Sociotechnical energy imaginaries of non-users of ECO-innovations: identification and perceptions of residential households not adopting solar energy

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Author Note

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Abstract

Yet to be written

Keywords: future imaginaries, Sustainability, ECO-innovation, diffusion of innovation,non-adopters

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Introduction

In the process of modernization, unsustainability is produced as a side-effect of economic and technological development (IPCC, 2014). The unsustainability becomes visible in the over-consumption of natural resources, loss of biodiversity and climate change problems. To overcome these problems, climate change urges national and local governments to make policies to enable energy transition from fossil energy sources that are free from emitting carbon in the atmosphere. The Dutch government aims to reduce the emission of carbon by 50% or more before 2030. One of the challenges in this vision is the transformation of more than 7 million houses, mostly moderately insulated and almost all heated by natural gas, to well-insulated houses, headed with energy from a sustainable source and in which clean electricity is used (EZK, 2019, p. 21). This goal means an extensive and expansive transformation of the Dutch society where everyone has to participate. The technology used for achieving this goal is mainly decentralized power generation through photovoltaic solar panels (PV), windmills and heat pumps (HP). Fossil-based transport shall be replaced by electric vehicles (EV), either with batteries or hydrogen (EZK, 2019). Technologies like these that enable a more sustainable way of living are addressed as called "ECO-innovations" (James, 1997) in this article, as described in the theoretical framework of this article.

These new technologies are more likely to be adopted by people that have more (Rogers, 1983), and thereby improve their position in relative comparison to the people that are unable to adopt(Gladwell, 2013; Merton, 1968). Thereby people that can innovate can sustain their lifestyle as consumers while lowering their environmental impact with the help of government subsidies, while people that are not adopting the new technology can only create a sustainable lifestyle by consuming less (Jhagroe & Loorbach, 2015). In this way, Jhagroe (2016) argues that the transitions increase the already existing gap between rich and

poor. A large amount of research is devoted to identifying innovators in general (Bogers, Afuah, & Bastian, 2010) and innovators of sustainable technology such as PV (Vasseur & Kemp, 2015). However, there is not much theory (that we know of) about the people who are not transitioning themselves to sustainable forms of energy. Therefore academic research on this topic is needed. Late adopters of an innovation are most likely to be individually blamed for not adopting an innovation or for being much later in adopting than the other members of their system, while careful analysis can show that an innovation maybe is not appropriate for this group (Rogers, 1983). Therefore it is important to study the people that are not adopting sustainable innovations in the present-day energy transition, to prevent stigmatization for this group. In understanding why the group is not adopting this, this article gains social relevance. This article studies the people that are not adopting ECO-innovations by conducting a mixed-method inquiry, including a quantitative part to identify the non-adopters, and a qualitative part to understand why they are not adopting. The former part is done via a multivariate regression analysis on the spatial diffusion of PV to find parameters predicting people not adopting. The latter part is done by conducting semi-structured interviews with people from the identified groups.

Problem statement

The (potential) disruptive effect that the energy transition has on the Dutch society creates a needs to precisely identify and understand the precarious publics that are - by not adopting – targeted by the process of innovating to a carbon-free society. According to Rogers, late adopters are stereotypically perceived as being traditional, uneducated, resistant to change, low economic resources, and that may become a self-fulfilling prophecy (Merton, 1995; Rogers, 1983, p. 107). However, the choice to adopt is also not only a matter of economic resources. A division of adopters vs. not adopters of new sustainable energy technology's merely on the availability of recourses neglects other motivations (Wyatt, 2003). This reasoning ignores that technological innovation is always an interplay between material

