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SOCIAL PRACTICES IN ENERGY-RELATED TRANSITIONS? THE COMPLEX EXAMPLE OF ELECTRICAL LIGHTING

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ABSTRACT

Reducing energy consumption from lighting is, in policy making, largely treated as a matter of *optimizing the individual lighting product*. However, this paper argues that since lighting is a highly cultural, historical and socio-material phenomenon, *energy efficient (or intensive) lighting patterns* evolve from something more and something else than what the individual lighting product provides. This is an important distinction as current lighting *patterns* have yet to become significantly more energy efficient, in spite of a general increase in energy efficiency of lighting *products.* Looking at lighting patterns as something that is both an outcome of several routinized performances of social practices such as cooking, dining and crafting, as well as several standardized systems supporting underlying norms for and nature of dwelling sizes, working hours, energy supply and lighting design, this paper opens up for a discussion of how and why current lighting patterns have come about.

KEYWORDS

Social practice, systems, transitions, sustainability, lighting, households

3S STRANDS

Transitions to Sustainability, Sustainable Consumption

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INTRODUCTION

In 2005, lighting comprised approximately 20% of the world's total energy consumption, and with today's concerns about energy security, resource depletion and climate change, this has made public as well as private lighting a target for various efficiency initiatives. In the EU, efficiency targets for light sources have been implemented in the Eco-Design Directive (2005/32/EC) which, amongst other things, has resulted in a phase out of the classic incandescent light bulb. Due to the high demands for efficiency, several new lighting products and technologies have developed with different qualities and characteristics. The Eco-design Directive sets out minimum energy performance requirements based on for lumen/watt. Focus is therefore largely limited to *the energy efficiency of the individual product.* However, studies show that, so far, this does not necessarily result in an overall reduction in energy consumption from lighting. In fact, current *ways* of illuminating seem to offset the savings that has been obtained by substituting lighting products (Evans et al., 2012). Along with other studies that find that lighting is highly cultural (Wilhite et al. 1996) and embedded in socio-material practices (Bille and Sørensen, 2007) this sparks curiosity in terms of investigating what really matters in terms of lighting. Is lighting energy? Is lighting a product? Is lighting an activity? And how do we obtain energy efficient, or even sustainable, lighting *patterns*? Many of the current frameworks for understanding dynamics of transitions towards sustainability either focus on large institutionalized systems, such as electricity systems, transportation systems or agriculture systems (eg. Verbong and Geels, 2007, Shot and Geels 2010) or focus on practices and the performance of practice in relation to stability and change (eg. Shove et al., 2012, Gram-Hanssen 2011). But since lighting can be understood as something that is *part* of practices (e.g Bille and Sørensen 2007, Jensen 2013) as well as it can be understood as something that is *part* of larger institutional changes (eg. Bolius 2013, EU Lighting the Cities 2013), it may be useful to approach lighting through a framework that seeks to uncover how practices and institutionalized systems *intersect.* Therefore this paper will revisit the elaborate and well documented history of lighting from the birth of the electrical light source through present time, by trying to uncover examples of practices as well as institutionalized systems in which lighting seem to have played a significant role. The *intersections* between these practices and systems are of particular interest, as these intersections can be understood as *outcomes of certain innovation processes* (Hargreaves et al, 2013). Changes, positive or negative, can therefore potentially be assessed through this kind of framework. In applying this kind of framework, focus is consequently moved *away* from optimizing the *individual* lighting product *towards* acknowledging that the product engages in systems as well as practices that influence the way the product is utilized, related to and talked about, which accordingly form lighting *patterns*. In this way, it becomes possible to assess what is playing a role for how lighting patterns develop, and thereby to suggest some aspects that may be useful to consider when trying to facilitate making these *patterns* more energy efficient.

In the following section, a framework for studying intersections between practices and systems, as proposed by Hargreaves et al. (2013), will be presented, where after the historic as well as current developments of lighting will be analyzed through this framework. Through the analysis, the intersections will be highlighted as symbolizing important aspects that may be worth considering when opting for energy efficient lighting *patterns.*

INSTITUTIONALIZED SYSTEMS AND PRACTICES

Before opening up for exploring how practices and systems *intersect*, it is important to get a sense of the frameworks behind exploring practices and systems *individually*. The following introduction is by no means meant to be exhaustive, as this has been done comprehensively elsewhere (eg. Geels 2011, Shove et al. 2012).

Common for theories of practice is that it is the *practices* that are the unit of analysis, rather than human individuals, technological systems or discourses. For theories of practices concerned with innovation and consumption dynamics (eg. Warde, 2005), the main attention lies in decentering individual action and choices towards focusing on the reproduction of practice and the performative co-evolution of elements of practice; 1) competences, 2) technologies and 3) meanings (Watson, 2012). Societal institutions are thus maintained and kept in place through the reproduction of practices. This practice approach acknowledges individual agency, however through treating people as carriers of practices (Reckwitz, 2002, Shove and Pantzar 2010). Theories of practice tend to emphasize *normality* (Shove and Walker, 2010) as well as local performance. This approach, that until recently mainly has focused on stability, is now expressing concern for understanding dynamics behind change as well (Gram-Hanssen 2011, Shove et al., 2012). The practice approach is sometimes criticized for being too focused on local performance and how things are *maintained*.

The multilevel systems approach to socio-technical change proposed by Rip and Kemp (1998) and later Geels (eg. 2005, 2010, 2011) is so far one of the most referenced and discussed frameworks for studying societal *change* towards sustainability (Markard et al., 2012). In this framework, the analytical focal point is a socio-technical *system*, and it is the *radical change* from one socio-technical system to another that is of interest. A further distinctive aspect of the multilevel perspective (MLP) is its focus on systemic *levels*. The micro-level characterizes emerging niches, the meso-level characterizes the dominant socio-technical system (regime) and the macro-level characterizes the overall 'landscape' that exerts various pressures on the regime (political issues, discourses etc) (Geels, 2011). The MLP only considers something to be a 'transition' when radical change occurs in the way in which a 'societal function' is fulfilled - in one regime replacing another (for instance the change from a fossil-fuel based regime, to a renewable energy based regime). This change occur when the right amount of pressure is put on the regime, by the exogenous landscape, which creates 'windows of opportunities' that is filled by radical new innovations developed in the niche spaces (Geels, 2011). The MLP approach is often criticized for simplifying a number of aspects as it tends to neglect details at the expense of a wide systems scope, as well as being criticized for being too focused on radical and novel innovation (eg. Smith et al. 2010, Genus and Coles 2008, Shove and Walker 2007, 2010), and therefore tends to neglect the inconspicuous.

