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EXPLORING PRO-ENVIRONMENTAL BEHAVIOUR SPILLING EFFECTS IN DUTCH HOMEOWNER ENERGY EFFICIENT RENOVATIONS

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Abstract

Energy efficient renovation (EER) of the owner-occupied building stock is identified as a key effort to pursue in order to mitigate climate change. However, current renovation rates continuously fall behind and a need to foster EER uptake is apparent. As homeowners' behaviour and decision-making are crucial in the context of EER, behavioural research holds vast potential for policy design and ultimately increasing EER uptake. So-called 'spilling effects' in the domain of pro-environmental behaviour (PEB) continuously catch the attention of researchers. Therefore, this article proposes a conceptual framework of 'spilling effects' in the context of homeowner EERs based on an integrative literature study, facilitating policy design.

1. INTRODUCTION

In 2019, the European Union (EU) presented the 'European Green Deal' (EGD) in accordance with the Paris Climate Agreement of 2015 (European Commission, 2019; United Nations, 2015). At the core of this effort lies the goal of climate neutrality until 2050 with a 55% reduction in greenhouse gas (GHG) emissions by 2030 (European Commission, 2019). A key initiative within the EGD is the 'Renovation Wave', aiming to "renovate 35 million inefficient buildings by 2030", as the EU expects 85-95% of the current building stock to still be standing in 2050 (European Commission, 2020). Among others, the Netherlands acknowledged the need for energy efficient renovation (EER) of its building stock and followed the EGD with their national climate agreement the 'Klimaatakkoord' (KA) in the same year (Rijksoverheid, 2019).

In addition to increasing climate awareness and its recognition in policymaking, the recognition of behavioural research in policymaking is also steadily increasing. With the emergence of behavioural public policy (BPP) and the establishment of behavioural insight teams in the Netherlands and abroad, governments anticipate policy improvements (Hallsworth, 2023; Kaufman et al., 2021). These approaches have been proven to hold considerable leverage among various climate-related, pro-environmental behaviours (PEBs) (Biely, 2022; Hallsworth, 2023; Kaufman et al., 2021; Maki et al., 2019).

However, besides the increasing efforts towards climate neutrality, and raising awareness of the importance of behavioural factors in that regard, such pro-environmental actions of climate mitigation are also inherently costly and Dutch national EER rates continuously remain below set goals (Ebrahimigharehbaghi et al., 2019, 2022). Kerr & Winskel (2020) argue that EER stands out as a unique low-carbon policy strategy due to its need for a cooperative effort between private households and public policy within the intimate setting of a home. The authors further add that there would exist a significant opportunity (and necessity) for private contributions towards potential retrofit investments (Kerr & Winskel, 2020). Accounting for these special circumstances and the growing application of BPP, the potential for its application in the context of EER becomes apparent.

However, due to the variety of behavioural concepts, aiming to investigate this conceptual plurality as a whole would exceed the scope of this study (Biely, 2022). Therefore, focusing on a specific concept in depth is deemed the most promising way by the authors to derive tangible results for research and policy. Thus, the concept of spillover effects (or broader: 'spilling effects') is promising. For the scope of this research, 'spilling effects' describe the relationship between two (usually subsequent) behaviours. This includes more specifically the influence of a certain behaviour [in t_{-1}] on the targeted behaviour [in t_0] (or vice versa), as well as the influence of the targeted behaviour [in t_0] on a non-targeted subsequent one [in t_{+1}] (or vice versa). The literature on spilling effects is manifold regarding scope of analysis and terminology alike (Dolan & Galizzi, 2015; Krpan et al., 2019; Nilsson et al., 2017; Truelove et al., 2014).

In the realm of PEBs, the existence of spilling effects (Maki et al., 2019; Nilsson et al., 2017) as well as in the specific context of EER (Egner & Klöckner, 2021; Irwin, 2021) is partially

proven. However, in relation to the Dutch context, research is still lacking. Therefore, this study answers the following research question:
"What are possible spilling effects in the context of Dutch homeowner energy efficient renovations, and how can they be embedded in a model to facilitate systematic analyses through research and policy alike?"
To answer this question, the study has the following structure. The next chapter explains the study methodology and research approach. Following this, chapter three first defines the concepts of PEB and EER and argues why EER should be classified as such a PEB. Afterwards, the chapter examines the concept of spillover effects in PEB as a promising concept for BPP and further provides an argument for the use of the term 'spilling effects' (in PEB) instead. Finally, the chapter gives an overview of several proven cases of spilling in EER contexts and identifies determinants of spilling and general EER uptake. Subsequently, the fourth chapter provides the main results of this study as a conceptual framework of spilling effects in the context of EER. Finally, this study discusses the results and possible implications for research and policy in the fifth chapter and concludes with limitations and final remarks in the sixth.