and social landscapes (Jasanoff & Kim, 2015). Due to both the risk and uncertainty of climate change, people use different discourses to depict the future (Cook, 2018). This process, which Jasanoff calls "co-production," is about how knowledge about the world is inseparable from how we choose to live in it (2004). The adoption of innovation is, in that manner, influenced by individual and public visions of the desirable future in terms of social practices, identities, norms, and instruments. These imaginaries are diverse, and thereby both innovators and non-innovators can be divided into numerous publics for innovation discourse. Thus the economic resources of adopters are maybe not a motivator for innovation increasing the possibility of adoption on a continues scale as suggested by research (Bernards, Morren, & Slootweg, 2018), but more as an enabler with a threshold from where the investment becomes possible. Sociotechnical imaginaries shape the future of the transition to a sustainable future, understanding this imaginaries for the non-adopters is key in understanding why this group is not innovating.

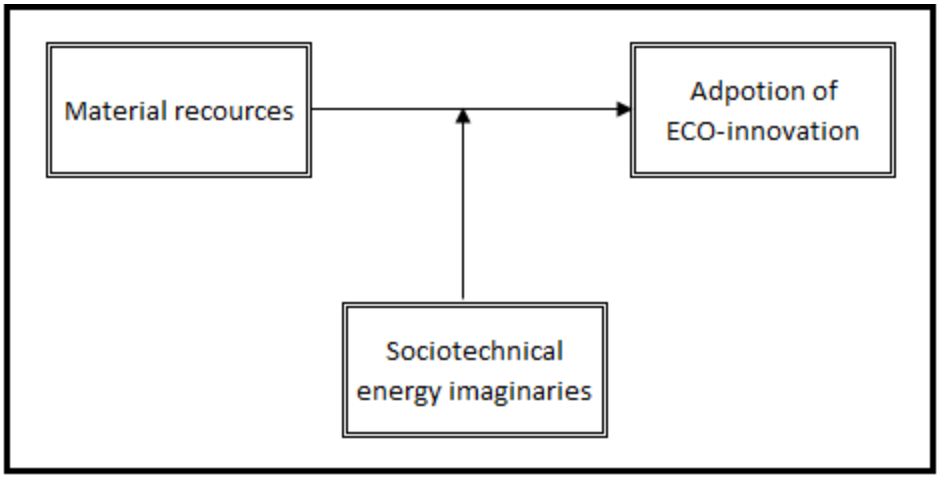

Figure 1. Conceptual model adaptation of sustainable technology

The real decision making for the investment in ECO-innovation is an interplay between the natural resources and the social world of the adopter, the effects this interplay has on the possibility of a household (not) to invest in sustainable innovations will be investigated in this article. Only the investigation of the interplay between these concepts will create an

understanding of why household are not adopting new technology. This understanding makes possible public issues in the transition to sustainable energy visible and can thereby help in creating a more inclusive framework for transitions. The conceptual model is shown in figure 1. Built from the findings from Rogers that laggards non-adopters are not just opposing to change, but can experience real boundaries in adopting innovation (Rogers, 1983), the research question in this article is the following:

What is the role of sociotechnical energy imaginaries, like climate apocalypse or sustainable future, in the adoption of ECO-innovation by residential households in the Dutch society?

This question is investigated in two parts. The first part of the research in this article is about identifying different social groups in the adoption of innovation based on natural resources, by an empirical study of the distribution of ECO-innovations in the Dutch landscape (James, 1997). By investigating the material factors, such as annual income, house ownership and characteristic of the house itself. By studying these factors, we create more insight into the factors that enable a household to adopt new technology. The social systems that are identified as not adopting ECO-innovation are further investigated in the second part of the article. This second part is an exploration of the normative framework of the social network of a household. This part is done by conducting extensive interviews amongst identified groups.

Theoretical framework

To investigate the sociotechnical imaginaries of the people that are not adopting an innovation, this article explores the normative framework of people from this group concerning sustainability. This chapter explains what we mean when we talk about imaginaries, the diffusion of ECO-innovation and social influence.