It is certainly important to keep in mind that these frameworks have distinctively different analytical intentions. The MLP approach tends to focus on production, supply and the diffusion of technologies, with a distinct focus on *change*. The practice approach on the other hand focuses on practices that technologies and products are part of, and how people interact with products through the performance of practices. Therefore, it is often applied to consumption studies. Further, as mentioned, practice approaches often focus on how certain practices are performed and *maintained*, and only recently on how they change.

However, in spite of the distinctive differences between the frameworks, there is also a key similarity; namely the intention to understand complex patterns of sustainability as well as unsustainability. Therefore a number of efforts have emerged that aim to either bridge the two frameworks (McMeekin and Southerton 2012, Watson 2012) or to find useful *intersections* between them (Hargreaves et al. 2013), as each framework, due to their differences, consequently elucidates aspects that the other one may fall somewhat short of. As this paper seeks to understand potential *intersections* between systems and practices through which lighting-related innovations occur, the following section will go into details with the framework developed by Hargreaves et al. (2013).

Identifying Intersections between Systems and Practices – Tools for Empirical Studies

Hargreaves et al. (2013) extends on Shove's (2003) integrative framework of 1) a 'vertical' approach looking at the path dependent stabilization and standardization of certain ways of living with certain products and systems, and 2) a 'horizontal' approach dealing with how people order and perform meaningful configurations of what is normal *across* these technologically embodied stabilized systems. Hargreaves et al. (2013) relates Shove's deliberations of a vertical approach directly to the regime-based multilevel perspective (MLP) and the horizontal approach to circulation of elements of practice, comprising a system of practices. Hargreaves et al's (2013) intentions with their developments of Shove's framework, is to emphasize and draw attention to the way systems and practices *intersect with one another in innovation processes*. They stress that the MLP underplays multi-regime interactions and actors that cut *across* regimes by focusing on single regimes around energy, food, transport etc. By acknowledging the ontology behind the practice approach it also becomes possible to explore the many dynamics that are results of the reproduction of practices and the circulation of elements between practices that goes across systems which is not necessarily possible when focusing on single innovation trajectories alone.

In Hargreaves et al. (2013) model of intersections, the notion of *elements* of practice is brought to our attention. Much like Watson (2012), Hargreaves et al. (2013) propose that stability and reproduction of practices derives from the repeated reproduction of practices, but they emphasize that this happens due to a *certain integration of elements,* which consequently also infers that innovation in practices derives from the making and breaking of links between elements.
They expand on this by referring to Pantzar and Shove's (2010) three circuits of reproduction; the first relates to how elements become integrated to form a certain practice, the second relates to how various practices come to hold each other in place (a system of practices) and the third one refers to temporal dynamics and path dependence, exploring how current practices evolved out of past ones (Pantzar and Shove, 2010). Through this, the *elements of practice* become an important analytical component, as well as the relation between practices and the circulation of elements between these practices. Although theories of practice are not particularly equipped to explore emergency of novelty, Gram-Hanssen (2011) has developed on this and is illustrating how practices can result from *adjustments in the various elements of which they are comprised – with special emphasis on (new) technologies.* Bearing this in mind, it is beginning to become possible to explore practices and systems where products or technologies play a crucial role – which they do in matters of energy consumption. Further, following Hargreaves et al.'s (2013) framework, the *history of practices* becomes essential in order to understand their current configurations. These points are

important in the efforts of approaching and exploring practices and systems empirically. With these analytical tools for empirical framing in hand, Hargreaves et al. (2013) suggest that the systems approach allows one to examine the emergence of novelty through the interactions between the vertically ordered levels of niche, regime and landscape, while the practice approach brings attention to the horizontal dynamics in how people order and perform meaningful configurations of what is normal *across* multiple systems as the practices follow their circuits of reproductions.

In order to explore these dynamics Hargreaves et al. (2013) suggest focusing on the *intersections* between the horizontal and the vertical approaches. As a first step, it makes sense *"to examine how niche, regimes and landscapes in particular systems interact with and impact upon multiple everyday practices, and how particular practices and systems of practices intersect with dynamics of several niches, regimes and landscapes"* (Hargreaves et al, 2013). In this way, it becomes possible to explore *"how regimes and practices interconnect with and bump into one another in the course of transitions processes—the points of intersection"* (Hargreaves et al, 2013). A stylized model of the framework can be seen in figure 1.

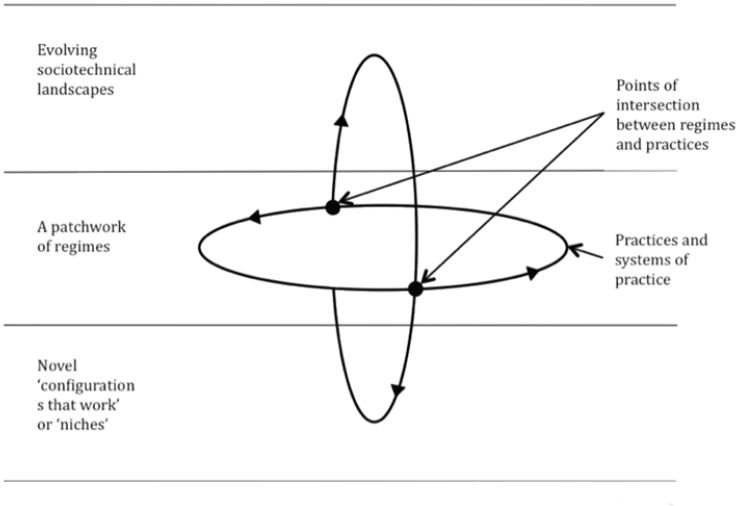

Figure 1 Intersections between systems and practices – the proposed model by Hargreaves et al. (2013).

