmental planning process in finding solutions for an ecologically sustainable energy transition.

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