Policy Brief
D4.4
July 2018

Addressing social implications of climate change mitigation: lessons from three novel technologies

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This Policy Brief is based on a Working Document by Janneke Hagens, Zahar Koretsky and Roeland Toemen (Radboud University)

The CARISMA Project started in February 2015 and received funding from the European Horizon 2020 programme of the EU under the Grant Agreement No. 642242. CARISMA intends, through effective stakeholder consultation and communication, to ensure a continuous coordination and assessment of climate change mitigation options and to benefit research and innovation efficiency, as well as international cooperation on research and innovation and technology transfer.

Summary

This policy brief sheds light on the question of what social implications climate technologies might have and how fear of and opposition to those implications are voiced by different stakeholder groups, and gives recommendations on how to respond. Findings from studies on bio-energy and carbon dioxide capture and storage (BECCS), direct air capture of CO2 (DAC) and smart grids are brought together. Inclusiveness and openness are needed to avoid 'one-size fits all' approaches which might be challenged by communities affected by climate technologies, and to identify much-needed opportunities and co-benefits of mitigation technologies.

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Radboud Universiteit
University of Piraeus Research Center
JIN Climate and Sustainability
Wegener Center
UNI GRAZ
ZEW Zentrum für Europäische Wirtschaftsforschung GmbH
SEI Stockholm Environment Institute
CEPS Centre for European Policy Studies
UNEP DTU Partnership
I4CE Institute for Climate Economics
ENVIROS

1 Introduction

The Paris Agreement, adopted in December 2015, has the objective to limit global temperature rise to well below 2°C, and strive for limiting it to 1.5°C above pre-industrial levels. This effort will succeed only if low carbon technologies are rapidly deployed, especially since current efforts are insufficient to close the emissions gap (UNEP, 2017).

However, implementing those climate technologies[1] is not a straight-forward matter. A multitude of environmental, economic and social factors have to be considered in order to make technologies work towards the Paris Agreement's objectives in particular and the overall sustainable development goals enshrined in the SDGs in general. And while there is a plethora of economic studies out there on the costs of climate change mitigation (often with quite speculative results, see Rosen and Guenther, 2015), studies on social impacts[2] of those climate technologies are more sparse. Understanding such social implications is, however, of great importance since opposition to climate technologies (thus slowing down mitigation action) can come in many forms and is seldomly based solely on environmental or economic arguments.

Climate technologies thought of by one stakeholder group as promising in terms of emissions reduction potential could be opposed by another group of stakeholders based on social impact arguments such as perceived health or employment risks (Wallquist et al., 2012), thus hindering implementation.

This policy brief sheds light on the question of what social implications climate technologies might have and how fear of and opposition to those implications are voiced by different stakeholder groups. However, rather than offering a complete overview, which has been done by others, this brief aims to bring overlooked issues to the fore.

In particular, our contribution comprises a more inclusive and participatory assessment of climate technologies and an 'opening up' (Stirling, 2008) to different viewponts on climate technologies and their effect. We argue that inclusiveness and openness are needed to avoid 'one-size fits all' approaches which might be challenged by communities affected by climate technologies, and to identify much-needed opportunities and co-benefits of mitigation technologies. In such a way, the eventual portfolio of mitigation technologies will be closer to the social optimium and the road to climate change mitigation could be made less bumpy.

2 Climate technologies: a complex field

The adoption of the Paris Agreement in 2015 was a historic moment for international climate change governance bringing almost all nations on board to fight global climate change. It is mostly up to signatories to choose their policies and actions to do their share

[1] We will use the terms climate technologies and climate mitigation technologies interchangeably
[2] We understand social impacts as those that directly impact the physical and emotional well-being of communities affected by climate technologies, see (Gasper et al., 2011),

to meet the agreements' goals (Asselt and Bößner, 2016). However, several studies show that current efforts are not enough to meet those objectives (e.g., Rockström et al., 2017) and that there is still a wide 'emissions gap' between what should be done and what is being done (UNEP, 2017). For that reason, technologies to mitigate global climate change have to be deployed rapidly (Rockström et al., 2017). But this is easier in theory than in practice.