2. METHODOLOGY

The vast range of concepts relating to spilling effects and their partial lack of conceptual clarity pose both a challenge as well as an opportunity to the analysis. Prior desk research revealed various publications across different backgrounds and fields of application. This study aligns with Torraco's (2005) concept of an integrative literature review, which is usually not systematic according to Snyder (2019). Therefore, this study does not claim a complete and holistic coverage of the phenomenon, but rather acts as exploratory research. However, this research integrates research from various sources, following the notion and recommendation of transdisciplinarity in this regard (Biely, 2022; Günther, 2009; Kaufman et al., 2021) and furthermore targets spilling effects in a broader sense (i.e. extending from intrapersonal phenomena to interpersonal ones).
Following Callahan's (2014) 'The Six W', the search for the data (more specifically the literature / articles in this case) was carried out by the first author and main researcher, myself (Who). Data collection began January 1st 2023 and continued until the 12th of September 2023 (When). Regarding the scope and method of data collection, relevant scholarly journal papers were reviewed, found on the online databases ScienceDirect, EBSCO, and Google Scholar, using multiple combinations and spellings of the following keywords (Where & hoW): *Adoption*, *Barriers*, *Behaviour*, *Behavioural Change*, *Behavioural Public Policy*, *Behavioural Spillover*, *Decision Making*, *Drivers*, *Energy*, *Energy Efficiency*, *Energy Efficient Renovation*, *Energy Retrofit*, *Energy Transition*, *Peer Effects*, *Photovoltaic*, *Policy*, *Policy Design*, *Policy Making*, *Pro-environmental Behaviour*, *Public Policy*, *Spillover, and Spillover Effect*. Only publications after 2010 were included, to guarantee the inclusion of the most recent developments in the field and the active disregard of possible outdated research. While trying to develop a conceptual framework for spilling effects in EERs, an important part were relevant reviews on spilling effects in the general context of PEB, like, for example, Dolan &

Galizzi (2015) or Maki et al. (2019), to form a theoretical foundation (Why). The main result of the research is the conceptual framework depicted in the fourth chapter (What).

3. LITERATURE REVIEW

The previously mentioned emergence of behavioural research in general and BPP in specific highlights global efforts to account for behaviour in research and policy. The need for this recognition is supported by Tian & Liu (2022), who follow Kaaronen (2017), and state human behaviour as the key driver of environmental problems. Although human behaviour seems to have such a leverage, it can be assumed that it has similar potential for climate mitigation as well. In this regard, the authors further give this as a reason that the field of PEB research also became an ever more emerging one over time, while attracting researchers across various disciplines (Qiu et al., 2014; Seebauer, 2018; Sun & Hong, 2017; Tian & Liu, 2022). As the field is still considered to be in early development, one can observe an unintentional variety and fuzziness in labels, names, and concepts relating to PEB (Tian & Liu, 2022). A situation very similar to 'spilling effects'. Therefore, this study follows Tian & Liu's (2022) extended definition of PEB as a behaviour "that consciously protects the environment and improves its sustainability" (p. 2). Baum & Gross (2017) hereby add, that besides being pro-environmental, such a behaviour "must bring about a reduction in an individual's environmental impact, both overall and over the long run" (p. 56) to also be environmentally significant. This study argues that EER fulfils the requirements for both general PEB and environmental significance, as described in the following subsection and explained along the general aim and different depths of EER.