The model essentially proposes specific intersections between practices and a certain system. Hargreaves et al. (2013) gives the example of a local UK initiative that proposes an alternative way of supplying local food, bypassing the big established supermarket, also seeking to make it affordable for suppliers to sell their produce locally, which makes it more sustainable (no transportation). However the project runs into problems, not due to issues solely connected to what in MLP terminology could be termed as the 'food regime', but also due to the initiative failing to approach practices, such as shopping routines and cooking practices. These practices are arguably part of what can be termed as a food regime, but is indisputably also related to other systems or regimes such as transportation, energy and waste regimes (Hargreaves et al, 2013). Looking at moments where systems and practices intersect, or bump into each other, therefore arguably makes it possible to

assess what hinders or facilitate certain changes and thereby understand some of the dynamics at play.

Hargreaves et al. (2013) then offers great possibilities for exploring the phenomenon 'electrical lighting' as lighting neither seem to be easily captured by looking at single systems such as an energy or a housing regime, nor does it seem to comprise a practice in itself (Jensen 2013).

With the analytical tools set out for

- Remembering that practices – what we embody and reenact – comprise and are comprised of societal institutions as well as,
- Understanding that changes in one practice can result in changes in another practice due to the circulation of elements of practice, and
- Keeping in mind that the history of practices are important for understanding their current configurations, besides
- Approaching change dynamics through the intersections between systems and practices,

it becomes plausible to start understanding some of the dynamics behind the phenomenon of 'lighting' as well as what is actually playing a role for potential change towards more energy efficient lighting patterns. For the purpose of delimitation, focus in this paper will primarily be on Danish lighting patterns.

RESIDENTIAL LIGHTING PATTERNS –WHAT ARE THEY AND HOW DO THEY COME ABOUT?

With the analytical approach presented above in mind, it seems beneficial to start by looking back at the recent history of (electrical) lighting, in order to approach what the current, Danish residential lighting patterns are actually comprised of. It is of course important to note that lighting is a very old phenomenon that dates back thousands of years and that the entire history holds many significant and interesting social and structural aspects (Garnert 1994, Bille and Sørensen 2007), but for the purpose of this paper, the retrospect ranges back to the late 1800's, just before the birth of the electrical light source; - the incandescent light bulb. Although the current European regulations and the *Danish* context of the directives will be the focus of this paper, major worldwide historic developments of electrical (residential) lighting will be presented as well, in order to put current developments into perspective. It is not the intention to give a full historic account of electrical light and its development, but rather to show significant aspects of what can be termed as practice and system related changes which is interesting to look at with special attention to identifying *intersections* between systems and practices. Looking specifically at how routinized performances of certain practices involving light intersect with certain standardized systems accumulated through these performances, opens up for a very broad discussion of *how* lighting patterns come about, which may not be restricted to dynamics within one practice or one system. This serves to potentially explain why the EU experience problems with their policy instruments for reducing lighting related energy consumption, which seems highly oriented around technological optimization and substitution of the *individual light source.*

The Birth of the Electrical Light

In 1879, Edison filed a patent application for the incandescent light bulb which has come to extensively shape the way we experience light today. Although Edison was far from the only person developing electrical light, it was Edison's incandescent light bulb for general lighting purposes that got widely recognized as he had developed an entire electrical system to go with it (Brox 2010, Lytken 2012). So far electrical lighting had only been used for display and spectacle (Brox, 2010). Putting these developments into perspective, Brox (2010) explains that the American rise of the middle-class during the mid-1800's resulted in the evening being turned into the 'consumer' hour, which meant that the stores had to light up the display windows. This probably played a role for the emerging demand for general lighting systems. Already at this stage, several aspects can be discussed in terms of systems and practices. Through a systems approach, one could argue that the industrialization and the urbanization (and hereby the rising middle class that wanted to shop in the evenings) during the 1800s would constitute some form of landscape level pressure on various regimes, which would then result in various niches developing. Edison and his incandescent light bulb and associated electrical system could, in this sense, be regarded as a niche development. But what regime should be in focus? As electrical light was the first thing to connect households to an electrical grid (Gooday, 2008) it had great influence on the development of the electrical grid developed. Therefore, the light bulb is essentially an important part of what can be termed as an 'energy supply' system or regime. Plotting these first considerations into Hargreaves et al. (2013)'s stylized model, it could look like figure 2.

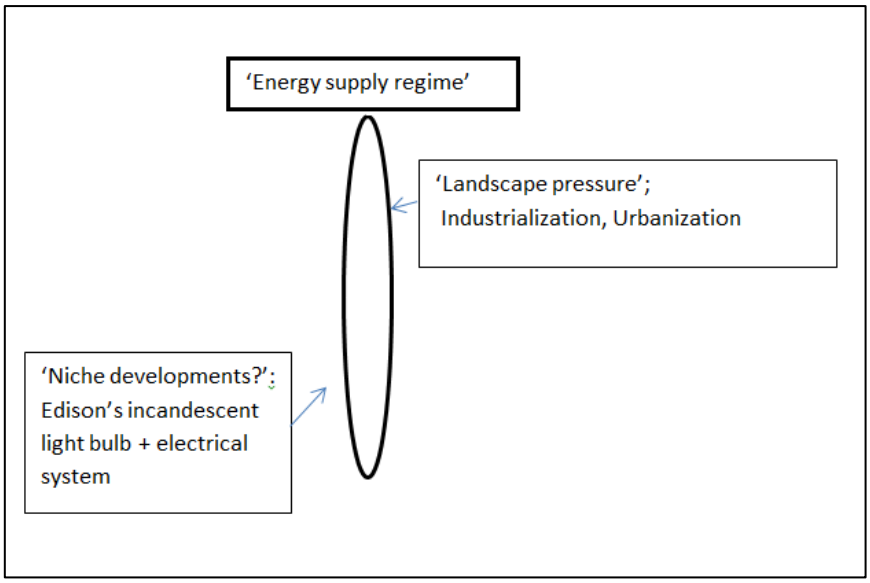

Figure 1: The vertical organization of the energy supply regime, landscape pressures and emerging niches (based on model by Hargreaves et al. (2013)