2.1 The complexity factor

Climate Change is often referred to as 'super wicked problem' largely because of its complexity and its time pressed nature, and because authority to address the problem is weak (Levin et al., 2012). Technologies to mitigate climate change exist but they all vary in costs and effectiveness and the Paris Agreement clearly recognizes that parties may be affected not only by climate change but also by 'measures taken in response to it' (UNFCCC, 2015), i.e. by impacts of climate technologies. Moreover, what is to be called effectiveness is not an objective criterion and different stakeholder groups might have diverging views on what makes a technology effective. For example, an environmentally successful technology could be effective from an emissions perspective (i.e. it can lower emissions significantly) while the same technology could have negative consequences for a society or a local community (health risks, economic risks, perceived injustice) leading to conflicts between stakeholder groups. What is more, not everyone will benefit equally from the implementation of a certain climate technology which could enhance the opposition of one stakeholder group to a specific technology. Those factors make the implementation of the Paris Agreement a complex undertaking and implementing those technologies does not lend itself to a straight-forward and rapid decision making process or a 'one size fits all' approach. On the contrary, contexts matter and what is good and accepted in one case might not be in another.

But while the economic and environmental impacts of technologies are more or less well researched, social impacts of technologies are not as well understood, nor how to best respond to emerging resistance or scepticism. However, those social impacts are often the root cause of opposition to climate mitigation projects, particularly from a community acceptance perspective (Wüstenhagen et al., 2007). Local communities oppose climate projects in their vicinity on many grounds, often only remotely related to economic and environmental issues. It is therefore vital to understand those social impacts better in order to overcome opposition and to facilitate acceptance of climate technologies and therefore paving the way for a swift deployment of climate technologies so urgently needed (Rockström et al., 2017).

2.2 Embracing complexity and diverging views

However, this should not mean that underlying complexities should be necessarily reduced and opposition to climate technologies should be neutralised. On the contrary, we argue that an 'opening-up approach' (Stirling, 2008) to technology assessment and planning may hold benefits for climate mitigation technologies. By including marginalised and neglected issues and voices and by 'embracing' controversy around technologies (Cuppen, 2018), social acceptance of climate technologies is likely to increase. Also, deadlocks might be avoided if impacted local communities' concerns are heard and taken seriously. This comprehensive approach which accepts and leverages complexity is likely to lead, ultimately, to stronger climate policies and quicker implementation because of increased social acceptance and decreased opposition.

Moreover, our case studies have shown that including a wider analysis of social impacts of certain technologies and taking into consideration a plurality of voices might lead to the identification of several hidden risks but also hidden co-benefits and opportunities. Those risks and opportunities might have not come to the fore by focusing strictly on economic and environmental benefits in a top down manner. Ultimately, understanding complexity and diverging viewpoints and taking them into honest consideration when engaging with stakeholders 'on the ground' affected by climate technologies is expected to increase social acceptance of climate technologies.

The following chapter presents, based on a more extensive working paper (Hagens et al 2018), some findings of three case studies and shows, how social factors and impacts have influenced and can impact climate technologies and their uptake. The three technologies discussed are bioenergy used with carbon capture and storage (BECCS), direct air capture (DAC) technology illustrated by the artificial tree concept and the somewhat less experimental technology of smart-grids.

3 Case study results: social impacts of climate technologies

3.1 Bioenergy and carbon capture and storage (BECCS)

Some scientists argue that meeting the Paris Agreement's objectives is likely not to be achieved without removing carbon from the atmosphere in addition to produce, distribute and consume energy generated without the emission of greenhouse gases (Rockström et al., 2017). Carbon Dioxide Removal (CDR) plays an important part in many of the mitigation scenarios in the IPCC's 5^{th} assessment report (IPCC, 2014).

The technology of carbon dioxide capture and geological storage (CCS) emerged during the 1970s and has, since the middle of the 1990s, been applied in a limited number of large-scale, fossil fuel-based industrial plants to prevent the emission of produced CO_2 to the atmosphere. While some argue that CCS would delay mitigation action and uphold certain carbon-intensive pathways (Stephens Jennie C., 2014), many mainstream researchers and institutions argue that it can play an important role in the efforts to meet the Paris Agreement's objectives (IPCC 2014; IEA 2017). So far, CCS has not lived up to the expectations with CCS projects on a variety of large-scale, stationary CO_2 point sources currently storing only 40 $MtCO_2$ annually. Main barriers are the unfavourable economics of CCS compared to incumbent technology, as well as a lack of political support and social acceptance.