3.1 Energy Efficient Renovation as Pro-environmental Behaviour

The main reason why EER meets the above-mentioned requirements is due to the fact that EER can drastically reduce a household's energy demand over a long period of time while at the same time improving the household's living conditions (Dolšak, 2023). In more detail, specific EER measures include but are not limited to improved insulation (e.g. floor, wall, and roof insulation, doors and window frames, as well as glazing) and switching from fossil fuel powered to sustainable heat and electricity generation (e.g. solar heaters, photovoltaic (PV) and heat pump installations) (Kerr & Winskel, 2020). Hereby, the European Commission gives six categories of EER measures in a report to provide technical guidance for such renovation measures published in 2014, namely 'Building envelope and thermal insulation', 'Space heating', 'Space cooling', 'Domestic hot water', 'Ventilation systems' and 'Lighting' (European Commission. Directorate General for Energy. et al., 2014).
However, Filippidou et al. (2017) state that the term energy (efficient) renovation lacks a common definition and refer to the European Commission report for classification. According to Filippidou et al. (2017) and the referred report, one can roughly differentiate four levels of EERs. Thus, the first level constitutes a so called 'low-hanging fruit'. This refers to EER strategies that are highly cost-effective, minimally intrusive, and typically offer a fast return on investment, sometimes leading to energy savings of up to 20-25%. Such strategies can encompass operational and maintenance improvements, change in the inhabitants' behaviour

as well as lighting enhancements (European Commission. Directorate General for Energy. et al., 2014). The second level of is termed ‘standard renovation’ and entails the concurrent and cohesive execution of several individual EER measures (European Commission. Directorate General for Energy. et al., 2014). The third level refers to ‘deep renovation’ following the European Commission’s Energy Efficiency Directive, as economically viable extensive overhauls that can markedly lower a building's energy consumption compared to its levels before the renovation. This results in exceptionally high levels of energy efficiency. Such thorough makeovers can be done incrementally and result in high levels of energy efficiency, commonly yielding energy savings exceeding 60% (European Commission. Directorate General for Energy. et al., 2014). The fourth and last level constitutes a (transition to a) ‘Nearly Zero-Energy Building’ (NZEB), referring to a highly energy efficient building which meets its remaining energy demands to a significant extent with renewable energy, ideally produced through the building itself (European Commission. Directorate General for Energy. et al., 2014). Such a differentiation can provide more specific insight, as it results in varying implications for the planning of EERs and related policymaking processes. It further highlights the lasting nature of such EERs compared to other rather day-to-day PEBs. Consequently, this specificity has implications on the nature of ‘spilling effects’ in this domain, as elaborated in the following subchapter.

3.2 Spilling Effects in Pro-environmental Behaviour

Regarding insights from behavioural research, the so-called ‘spillover effect’ (or broader: spilling effects) continuously catches the attention of researchers and policymakers alike. However, research associated with spilling effects regarding PEB is considered to be “still in its infancy” (Ye et al., 2022, p. 1), reflecting the early stage of PEB research mentioned above.

The spillover effect traditionally acts as an umbrella term for the influence of a person’s specific behaviour on a subsequent behaviour of this person, which are interlinked by a certain motive (in this context PEB), as a result of an intervention (Dolan & Galizzi, 2015). However, the use and interpretation of the term broadened over time (Nilsson et al., 2017). An example of these developments is the concept of ‘behavioural spillunders’ introduced by Krpan et al. (2019), referring to the valuation of the targeted behaviour influencing the precedent one (Krpan et al., 2019, p. 1), rather than the other way around (spillover).

Within the context of PEB, scholars currently define various types of spillovers, different directions of spillovers, and explore factors moderating spillover relationships, while at the same time using different names for similar concepts (Dolan & Galizzi, 2015; Irwin, 2021; Krpan et al., 2019; Maki et al., 2019; Nilsson et al., 2017; Truelove et al., 2014). Furthermore, a parallel stream of literature exists examining so called ‘peer-effects’ (or, for example, also ‘spatial spillovers’) (Irwin, 2021). Therefore, this study proposes a new terminology, due to the diversity of concepts and labels, but also their partial overlaps (i.e. fuzziness), as well as the early stage of the research field itself. The aim is to provide conceptual clarity, foster understanding, and facilitate research and application. Following this argument, we introduce the term of ‘spilling effects’, summarising concepts generally used to investigate intrapersonal

behaviour (such as spillover and spillunder) as well as interpersonal behaviour (such as spatial spillover or peer effects).