Before the era of the electrical light, illumination was mainly obtained through gas lamps which again superseded kerosene- and candle light. Lytken (2012) explain that one of the reasons why electrical light did not become dominant in some of the European countries, including Denmark, at

the same time as in the US, was due to the strong gas supply system. In MLP terminology, this can be characterized as two competing regimes, - the '*gas supply* regime' and the '*electricity supply* regime'. However, it may also be characterized as two competing technological systems that are both part of an '*energy supply* regime', where the electricity system gained momentum through certain nurtured niche developments. As an analytical framing for exploring lighting, the regime notion is beginning to cause some problems. What should be termed regimes and what should be termed niche-developments? However, as the gas-based light and the systems behind it for a while competes with, but eventually gets replaced by, electrical light and the systems associated to that, one may content to treat the gas supply system as one regime and the electricity supply systems as the replacing regime, *when focusing on the energy supply system as a societal function.* In MLP terminology, this should then serve as a transition, as the energy supply system is radically changed in terms of grid structures, resources and use. It is important to bear in mind that these developments are closely connected to the diffusion of lighting systems, as light sources change significantly, going from gas light to electrical light. However, although lighting technology changed, the way the light as illumination was *used* did in fact not change. Gaslight as well as electrical light was to a great extent compared to the natural source of light – the sun. Because before electrical and gas-based light, the main source of light *was* the sun. Kerosene- and candle light was used (scarcely) in the evening hours, and when the candle or the allocated amount kerosene was burned out, the day was over (Brox, 2010, Thorndahl 2001). Not only was the day (and night) defined and confined by natural light, but the nature of the light is also important to consider. For one, the incandescent bulb - that we nowadays associate with low-level, warm light - was considered very bright when it first appeared (Lytken 2012). This was due to it being compared to the very dim light from candles, kerosene and gas lamps. Second, and perhaps more importantly for the purpose of this paper, the way that the households had been organized around a few kerosene and or candle lights, continued to be organized this way when gas-light and later electrical light was introduced. Due to the high cost of light (Fouquet, 2008) and the inflammable nature of fire-based light, lamps were positioned centrally in the room, and the light would only be lit where people were present (Thorndahl, 2001a). This way of structuring the household was tightly coupled with families gathering around the single light source in the night time (Thorndahl, 2001b). When the electrical light source was introduced in Denmark between 1891 and 1940s (Thorndahl, 2001c, Olesen and Thorndal 2004, Gram-Hanssen 2008a), replacing the fire-based gas light, families continued having single, central light sources although the cost of light decreased and the fire risk was gone (Thorndahl, 2001b). This may very well be due to household related practices, as dwelling life was organized in certain meaningful ways, and therefore reproduced and maintained that way. Thus, the way that practices such as dining and crafting were organized around illumination in the early 1900's were different than it is nowadays (Thorndahl, 2001c). The aspect of gathering played a large role, and a mere technological change of the light source and the related energy system – radical and wide-ranging as it may be – did not have any immediate effect on these activities. This was in spite of various experts such as architects, lamp designers and even the power companies trying to 'educate' the residents in terms of effective illumination of the home (Thorndahl, 2001c). Looking at this through Hargreaves et al. (2013) model, these aspects could be approached through the horizontal approach, symbolizing how people make sense of the activities comprising normality in the organizing of daily life, see figure 3.

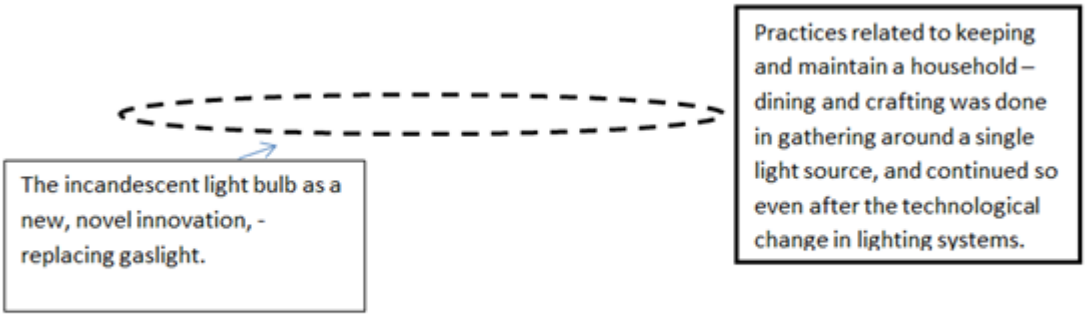

Figure 2: Household-related practices as a horizontal organization of normality in households, where lighting plays a role (based on model by Hargreaves et al. (2013))

It is interesting that the use of light stayed the same in spite of a fairly significant technological change. So far it seems possible that what, in MLP terminology, can be termed as the 'energy supply regime' *as well as* what through a practice approach can be termed 'a system of household related practices', are of importance when trying to understand what residential lighting actually is. In the same time it tells us that light was something that was an important and visible part of residential life, but it was not necessarily related to energy-consumption although it at the same time had great influence on the electrical grid and its development.

Focusing on *intersections* between the vertically organized energy supply system, and the horizontally organized household practices, opens up for exploring what these dynamics may have entailed for the changes in lighting patterns that actually occurred in the 1950ies - lighting patterns were no longer mainly comprised by a single and central light source, but instead many smaller light sources in the corners of the various rooms. In order to do so, going a bit further into the dynamics behind the link between the electrical grid, the houses and the development of light is necessary.

With the introduction of the incandescent light bulb, light was initially the only, and for a long time the main, energy consuming activity connected to the home (worldwide) (eg. Brox 2010, Gram-Hanssen 2008a). The power utilities were therefore initially called the Lighting Companies (Brox, 2010). As the lighting companies needed a steady demand (due to the structure of the grid), they addressed the households extensively in order to increase household energy consumption so that it could complement the municipal drain (Brox, 2010). The lighting companies therefore charged lower rates to customers who consumed more than a minimum amount of energy, and actually developed demand meters that would *encourage* consumption (Brox, 2010). The lighting companies started campaigning for other kinds of electrical equipment for the home during the early 1900's (Olesen and Thorndahl 2004, Brox 2010). Simultaneously, lamp designers had various ways of discursively construct what homely, domestic light should be by engaging in public discussions (in magazines and newspapers), deeply embedded in, and influencing, the concurrent interior fashion practices; PH, a famous Danish lighting designer, was for instance embedded in the emerging practice of decorating

simplistically and functionalistic, which was a response to the previous voluminous Victorian style that has dominated the early 1900's (Lytken, 2012).