Since a few years, the combination of CCS with bioenergy (under the name BECCS) has emerged in the debate. Applying CCS to bioenergy installations means that energy is produced with 'negative' emissions since the carbon sequestered in plants through photosynthesis is not released back into the atmosphere, but is captured and stored, thus leading to net negative emissions (Pour et al., 2017). While some argue that BECCS might face less public scepticism than fossil-based CCS because of the renewable source of the fuel and the potentially positive climate effects, others argue that the controversy around biomass and the scepticism to CCS will lead to greater resistance (Biofuelwatch, 2012).

Literature reveals that social impacts, in particular land-use issues where biomass for energy production might compete with food crops, might materialise with BECCS (Beringer et al., 2011; Miyake et al., 2012). Equity issues also might play a role, for example when those producing the feedstock for bioenergy plants are potentially not the ones who are benefiting from its use in power or fuel generation (Dooley and Kartha, 2017).

Case studies on fossil-fuelled CCS projects have shown that trust in institutions and perceived risks to health and safety have been important factors in opposition to proposed CCS sites. In case studies in the Netherlands, project implementing stakeholders such as policymakers and project developers were seen as untrustworthy and lacking integrity, and as pursuing only their own interests in an unfair manner (Terwel et al., 2012). Moreover, perceived health risks as a consequence of leaking CO_2 or safety risks from potential earthquakes have led to opposition in the UK (Shackley et al., 2004). These factors have even led to the cancellation of projects (Terwel et al., 2012).

Interestingly, this opposition to CCS sometimes seems to be rooted in misconceptions about the technology such as an exaggerated risk perception (Wallquist et al., 2012). But while some studies suggest that acceptance increases if CCS technology is to be applied to renewable energy projects such as biomass (Pietzner et al., 2011; Wallquist et al., 2012), BECCS will not automatically face less opposition, particularly since environmental NGOs have become vocal in their opposition even to bioenergy projects (Scheer and Renn, 2014)).

Safety concerns and low trust in institutions can lead to what is often summarised as a 'not in my backyard' attitude, which can lead to mounting local opposition which can delay or even cancel projects, as seen in many parts of Europe (Oltra et al., 2012). Interestingly, this NIMBY attitude oftentimes co-exists with overall support of renewable energy. This is illustrated by a case study in the UK where over 80% of people supported wind energy in general but locally onshore projects have been slow to take off due to opposition (Bell et al., 2005).

The emergent debate on BECCS would benefit from an opening up of the currently polarised debate. An open conversation on the merits and drawbacks, the conditions under which BECCS might work favourably for both climate change mitigation and sustainable land use, and building of trust in the institutions that need to regulate the responsible implementation of BECCS, if any, would be a useful starting point.

3.2 Direct Air Capture (DAC): Artificial Trees

Another example of CDR is the concept of 'Direct Air Capture' (DAC), or artificial trees as suggested by (Lackner et al., 2012). The latter name builds on the technology's potential to look like real trees. And, like trees, the installations would sequester CO_2 from the atmosphere. DAC could potentially be subject to the same attitudes of NIMBY as wind power or CCS, given the potential large size of air capture projects and the need for a geological storage reservoir, but since the location does not much matter (except for the proximity of a suitable storage site), local concerns might be limited or could be avoided by selecting locations far away from inhabited places.

Our analysis of stakeholder views on artificial trees confirmed earlier findings that how the technology is framed can have significant impacts on public acceptance. Lessons from BECCS already showed that framing CCS as renewable energy (when combined with bioenergy) affects public acceptance (Wallquist et al., 2012). Framing, in this context, is understood as the use of symbols and language to link information about certain phenomena (and technologies) to pre-existing values and ideas of people (Mallett et al., 2018).

Framing DAC as geoengineering (The Royal Society, 2009), which generally comprises several large-scale technological propositions to artificially modify the Earth's radiative balance or atmospheric composition to address climate change, would decrease technology acceptance given the significant opposition potential, particularly compared to "conventional" mitigation (Scheer and Renn, 2014). This framing probably does not weigh up against the fact that studies have shown that when natural analogies are employed (such as trees), geo-engineering can become more acceptable to the general public (Corner and Pidgeon, 2015).