Although the concept of PEB reaches far beyond energy conservation and efficiency improvements (e.g. EER), it can be assumed that when the engagement in EER is defined as an environmentally significant PEB, spilling effects can be present. This assumption is confirmed by several studies across different national contexts for different types of spilling effects regarding homeowner EERs (Egner & Klöckner, 2021; Irwin, 2021; Serra-Coch et al., 2023). Thus, it is possible to differentiate between four types of such effects, which themselves are moderated by various factors. The figure in section four (*Figure 1*) depicts these findings and maps them along a timescale.

The first type of these spilling effects are effects related to temporal spillover, defined by Nilsson et al. (2017) as "[conducting] behavior A in time 1 affects the probability of conducting behavior A in time 2" (p. 574). Therefore, these spillings would relate to a former EER increasing/decreasing the likelihood of another EER and were proven by (Egner & Klöckner, 2021) in the context of Norway through a quantitative analysis of two surveys among homeowners (combined n = 6402). Thus, the authors prominently state that, according to their results, "respondents who completed energy retrofits in the past three years are significantly more likely to undertake new energy retrofit" (Egner & Klöckner, 2021, p. 1).

A second and more complicated, although more intensively researched, type of spilling effects are those referred to as behavioural. These spilling effects occur from a specific first behaviour to a different second behaviour (Nilsson et al., 2017). In the context of EER, such behaviours would, for example, be other PEBs. However, Egner & Klöckner (2021) state that EERs have very little similarity to other PEBs and therefore could even not be perceived as PEB by individuals. This point is supported by Wilson et al. (2018), arguing that EERs are rarely perceived as a distinct action, but are part of larger efforts of individuals improving their home. Ebrahimigharehbaghi et al. (2022) also support this point by proposing to bundle EER efforts together with general efforts for home maintenance. Although maintenance could be such a similar behaviour leading to an EER through spilling, the proposition of bundling both behaviours rather than conducting them sequentially (hereby maintenance being the first) rather confirms the earlier statements. These circumstances raise the question of whether an EER could also be triggered by other (not necessarily pro-environmental but) highly impactful or life-changing behaviours (LCB), directly influencing/changing people's needs regarding their home (e.g. birth of a child or marriage/divorce).

The third category mentioned by Nilsson et al. (2017) is spilling across contexts. When investigating EER, this would refer to an individual who conducted an EER in one context (e.g. a first house) engaging in a second EER in another context (e.g. a second house). Therefore, Egner & Klöckner (2021) "judge contextual [spilling] to be nonexistent in most countries, as the vast majority of individuals only have one home to retrofit. Retrofitting of subsequent homes when moving house could be said to be defined as temporal spillover" (p. 3). According to the authors, such contextual spilling would rather likely be present in countries where large shares of the population own second homes (e.g. Norway) (Egner & Klöckner, 2021). Regarding the Netherlands, this is not the case. When including landlords, such contextual spilling effects could also be present (e.g. from their private to their rental

homes), according to the authors (Egner & Klöckner, 2021).
The last category of spilling effects observed in the context of EER is the phenomena of interpersonal spilling. In the literature, this concept is largely referred to as 'peer-effects', 'contagion' or 'spatial spillover' targeting the influences of the individual's surroundings on the individual (Irwin, 2021; Mundaca & Samahita, 2020; Noonan et al., 2013; Serra-Coch et al., 2023). In the context of EER, such spilling effects seem to be present for the installation of photovoltaic (PV) (Irwin, 2021; Mundaca & Samahita, 2020; Serra-Coch et al., 2023), as well as heating, cooling, and air conditioning (HVAC) systems (Noonan et al., 2013), since both of these measures can be related to the EER levels two to four mentioned above. These effects were identified throughout several national contexts (e.g. USA, Norway, Switzerland) (Egner & Klöckner, 2021; Irwin, 2021; Serra-Coch et al., 2023). Although the investigated studies would generally refer to positive interpersonal spilling, Noonan et al. (2013) note that the adoption of an inefficient HVAC system due to interpersonal spilling could occur as well. This could then be understood as a negative interpersonal spilling effect in the case of EER. In this regard, Serra-Coch et al. (2023) differentiate between active and inactive effects. The first refers to the active transfer of information from peers who experienced an EER to the individual (e.g. through word-of-mouth). The latter refers to a passive spilling, for example through the individual visibly noticing its peer's PV adoption without actively getting informed (Serra-Coch et al., 2023). As PV can be perceived as a comparably visible EER measure, the question remains whether inactive interpersonal spilling effects are also present for other types of EER measures.
Regarding environmental significance, Baum & Gross (2017) state that it is necessary to include the context of a certain behaviour and its relationship with the environment to derive meaningful results. They identify four levels of determinants of environmental significant behaviour, namely, *Internal factors*, the *Individual-level context*, the *Social-cultural context*, and the *Techno-economic context* (Baum & Gross, 2017). In the case of EER, Dolšak (2023) defines five key determining factors for the uptake of EERs, described as 'barriers and drivers' (a phrase commonly used to describe such phenomena (Kaufman et al., 2021)). These are namely *Information and policy measures*, *Economic factors*, *Socio-economic characteristics of households*, *Technical – buildings characteristics*, and *Behavioural factors*. Looking at these two categorisations of determinants, it becomes apparent that accounting for all these factors is necessary when looking at EERs as environmentally significant PEBs and the related spilling effects in this regard.