Taking on a systems approach, many of these dynamics can be characterized as movements at the different, systemic levels. The general tendencies to break with the voluminous and more whimsical Victorian style, towards a functional style driven by logic would probably be characterized as exogenous landscape level dynamics, founded in philosophical and cultural changes. The power utilities and the lamp designers would be characterized as incumbent actors (Geels, 2011), as the electrical grid at this point would be characterized as the dominant regime (however newly founded) and lamp designers would thus emphasize lamp design that would fit the emerging lighting patterns. For instance, the lampshades were developed to wrap the 'overly bright' incandescent light bulb (Lytken, 2012). The power utilities' efforts could be seen as an attempt to meet landscape pressures that equated energy consumption with wealth; by 1950, Denmark was still among the bottom 5 European countries with the lowest energy consumption per capita, which resulted in historians and technologists characterizing Denmark as an underdeveloped country (Olesen and Thorndahl, 2004). What is also interesting to note is that until the 1950s the power utilities controlled the 'pace of the day' so to speak, as they would turn the power off and on a few times by night, making the residential lights blink, in order to signal to the residents that the power would be turned off. The residents would then have time to bring forth a kerosene lamp or a candle, in order to navigate to bed (Thorndahl, 2001c). This phenomenon would also be characterized as incumbent, regime based action that was determined by the existing capacities of the grid.

If we approach these various aspects through a practice approach, the story will look a bit different. As a practice approach presupposes that structure and agency is an outcome of performed practices, the power utilities efforts should in this case be seen as interacting with certain *elements* of various household related practices. Advocating for electrical appliances such as washing machines, would in effect only initially fiddle with the material element of a cleaning practice that later on would have implications for, and be molded by, existing cleaning practices (Gram-Hanssen, 2008b). This also corresponds with the various electrical products not actually being domesticated before years later (Gram-Hanssen 2008b, Olesen and Thorndahl 2004). The lamp designers' visions would essentially be a product of other practices that related to decorating and organizing the household. The power utilities rhythm in terms of when to turn the power on and off would also be a result of the so far heavily practiced routine of everyday patterns that would begin with the sunrise and end with the sunset. There was no demand for electricity during the night, and therefore no production of electricity. When Danish residential lighting patterns started to change in the 1950s lamps in various corners in the house emerged. The light became more 'functional' as lamps now would have *designated functions and situations of use*. As mentioned, the single lamp in the middle of the room had so far been the dominant lighting patterns in Danish households, and the same lamp had been used for all situations – dining, reading, crafting etc. This reorganization of lighting patterns should be seen as interlinked with social structures also changing – it was no longer necessary to gather around one lamp (Thorndahl, 2001c). Electric light had further turned from being a luxury in the beginning of the 1900, only available to the wealthiest families, to having become a generality or even a necessity by the 1950s. At that time, the night had also been colonized, and society in general developed many nightly activities (night-shifts etc.) as people were now 'free' to choose when to work, sleep etc. (Olesen and Thorndahl, 2004).

Not only does it seem plausible to identify bumps between an energy supply system and household related practices, the energy supply system could be said to have bumped into interior design practices as well, causing elements of practices to circulate. For instance, the introduction of various electricity based household equipment may have change meanings as well as competences connected to practices of cooking and cleaning. This has on the other hand, also affected the energy supply system that got expanded and stabilized through the expanding use of electricity using products, including lighting. The stylized model is then expanding, see figure 4.

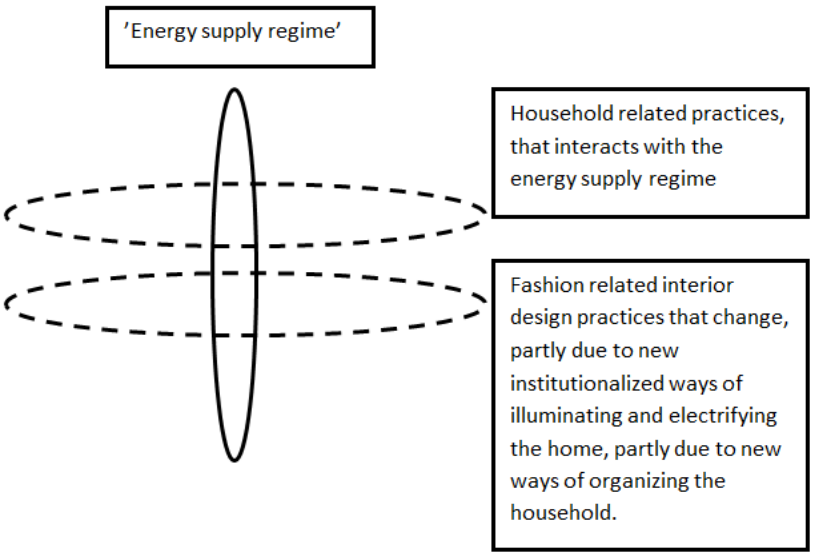

Figure 3: the vertically organized energy supply regime and the horizontally organized systems of household practices and design practices – intersections (based on model by Hargreaves et al. (2013))

By the 1970ies, turning off light and generally economise energy consumption was inconceivable and resources were deemed inexhaustible. Therefore, with the energy crisis in the 1970'ies, energy saving campaigns, such as the 'Sluk Lyset'[1] campaign, was put on the agenda trying to educate the consumer. This is interesting, as more energy efficient fluorescent light had actually started emerging in America in the 1930s and 1940s. As Brox (2010) explains, government officials were concerned that ever-increasing consumption (coal-based) would exceed known coal resources, and thereby supported studies into 'colder' light, which is more efficient lighting, due to the amount of energy required to obtain certain color temperatures.[2] However, the studies were not turned into practice until years later. Brox (2010) states that this was due to the fluorescent tube requiring different plug in, due to flickering and due to blue/cold light not being accepted as 'proper' indoor lighting. The fluorescent light was not found in households until long after it had been enrolled as an industrial light source, where the economic efficiency mattered more than the quality of the light source (Brox, 2010). Based on the above, there are many interesting things to add about the

[1] Danish for 'turn off the light'.
[2] Color temperatures are measured in Kelvin degrees (K). To produce 3500 K (cold light) is less energy intensive than producing 2700 K (warm light)).