However, our analysis of online commentaries also showed that framing DAC technology as artificial trees did not provoke positive associations. It prompted cynical and opposing reactions in a variety of online outlets. The sobering conclusion is that it is not a given that a natural frame generates the desired reactions as some frames might give the desired response.

In general, influencing public opinion by suggesting a frame by industry or researchers might backfire. Also in the case of DAC, an open conversation could help in clarifying opportunities and challenges.

3.3 Smart grids

While our analysis of BECCS and DAC technologies focused on the (often negative) views of affected and impacted communities, our analysis of the smart-grid innovation system focused more on the opinions and viewpoints of the expert and practitioner community. While those views might display a certain 'techno optimism', we wanted to explore how smart grids could have positive impacts on implementing communities.

Smart grids have become indispensable for increased renewables uptake on the grid as they offer flexibility and energy savings potential (Erlinghagen and Markard, 2012), allowing customers to become more involved in the energy transition as 'pro-sumers' (Zafar et al., 2018) who react to price signals thus balancing supply or production with demand (Rauf et al., 2016). In addition, our comprehensive literature and media review[3] revealed several other benefits and opportunities such as community empowerment, increasing the reliability of electricity supply, reduced energy costs as well as an opportunity to collective learning and community building.

However, smart grids were not free from criticism as several interviewees brought risks such as privacy and security concerns to the fore as well as equity issues if those who pay for the infrastructure are not the same who are going to benefit from it. Moreover, while some sources saw smart grids as increasing the autonomy of users, some sources feared the loss of autonomy vis-à-vis energy providers.

These opportunities and risks were broadly confirmed by our engagement with practitioners and experts in the smart grid sector who also put co-benefits to the fore such as community building and learning opportunities besides the technical advantages of increasing grid flexibility and decreasing costs. This illustrates how a technology developed to perform a specific engineering function might contain several 'hidden' opportunities which are not instantly apparent if one does not take into account social impacts in the policy planning process.

4 Key lessons learnt and way forward

Our case studies and literature reviews have shown that different stakeholder groups may assess and evaluate one and the same climate technology differently. This also rings true for large-scale and novel climate technologies. How a technology is viewed depends less on the technology itself than on understanding, trust in institutions and the alignment of interests between stakeholders.

In order to bring any opposing views together for more constructive policymaking and project implementation, it is vital to go beyond economic and environmental calculations and to take into consideration social impacts of technologies on local communities.

Moreover, climate technologies are highly contextual, meaning that an approach and circumstances which worked in favour of a certain technology in one place might not work in another. It is therefore important to avoid 'one-size fits all' approaches and to take into consideration local specificities.

When doing so, issues such as trust and transparency are of utmost importance as opposition to climate technologies can be vocal and obstructive if actions of and stakeholders are not perceived as honest and trustworthy and underlying interests are not communicated clearly. Moreover, issues such as equity should be taken into consideration.

[3] See Annex II of Fujiwara et al. (2017).

Trying to frame issues differently might lead to increasing acceptance of climate technologies, but this might have unintended consequences and might even backfire if the framing is perceived as dishonest.

Here, opening up the technologies and their assessment to a plurality of opinions and viewpoints is vital in order to facilitate their acceptance. While resistance to a technology might not be based on science, it reflects real concerns. Opposition can lead to the abandonment of climate-relevant projects. Therefore, taking concerns seriously and providing space for honest discussions by embracing complexity instead of trying to level it might be a promising way forward. Local, bottom-up voices need to be assigned legitimacy.

This is compounded by the finding that having an open discussion and accepting local voices as genuine sources of information could help to identify hidden opportunities and co-benefits (as well as risks) which would have possibly remained hidden if a top-down implementation process had been chosen with little regard to local opinions.

Ultimately, taking all those lessons learnt into consideration and engaging in a transparent and open-minded manner with affected stakeholders frequently while planning and implementing any project is a pre-condition for the project's acceptance by all stakeholders and thus for strengthening climate action.