4. RESULTS

Taking the above-mentioned literature into account, the following conceptual framework is presented, as depicted in the figure (Figure 1) below. This model accounts for the different types of intrapersonal and interpersonal spilling and shows different possible ways in which the uptake of EER as the targeted behaviour could be influenced by other behaviours as well as influence other behaviours itself. The framework further emphasises the context of the specific behaviour and lists important factors that can influence the strength of the spilling effect, its direction, as well as its general occurrence. Therefore, the different layers and their

proximity to the behaviour highlight the level of influence of the homeowner on these layers (motivated by (Baum & Gross, 2017)).

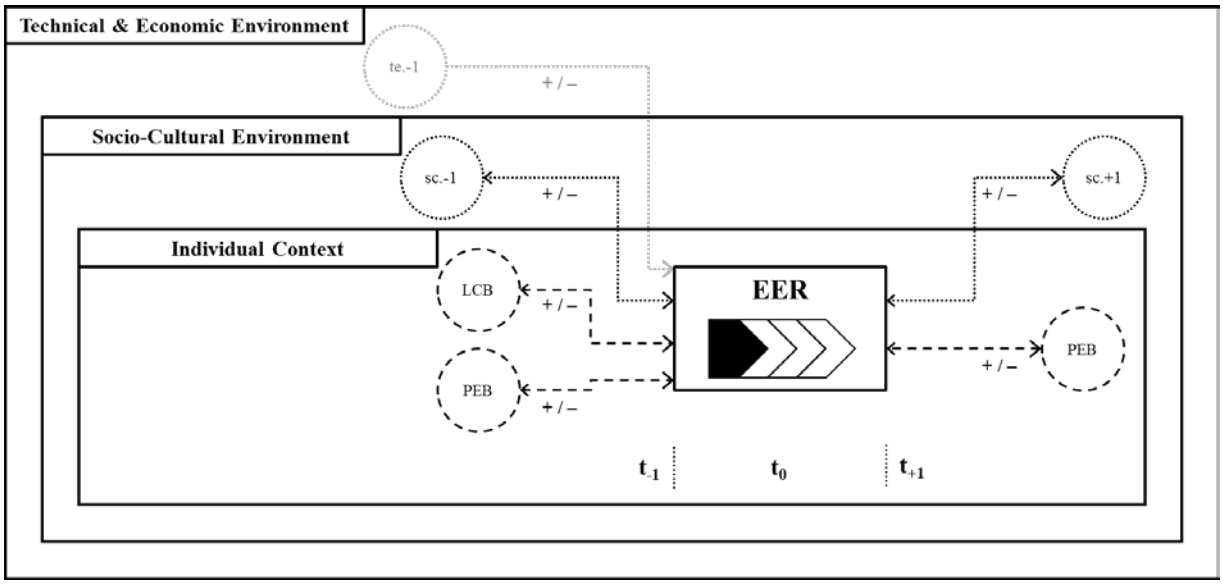

Figure 1: Conceptual framework of spilling effects in EER (own illustration)

Complementing the figure above, the following table (Table 1) provides an extended explanation and further adds relevant factors for EERs per layer. In this sense, the term 'promoting' refers to a positive influence (+) of one behaviour on another (in terms of likelihood of engaging in the latter), while the terms 'permitting' and 'purging' refer to the contrary (–) effect (Dolan & Galizzi, 2015). The arrows follow a similar logic, the right-sided depicting spillovers, while the left-sided depicting spillunders.