Sociotechnical energy imaginaries

Imaginaries describe the way people imagine their social surroundings and is made visible in images, stories, and legends, necessary for a common understanding of practices and a widely shared sense of legitimacy of things like borders and nationalities (Taylor, 2004). These shared understandings are embedded in social practices that shape the future through the development of, e.g., norms, policies, and technology. Before shooting into space, it is first the imagination dreaming about it (Jasanoff & Kim, 2009). Methods to investigate the role of imaginaries in the production of technology are conceptualized in the interpretive framework of CO-production by Jasanoff and Kim (2015) and argues that the interpretation of knowledge depends on the interest of society. Though they can originate in the visions of single individuals, sociotechnical imaginaries are collectively held by making the image public and brings together the normativity of the imagination with the materiality of networks in the production on technological [energy] projects. Adaptation of new technology is thereby not merely a matter of ability, but also a matter of vision. In the adaptation of PV, the public image is complicated by the depiction of the climate. Levy and Spices (2013) convincingly derive differed imaginaries from observation and analysis of the various framings of the climate actors and the media on sustainability. These four core imaginaries they identify are the 1) "fossil fuels forever": this (obsolete) popular imaginary viewed abundant cheap fossil fuel as the prime motor behind competitive industrialization. 2) the "climate apocalypse" imaginary paints an alarming picture of the coming decades, visible in movies like "day after tomorrow" (*The day after tomorrow*, 2004). The article of Cook (2018) shows that people that hold this imaginary see change as inevitable and attempts to avoid it are useless. 3) "techno-market" is the combination of capitalism and sustainability. In this view, the marked provides a new product that enables life as consumers in a sustainable way's. Cook (2018) also identifies a technology imaginary where people see a future where new technologies will provide a solution of the climate crisis, e.g., building vertical tubes in the ocean to help the ecosystem cure itself by increasing the mixing of nutrient-rich with the

relatively barren waters at the ocean surface (Lovelock & Rapley, 2007). 4) "Sustainable lifestyle": less materialistic lifestyle inspires these movements to lower the environmental impact, no additional assets are needed to achieve this goal. In this view, solar does not necessarily need to be adopted to reduce the production of CO2.

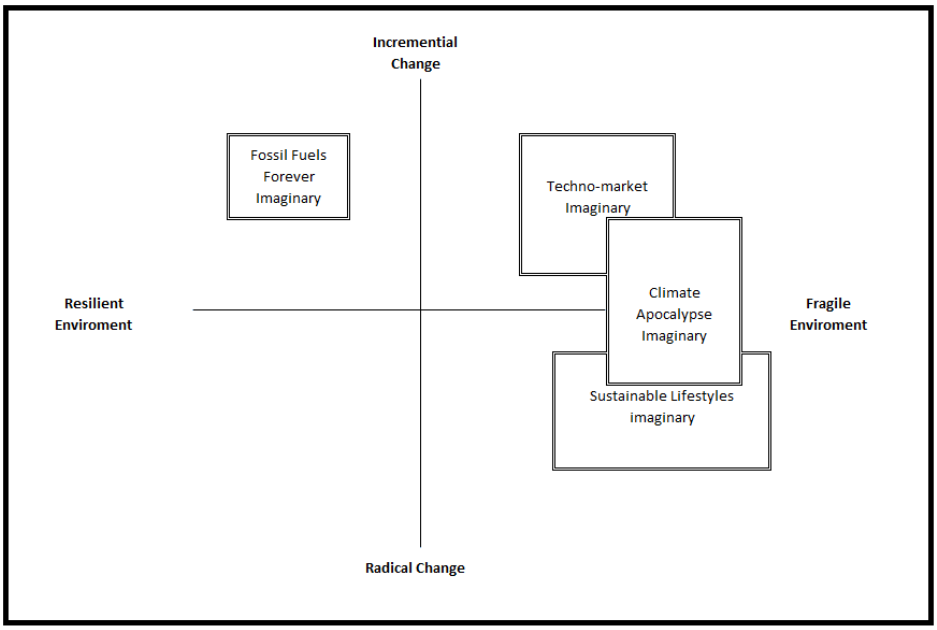

Figure 2. Climate Change Imaginaries (Levy and Spices, 2013)