References

Asselt, H. van, Bößner, S., 2016. The Paris Agreement: Rebooting Climate Cooperation · The Shape of Things to Come: Global Climate Governance after Paris. Carbon Clim. Law Rev. 10, 46–61.

Bell, D., Gray, T., Haggett, C., 2005. The 'Social Gap' in Wind Farm Siting Decisions: Explanations and Policy Responses. Environ. Polit. 14, 460–477. https://doi.org/10.1080/09644010500175833

Beringer, T., Lucht, W., Schaphoff, S., 2011. Bioenergy production potential of global biomass plantations under environmental and agricultural constraints. GCB Bioenergy 3, 299–312. https://doi.org/10.1111/j.1757-1707.2010.01088.x

Biofuelwatch, 2012. BECCS (Bioenergy with Carbon Capture and Storage): Climate saviour or dangerous hype? By Rachel Smolker and Almuth Ernsting. Availalble on http://www.biofuelwatch.org.uk/files/BECCS-report.pdf (July 2018)

Corner, A., Pidgeon, N., 2015. Like artificial trees? The effect of framing by natural analogy on public perceptions of geoengineering. Clim. Change 130, 425–438. https://doi.org/10.1007/s10584-014-1148-6

Cuppen, E., 2018. The value of social conflicts. Critiquing invited participation in energy projects. Energy Res. Soc. Sci. 38, 28–32. https://doi.org/10.1016/j.erss.2018.01.016

Dooley, K., Kartha, S., 2017. Land-based negative emissions: risks for climate mitigation and impacts on sustainable development. Int. Environ. Agreem. Polit. Law Econ. 1–20. https://doi.org/10.1007/s10784-017-9382-9

Erlinghagen, S., Markard, J., 2012. Smart grids and the transformation of the electricity sector: ICT firms as potential catalysts for sectoral change. Energy Policy, Renewable Energy in China 51, 895–906. https://doi.org/10.1016/j.enpol.2012.09.045

Fujiwara, Noriko, Keith Williges, Andreas Tuerk and others (2017). D6.3: Report on the knowledge gaps about key contextual factors. CARISMA project: http://carisma-project.eu/Portals/0/D6.3%20Report%20on%20the%20knowledge%20gaps%20about%20key%20contextual%20factors.pdf (July 2018).

Gasper, R., Blohm, A., Ruth, M., 2011. Social and economic impacts of climate change on the urban environment. Curr. Opin. Environ. Sustain. 3, 150–157. https://doi.org/10.1016/j.cosust.2010.12.009

Hagens, Janneke, Zahar Koretsky, Roeland Toemen (2018). Social implications of climate change technologies. CARISMA working document: July 2018: www.carisma-project.eu.

IEA 2017: Energy Technology Perspectives. OECD/IEA: Paris, France.

IPCC, 2014. Technical Summary, in: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T., Minx, J.C. (Eds.), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York.

Lackner, K.S., Brennan, S., Matter, J.M., Park, A.-H.A., Wright, A., Zwaan, B. van der, 2012. The urgency of the development of CO2 capture from ambient air. Proc. Natl. Acad. Sci. 201108765. https://doi.org/10.1073/pnas.1108765109

Levin, K., Cashore, B., Bernstein, S., Auld, G., 2012. Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. Policy Sci. 45, 123–152. https://doi.org/10.1007/s11077-012-9151-0

Mallett, A., Jegen, M., Philion, X.D., Reiber, R., Rosenbloom, D., 2018. Smart grid framing through coverage in the Canadian media: Technologies coupled with experiences. Renew. Sustain. Energy Rev. 82, 1952–1960. https://doi.org/10.1016/j.rser.2017.06.013

Miyake, S., Renouf, M., Peterson, A., McAlpine, C., Smith, C., 2012. Land-use and environmental pressures resulting from current and future bioenergy crop expansion: A review. J. Rural Stud., Growing Old in Rural Places 28, 650–658. https://doi.org/10.1016/j.jrurstud.2012.09.002

Oltra, C., Upham, P., Riesch, H., Boso, À., Brunsting, S., Dütschke, E., Lis, A., 2012. Public Responses to Co $_2$ Storage Sites: Lessons from Five European Cases. Energy Environ. 23, 227–248. https://doi.org/10.1260/0958-305X.23.2-3.227