emergence of lighting patterns. The general concern for the environment that became explicit and wide-known with the oil-crisis in the 1970s would, in MLP terminology, be characterized as landscape dynamics, putting pressure on several regimes (energy supply, transport regime etc). It would require for the regimes to respond and thus opening up for niche developments (which to some extend happened in Denmark, through new, alternative ways of organizing the household in co-housing schemes, where sharing and cutting back on the use of resources was put on the agenda). The 'delayed' domestication of fluorescent light bulbs may be explained through a technological mismatch between the new lighting product and the existing supporting technology (plugs)or fluorescent light technology having 'teething troubles'. However, through a practice approach, the oil crisis would merely be an outcome of the increasingly energy intense practices that had developed within a short period of time, through the electrification of cooking and cleaning etc. Although electrical lighting would perhaps not be the most significant, the abovementioned changes within domestic electrical lighting patterns serve as an example. The way the illumination patterns of a household changed over a relatively short period of time after the introduction of electrical lighting, together with changes in electrified practices such as cooking ad cleaning, suggest that the oil crisis could be seen as a result of the performance of various increasingly energy intensive practices, and not as something exogenous. Further, the 'mismatch' between the fluorescent lighting technology and existing lighting patterns could be explained through elements of meanings connected to appropriate lighting for various practices in which lighting takes part, which suggest that warmer light was preferred over cold light for many occasions.

The above can be seen stylized in figure 5.

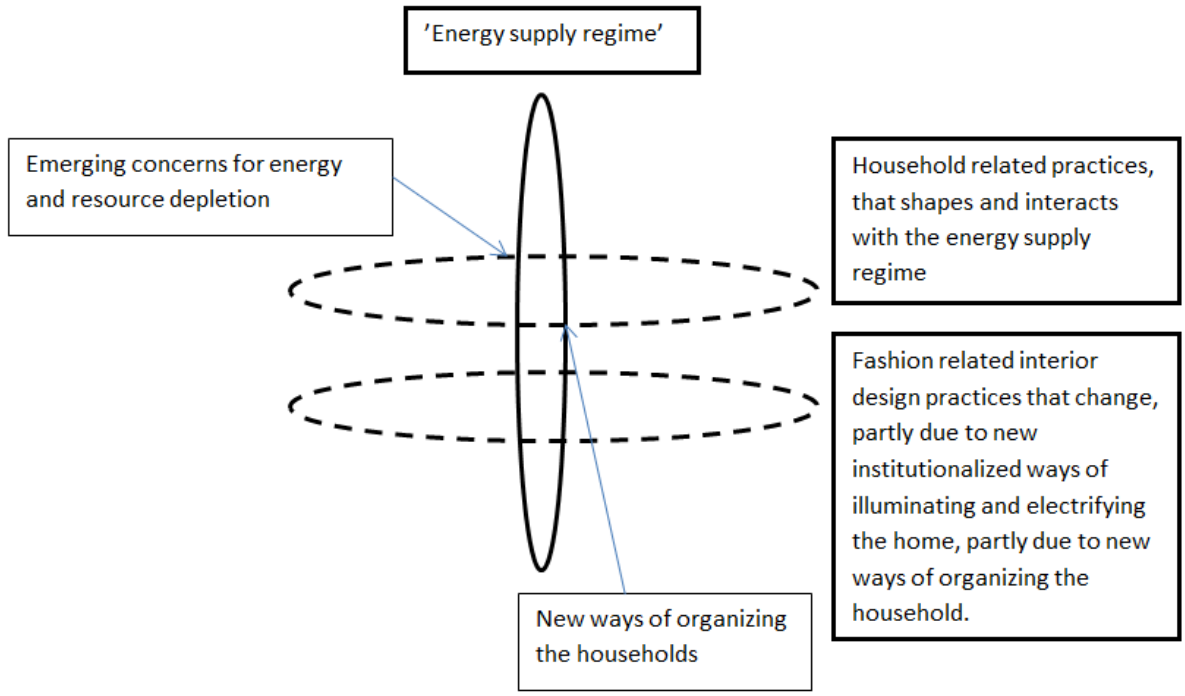

Figure 4: Changes in energy supply system and how households are organized due to emerging concerns for the environment (based on model by Hargreaves et al. (2013))

So far, lighting seems shape and be shaped by several practices related to organizing the household, but also practices connected to designing and structuring the physical aspects of a household. Further, lighting seems to play a role for some of the changes that have occurred in what can be termed as an energy supply system. What does that entail for the shaping of lighting patterns and the possibility for turning these patterns energy efficient or even sustainable? Bearing this question in mind, this brief and exemplified description of some of the historic developments of electrical lighting may equip us to understand what happens in the electrical lighting arena today.

The Curse of the Electrical Lighting

In 2005, the European Commission launched an eco-design framework directive that from 2009 specifically came to include efficiency requirements for electrical lighting as well (EC, 244/2009). At the moment, the consumer meets a wide range of lighting technologies, such as 1) the compact fluorescent light bulb (CFL -in Danish: 'A'-pæren'), 2) the halogen light, both as spots and bulbs, and 3) the latest arrival; the light emitting diode technology (the LED). Although many of these relatively more energy efficient lighting technologies have been under development for long (as already mentioned, the fluorescent tube already appeared in the 1940s the actual phenomenon or phrase 'energy efficient light', at least in Denmark, is a fairly recent one. The EU commission's efficiency strategy is ambitious, increasingly raising the standards for performance.

In an MLP terminology, tougher regulations may exacerbate existing problems with the regime in question (Geels, 2005), however, in this case, it is not clear what regime is being challenged. Energy efficiency standards are being implemented widely, not just for lighting, so the regime in question could potentially still be the 'energy supply regime'. In this case, it is interesting that regulations exerted on one regime, due to the products and services it aims to regulate, will have direct consequences for 'adjacent' regimes and vice versa, as lighting, as will be sketched out in the following, is not only a part of several practices, but also increasingly becoming a more significant aspect of what can be characterized as several systems/regimes.

Recent developments of new lighting technologies, such as LED, have significantly altered what lighting 'is'. The scene is appropriately set by the president of the independent organization Danish Lighting Center (DCL), who, in a recent volume of DCL's professional magazine states that "*the lighting technology has moved from being low-tech with a light switch on the wall and few light sources, to becoming high technology with programmable light, and various lighting sources"* (translated, LYS, 2012[3].). The LED is playing a crucial role in this transformation. The LED is not a new technology as such, in fact the first report on luminous semiconductors (LED's are semiconductors) dates back from the beginning of the 1900's. However, it was mainly used as signal and display lighting until very recently (2007) where it has emerged as general light sources in offices and hotels[4]. The LED lighting technology has therefore only recently become part of the range of general light sources. in MLP terminology, the LED could then be considered as a niche development that, due to landscape pressures in terms of energy concerns, has gained momentum as a general light

[3] LYS 2012, volume 3 p. 5

[4] dcl.dk project PSO 340 044

source by linking up to the high-efficiency demands. The LED is highly banked upon as it is becoming one of the most energy efficient lighting technologies (measured in lumen pr watt) that we know of (eg. Green Paper, 2011).