Diffusion of ECO-innovation

According to Rogers (1983), the adoption of the innovations depends on the perceived relative advantage of innovation, the complexity of the innovation, the social influence, and required knowledge and costs. In this article, the spread of new technology in society is conceptualized by the process of diffusion of innovation, "the process by which an innovation is communicated through certain channels over time among the members of a social system." (Rogers, 1983, p. 5). In this study, the focus is on ECO-innovations: new products and processes which provide customer and business value but significantly decrease environmental impacts (James, 1997). This combination of reducing carbon emission and provide economic opportunity's, which is also the way the energy transition is described in the klimaatakkoord (EZK, 2019). Innovation is communicated from individual to another via channels, that can

Table 1

Roger's five perceived components of innovations (Rogers, 1983).

Attributes	Definition
Relative advantage	The degree to which an innovation is perceived as better than existing (economic, advantage, social prestige, convenience, or satisfaction).
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and the needs of potential adopters.
Complexity	The perceived difficulty to understand and use the innovation.
Trialability	The degree to which the adoption of an innovation is experimented without making long-term commitments or incurring significant costs.
Observability	The degree to which the results of an innovation are visible to others

be things like media or personal relations. The strength of the ties an individual maintains with a communicator of an innovation influence the change of successful adoption. Time is involved in the speeds that communication "passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to the implementation of the new idea, and to confirm this decision towards the rest of the world" (Rogers, 1983, p. 36). Thereby the time that it takes to spread innovation in a social system is key in this research. The innovation is distributed in a social system. There are differed types of social networks, and this article focused on private residential spatial networks. Rogers (1983) classified the categories of the adopters as innovators, early adopters, early majority, late majority and laggards, and innovation is spread through a network in the respective order. This diffusion of innovation theory leads us to conclude that the diffusion of ECO-innovation follows a visible spatial path from innovators to the majority in a local network trough, in which the strength of the relations influences the speed of adoption. From this innovation theory, this article uses five steps in the adoption process of innovation: 1) knowledge about the system and the climate problem, 2) persuasion factors via the

communication channels, 3) way of decision making, 4) implementation, and 5) confirmation.

(Undetected) Social influence

Individuals in society do not act as independent decision-making units, but their behavior is influenced by the other members of the reference group (Salazar, Oerlemans, & Stroe-Biezen, 2012), defining social influence as the change in an individual's attitude or behavior that results from the interaction" with other individuals or social group. Salazar et al. (2012) studies the social influence that peer groups like colleagues, family, and friends may have on sustainable consumption. They find evidence for "herd behavior" (imitations of others) and for "social learning" (learning via network). Nolan, Schultz, Cialdini, Goldstein, and Griskevicius (2008) also investigated the persuasive impact of normative social influence. Additionally studied the detectability of this social influence. In the study, even though participants expressed that social norms dod not influenced their energy conservation, the results show a high correlation between the descriptive norms of the network and those of the participants self. The false perception that people have of social influence leaves the researchers to conclude that "naive psychology-based" beliefs about energy conservation were inaccurate predictors of actual energy conservation. Social influence gives problems in predicting the diffusion of ECO-innovations since peoples motivation for adoption is less rational than they believe themselves. In this article, the focus is on the normative frameworks on an emergent level. The aim is to investigate how the individual believes fit in the social context of the individual. From these emergent patterns we try to gain knowledge about why people are not adopting ECO innovations.

Study 1: identify non-adapters

The first part of this study is about the identification (and localization) of people that are not adopting ECO-innovation. This part of the study is conducted as a preparation for the second part of this article.