Following Egner & Klöckner's (2021) and Wilson et al.'s (2018) rational and due to an EER's possible magnitude as well as socio-demographic determinants, we assume that LCBs in addition to PEBs could also lead to spilling. An example of such an LCB would be the birth of a first child and the family's changing needs regarding their current living environment. PEB in this figure refers to any PEBs including prior/future EERs.

Time (t_{-1}, t_0, t_{+1}) has been added as a dimension to facilitate understanding and accounting for the specific nature of EERs compared to other PEBs (e.g. possible time-horizons of EERs of weeks or months).

5. DISCUSSION

Spilling effects can be identified as leverage points for BPP (Biely, 2022; Noonan et al., 2013). However, policymakers must pay particular attention and also account for possible negative effects of spilling. Research indicates that the likelihood of EER uptake decreases when individuals previously engage in PEBs of lower complexity (Maki et al., 2019; Truelove et al., 2014). On the other hand, the likelihood of spilling increases when tasks share higher degrees of similarity (Maki et al., 2019; Truelove et al., 2014). In the context of EER,

these findings could imply that homeowner involvement in home maintenance (similar but not necessarily PEB) could increase their likelihood of engaging in EER. However, incentivising people through policy to behave very environmentally conscious could counteract policies aimed at incentivising people to engage in EER. Furthermore, Kerr & Winskel (2020) point out that the scope of the public contribution remains uncertain and is dependent on political priorities and the attractiveness of EERs compared to other low-carbon transition options.

Table 1: Types of spilling effects in EER & influential factors
based on Dolan & Galizzi (2015), Dolšak (2023), Egner & Klöckner (2021), Krpan et al. (2019), Maki et al. (2019), Nilsson et al. (2017) and Truelove et al. (2014)

Spilling Effects in Relation to the Environment + : promoting – : permitting/purging	**Influential Factors** *exemplary excerpt*
Technical & Economic Environment	
+ / – Environment t_{-1} → EER t_0	*Energy prices, Fiscal support, Information, Infrastructure, Institutional framework, Policies and regulations, Retrofit costs, Time horizon*
Socio-Cultural Environment	
+ / – Environment t_{-1} → EER t_0 spatial / peer-effects	*Social norms, Status considerations*
+ / – EER t_0 → Environment t_{+1} spatial / peer-effects	
Individual Context	
+ / – Prior PEB t_{-1} → EER t_0 behavioural, contextual, (temporal)	*Attitudes, Awareness, Identity & Self-image, Intentions, Knowledge, Lifestyle, Preferences, Socio-demographics (e.g. age, education, gender, geographic location, household size, income, marriage status, presence of children), Values*
+ / – Prior LCB t_{-1} → EER t_0 behavioural, contextual, (temporal)	
+ / – EER t_0 → Following PEB t_{+1} behavioural, contextual, (temporal)	

These simple examples highlight the complexity of the topic at hand and the caution policymakers need, not only when designing policies using spilling effects, but when designing policies in general.

6. CONCLUSION

In the case of Dutch homeowner EERs, possibilities for different types of spilling effects can be identified. In this context, spilling could occur intra- and interpersonally and could be affected by other PEBs or even other life-changing events and behaviours. Furthermore, a

multitude of influential factors moderate these relationships and should act as a guideline when designing and evaluating policies, as they can provide key insight on whom, how, and what to design for. The proposed model provides possible directions for further research, as spilling effects in relation to EER are currently under-researched in the context of the Netherlands. As the model is based on international literature, it is yet to be determined which specific factors play what role in this relationship and to what extent. Furthermore, it is possible that not all types of spilling are present in every EER context (cf. second homes in Norway). Therefore, this study has certain limitations, due to its scope and methodology.
The study calls for a qualitative and quantitative exploration of the identified factors and interrelationships. It follows former scholars' calls for inter- & transdisciplinarity, especially when investigating highly complex topics like EER. Finally, it calls for a much needed refinement of the concept of spilling effects, as briefly attempted in this work.

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