Besides being an energy efficient light source, the LED is also the only available lighting technology that is an *electronic* product, which means that new professions are entering the lighting sector. Additionally, in being an electronic product, it can 'do' different things than the well-known light sources; For instance, the LED light can have many different colours (red, blue, green and everything in between), and since the LED is an electronic product, the LED light source is digitally accessible which makes it possible to dynamically control the mix of colours as well as the colour temperature (the warmth/coldness in the white light). These new qualities have opened up for discussing and using light in different ways than we are used to. As an example, the LED and its' digitally addressability is interesting in relation to the emerging scheme of *smart houses*. An LED light source can network with control devices to enable centralized control and information feedback for maximum energy savings, which is something that is increasingly dealt with in terms of managing energy savings within the home (eg. Han et al, 2010). Further, new discussions of how to digitally light cities more dynamically are emerging (EU, 2013). Additionally, as the LED technology is very versatile it is also discussed in terms of *application*, as it can be built in to furniture and the structures of the house.

Being a dynamic light source, the LED as a light source also feeds into the health discussions about light and circadian rhythms. Research show that light with a certain spectral distribution disrupts the day's natural rhythm which is unhealthy, as it disturbs the circadian rhythms. So, in this sense, the LED can meet these issues by 1) being dynamic and potentially be steered to follow the daylight and 2) by excluding certain wavelengths (Corell et al, 2009). The study of artificial light and its impact on humans is not new. Frederick Taylors' experiment with light sources in the workplace is a well know example that dates back to 1911. And health issues were actually also debated along with the introduction of the incandescent light bulb. Danish weekly magazines would present articles on the light from kerosene light being better for the eye than the intensive, electrical light (Lytken, 2012). The health related discussions that seems to be flourishing at the moment, are perhaps due to the fact that it is possible to tailor the exact spectrum of light that is wanted, through the LED technology. Indeed, with light in relation to health in mind, a newly founded school in Copenhagen municipality has been equipped with 90% dynamic LED light sources[5]. This has been implemented to support the learning curves and stimuli of the students, as well as forming an example of state of the art research implemented in architecture.

Having the historic assessment of potential intersections shaping lighting patterns in mind, it is interesting to equally assess the current situation of lighting. Based on the above brief description of emerging lighting systems and related dynamics, several interesting things occur looking at systems, practices and intersections. As mentioned, the LED lighting technology would, in MLP terminology, be treated as a niche development, that currently, due to landscape pressures related to energy efficiency requirements are gaining momentum as a general lighting source, even though it for long has been regarded as a completely different thing with different application. However, the LED light source does not only feed into the energy supply regime that is under energy efficiency landscape

[5] Source: interviews with KHR architects and Louis Poulsen Lighting .

pressures, - it also opens up for health discussions due to the prevailing considerations about lighting in terms of well-being and learning curves. This may considered as a certain discourse that certain professions and research areas are emphasizing, in order to influence the direction in which lighting and lighting design develops. Further, being a technology with a lot of potential for what can be termed as an emerging 'smart housing' regime, the building sector and thereby housing regime is also important to acknowledge as playing a role for what happens with current lighting developments. Emerging residential lighting systems may however equally exert changes on household related practices or standardizations in terms of a new housing regime. According to a study I have done elsewhere the technology is not in focus when people illuminate their home. It is through various practices and related activities connected to the home that lighting comes to make sense. This corresponds very well with what can be learned from the historical use of light. The current lighting patterns are incidentally very much alike the ones that developed in the beginning of the 1950s, with small lamps scattered around the house, all with functional and specific usages. One difference is however remarkable, and that is the emerging pattern of halogen spots built into ceilings in hallways and bathrooms as well as cupboards in the kitchens, resulting in new, ambient and unintended stagnation (potentially increase) in energy consumption (eg Southerton and McMeekin, 2012). The reasons for this spot-based ambient light trend are interesting to follow up on, and more research should be done. However it does seem to indicate that it is not necessarily energy consumption that is in focus when illuminating the home .However complex lighting may start to seem, the scene is not yet entirely set. The LED is not only a 'different' light source in terms of being electronic, - it is also different in its way of shedding light. The LED, due to its design, produces a directional light from each diode. The other more well know light sources cast of a much more omnidirectional light. This creates some challenges for lamp designers, who with the introduction of the LED are starting to think differently in terms of design. At the moment Louis Poulsen, as an example, is looking towards simplistic, futuristic designs for their LED based lamps, which is a new wave within their way of designing[6].

In figure 6, the intersections between regimes and practices that we have already established is sketched out, with the addition of the intersections that seem to appear from some of the more recent and still on-going developments.

[6] Based on interview with LP, October 2012.

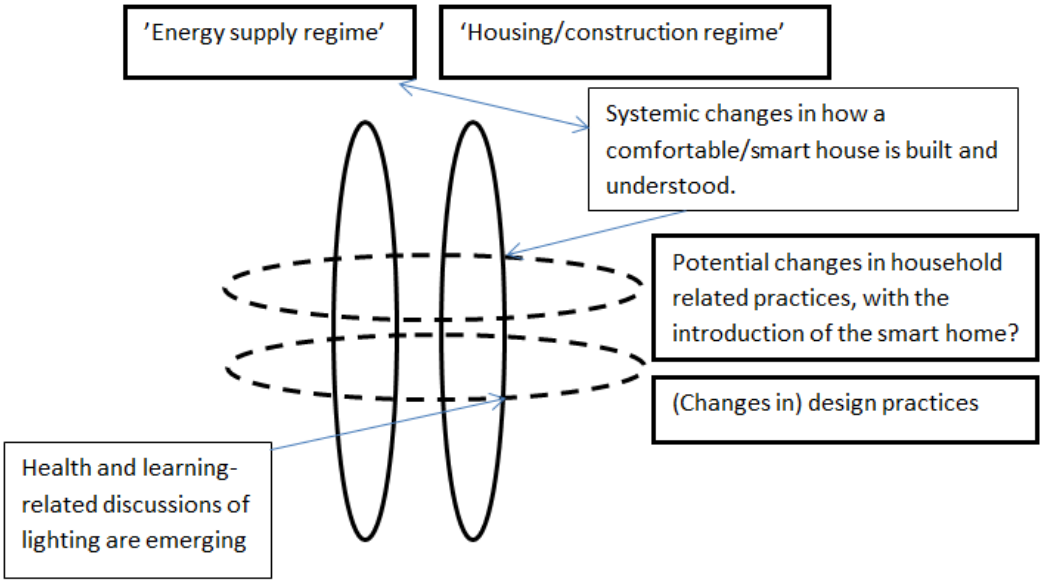

Figure 5: multiple regimes and systems of practices that intersects when trying to understand the current arena of electrical (residential) lighting (based on model by Hargreaves et al. (2013))