Method

Data. ("Stedin peer database," 2019) provided the data for the geographic location of PV. This dataset contains 100.000+ locations with PV. ("Basisregistratie adressen en gebouwen (bag)," 2019) is used for information about the houses in the area. ("Rotterdam in cijfers," n.d.) contains data about the city Rotterdam and used as a source for the following data: residential mobility, election results, annual income. The data about Rotterdam limits the scope of (some parts of) this study to the Rotterdam area[1].

Thresholds. Because this study views natural resources as enablers for innovation (not as motivators), the household income is in this study used as an interval variable. To transform the interval variable to interval variable, this article uses the Dutch tax scales (belastingschalen) (Belastingdienst, 2019).

Procedure. Insight in the variables predicting (non-)adoption is obtained via a multivariable regression analysis. The data is divided in separate groups: 1) "Natural variables", containing the natural part of the Co-production as described by Jasanoff (2004)[2], and "contextual" parameters such as household income.

Results and Discussion

Study 2: Understanding non-adaptors

Although Rogers (1983) defines lagers of innovation typically as low educated and reluctant to change, he also argues that this group can have real reasons for not adopting.

[1] I'm not sure of the whole scope of the project is about Rottedam, or anly for the parts where we do not have all the data. Specific data about residential mobility is only availeble for Rotterdam

[2] Not sure is I can already investigate the imaginative part of Co-production in this part of the study. It would be nice if I could find data on a normative/imaginary part of this study, so I can identify social groups in a better way, but I cannot think of any data . Only maybe the data about results from voting. By doing k-fold cross validation it's possible to learn from the data itself if there are political parties that correlate with a high PV-adoption. Than it would be able to predict, controlled for the other variables, the adoption rate per party.

Table 2

parameters regression analysis

Variable	Rotterdam	Netherlands
Natural resources		
InstalledPV	x	x
HousePrice	x	x
SizeHouse	x	x
ConstructYear	x	x
SizeRooftop	x	x
Contextual parameters		
ResidentMobility	x	
Ownership	x	x
DistrHeat	x	x
Income	x	x
ElectionResults	x	x

This part of the article investigates the arguments this from the lagers identified (and localized) in part 1 of this study by interviewing people from this group. In this part of the study, people that are identified as having the resources to adopt ECO-innovation, but are however not adopting the innovation, are selected for interviewing participants about their views on the future energy system and the role of ECO-innovation in that view. These interviews are analyses to find emerged patterns in the normative frameworks from this group.

Method

Participants. *Description of the participants based on the knowledge from part one of this article. Dit kan nog niet helemaal worden geschreven omdat deel 1 eerst geaadn moet worden.*

Procedure. From the social groups that are identified as not adopting ECO-innovation, qualitative research will be conducted in the form of semi-structured

interviews. Selecting participants consist of two parts. The first part of the selecting process is selecting the locations for sampling. This part is done by purposeful sampling [add source], where we sought areas with specific characteristics that are defined in the first part of this study. By doing so, we hoped to find representative participants to investigate differed variables like income, social influence and ownership of a house. The second part is selecting the participants within the selected area. In this part the participants were selected via a non-probability convenience sampling (Creswell & Poth, 2018). This procedure is chosen because it is the (relative) most easy way to enter the field and we did not see any reason to further complicate the selection process. Researchers went to the selected area, "randomly"[3] selected houses to ring doorbells and asked people for participation.

The interviews were semi-structured. The interviews had two main focus points: the participants view on their attributes towards ECO-innovation (Rogers, 1983), and how they perceive the future of the climate. By asking about how they view the relative advantage of the technique, the compatibility with the system that they have at the moment, how they view the complexity of the systems and it they know other people who have the technology (Rogers, 1983). To investigate the views in the future climate, the interview focused on the way the participants view the stability of the eco-system and how the view change on a global scale (Levy & Spicer, 2013).

Results and Discussion

General discossion

[3] Not sure how to write this

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Figure captions

Table captions