Pietzner, K., Schumann, D., Tvedt, S.D., Torvatn, H.Y., Næss, R., Reiner, D.M., Anghel, S., Cismaru, D., Constantin, C., Daamen, D.D.L., Dudu, A., Esken, A., Gemeni, V., Ivan, L., Koukouzas, N., Kristiansen, G., Markos, A., ter Mors, E., Nihfidov, O.C., Papadimitriou, J., Samoila, I.R., Sava, C.S., Stephenson, M.H., Terwel, B.W., Tomescu, C.E., Ziogou, F., 2011. Public awareness and perceptions of carbon dioxide capture and storage (CCS): Insights from surveys administered to representative samples in six European countries. Energy Procedia 4, 6300–6306. https://doi.org/10.1016/j.egypro.2011.02.645

Pour, N., Webley, P.A., Cook, P.J., 2017. A Sustainability Framework for Bioenergy with Carbon Capture and Storage (BECCS) Technologies. Energy Procedia, 13th International Conference on Greenhouse Gas Control Technologies, GHGT-13, 14-18 November 2016, Lausanne, Switzerland 114, 6044–6056. https://doi.org/10.1016/j.egypro.2017.03.1741

Rauf, S., Rasool, S., Rizwan, M., Yousaf, M., Khan, N., 2016. Domestic Electrical Load Management Using Smart Grid. Energy Procedia, 3rd International Conference on Power and Energy Systems Engineering, CPESE 2016, 8-10 September 2016, Kitakyushu, Japan 100, 253–260. https://doi.org/10.1016/j.egypro.2016.10.174

Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic, N., Schellnhuber, H.J., 2017. A roadmap for rapid decarbonization. Science 355, 1269–1271. https://doi.org/10.1126/science.aah3443

Rosen, R.A., Guenther, E., 2015. The economics of mitigating climate change: What can we know? Technol. Forecast. Soc. Change 91, 93–106. https://doi.org/10.1016/j.techfore.2014.01.013

Scheer, D., Renn, O., 2014. Public Perception of geoengineering and its consequences for public debate. Clim. Change 125, 305–318. https://doi.org/10.1007/s10584-014-1177-1

Shackley, S., McLachlan, C., Gough, C., 2004. The public perception of carbon dioxide capture and storage in the UK: results from focus groups and a survey. Clim. Policy 4, 377–398. https://doi.org/10.1080/14693062.2004.9685532

Stephens Jennie C., 2014. Time to stop investing in carbon capture and storage and reduce government subsidies of fossil-fuels. Wiley Interdiscip. Rev. Clim. Change 5, 169–173. https://doi.org/10.1002/wcc.266

Stirling, A., 2008. "Opening Up" and "Closing Down": Power, Participation, and Pluralism in the Social Appraisal of Technology. Sci. Technol. Hum. Values 33, 262–294. https://doi.org/10.1177/0162243907311265

Terwel, B.W., ter Mors, E., Daamen, D.D.L., 2012. It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. Int. J. Greenh. Gas Control 9, 41–51. https://doi.org/10.1016/j.ijggc.2012.02.017

The Royal Society, 2009. Geoengineering the climate: science, governance and uncertainty. The Royal Society, London.

UNEP, 2017. The Emissions Gap Report 2017. United Nations Environment Programme.

UNFCCC, 2015. Paris Agreement (No. FCCC/CP/2015/10/Add.1). United Nations Framework Convention on Climate Change, Paris.

Wallquist, L., Seigo, S.L., Visschers, V.H.M., Siegrist, M., 2012. Public acceptance of CCS system elements: A conjoint measurement. Int. J. Greenh. Gas Control 6, 77–83. https://doi.org/10.1016/j.ijggc.2011.11.008

Wüstenhagen, R., Wolsink, M., Bürer, M.J., 2007. Social acceptance of renewable energy innovation: An introduction to the concept. Energy Policy 35, 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Zafar, R., Mahmood, A., Razzaq, S., Ali, W., Naeem, U., Shehzad, K., 2018. Prosumer based energy management and sharing in smart grid. Renew. Sustain. Energy Rev. 82, 1675–1684. https://doi.org/10.1016/j.rser.2017.07.018