Another challenge that is important to acknowledge is that since the LED is an electronic product, many EU directives need to be complied with, that producers did not have to consider before. According to DELTA[7], LED producers need to know about, and comply with, nine different directives, which is significantly more than for other lighting technologies.

Looking at the LED not only as an electronic product but as a new light source, a need for new and other skills has emerged, as well as a need for new standardizations[8].

[7] Based on presentation by Claus Rømer Andersen (former EMC consultant at DELTA) at a workshop about LED ("ATV: LED - den lysende revolution") 24/10/12.

8 European Quality Charter http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/files/documents/eu_led_quality_charter.pdf

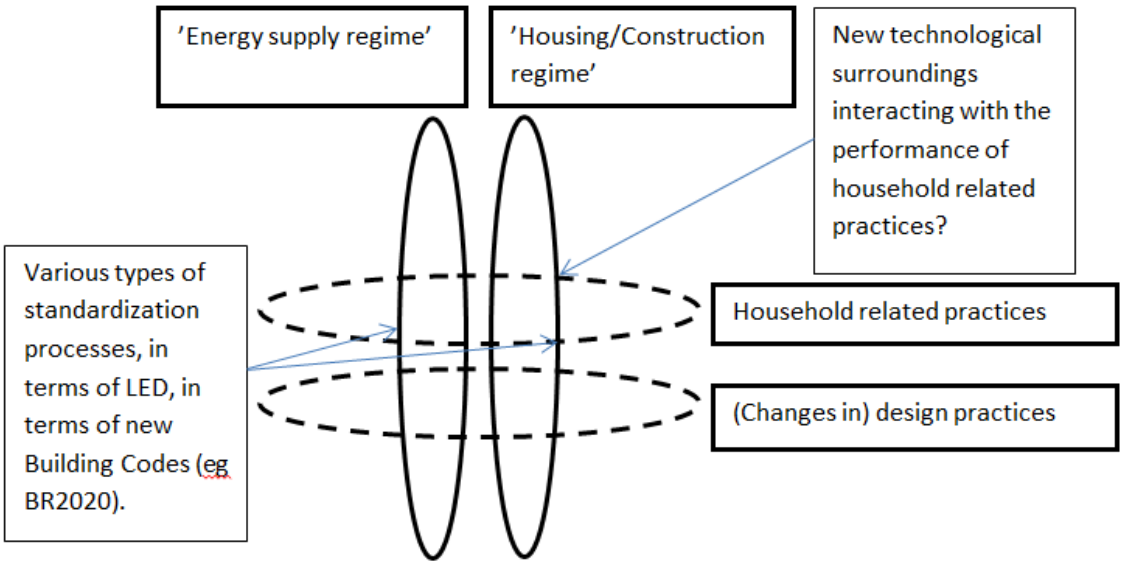

Figure 6: Current glimpse of the complex web of (electrical, domestic) lighting (based on model by Hargreaves et al. (2013))

CONCLUDING REMARKS

There are conceivably many other practices and systems that could be useful to consider when discussion lighting, but the point with this paper is rather to show that it is in fact useful to look at *intersections* between these, when trying to understand some of the complex development patterns that a phenomenon like lighting undergoes. Responding to Hargreaves et al. (2013) call for identifying situations where systems and practices bump into each other during transition processes, this article has explored potential bumps between some of the main systems and practices in which lighting plays a role. How good as well as efficient lighting is to be obtained is evidently multifaceted and complex. But instead of regarding this as an unhelpful overcomplicated turn of event, it may be useful to remind ourselves of the importance of having a broad focus when making policies for energy consumption. As it appears, lighting is not just a matter of products capable of substitution, but also developments within several institutionalized systems such as housing/building codes and energy supply systems, as well as the on-going reproduction and organization of household related practices as well as design practices. Obtaining good as well as efficient lighting *patterns* may require a shift from focusing on optimizing the individual lighting product towards focusing on how standards and requirements for lighting products interact with standards and requirements for building codes and smart home visions as well. It is equally important to acknowledge that activities within the home, in which lighting plays a role, are organized around different considerations than merely efficiency. Efficient light should therefore not only be promoted as efficient or economical, but just as much in terms of quality and what situations the particular light sources facilitate. With the many design possibilities for the LED, both in terms of shape, functions and spectral distributions, lighting is no longer a matter of 'one, general light source'. Focusing on - as well as demonstrating that - different versions of the light source may fit different situations respectively,

seems crucial. Giving up the idea of 'one solution fits all' may in fact be useful in order to potentially promote appropriate, recognizable configurations of lighting patterns that work. It is important to remember that changes in practices can come about by making or breaking links between elements of practice. If links are made between *material solutions* comprised of dynamic LED light sources and meanings related to appropriate lighting, the smart and efficient lighting patterns may be embraced as a working solution in the home. However, competences related to making appropriate lighting with smart, dynamic light sources have to be facilitated and helped through the configuration of the house. If the physical installations and layout of the house do not support lighting patterns based on what is socially defined as 'appropriate lighting', then the links are not likely to be made. Breaking links between meanings related to 'appropriate lighting' and halogen and incandescent light thus also a challenge that needs to be faced. Lastly, it is important to acknowledge that if practices are closely linked to the institutionalization of systems, changes in practice may yield changes in systems as well, potentially causing changes in *what* needs to be standardized and *how* it should be standardized. Focusing on ensuring space to create configurations that work across systems and practices, instead of silo-based schemes for each system, may be beneficial.

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