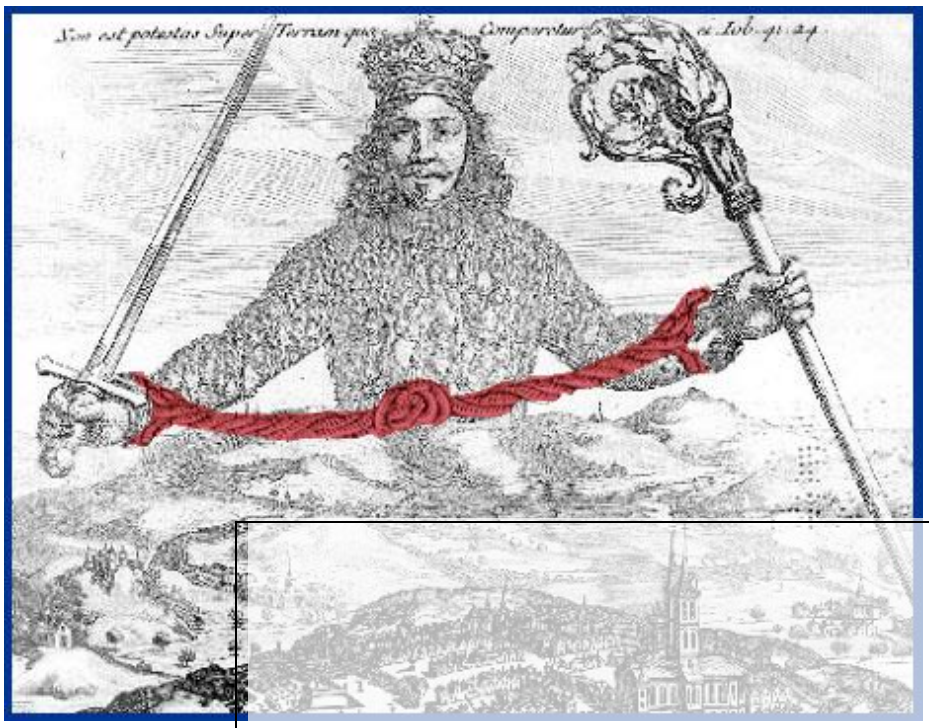

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Libertarian paternalistic instruments fostering sustainable energy consumption

*An analysis based on energy-efficient LED technology**

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Introduction

Germany and many other countries, like the European Union member states, have committed themselves to massive reductions of energy consumption in the upcoming years. By 2020, the German government wants electricity consumption to be reduced by 10 percent compared to 2008. By 2050, consumption is scheduled to be reduced by 25 percent[1]. A small comparison of facts shows that according to the current state of affairs, this goal can only be achieved with a major rethinking and behavioral changes in the population: Germany's gross electricity consumption in 2008 was approximately 618 terawatt hours and approximately 594 terawatt hours in 2016[2]. This equals savings of only about 4% within 8 years. The ambitious goal of 10 percent energy reduction in 2020 seems to recede into the distance.

Significant savings potentials can be found in private households, which require between 15-20% of total energy consumption in OECD countries. In Germany, this number is even higher with up to 25% of the total annual energy demand. As sharply rising energy prices in Germany continue to burden consumers, additional hard or even soft paternalistic interventions[3] by the government are largely unrealizable or can only be implemented with great resistance.

Despite increasing environmental awareness, people's behavior and actions are not adjusting in a sustainable way. There are various reasons for this behavior such as a lack of information or the low priority people attach to energy savings (Steg, 2008). Hirst & Brown (1990) question the decisions of households when it comes to investing in energy-efficient solutions. Despite the long-term benefits of these investments, the demand for these products is still low. They argue that a possible "energy efficiency gap"[4] would hinder the achievement of climate policy goals.

This paper investigates economic policy measures that may contribute to a reduction of the energy efficiency gap. Since for regulatory reasons governmental interventions should be

[1] see https://www.bundesregierung.de/Webs/Breg/DE/Themen/Energiewende/Fragen-Antworten/1_Allgemeines/1_warum/_node.html

[2] see https://de.statista.com/statistik/daten/studie/256942/umfrage/bruttostromverbrauch-in-deutschland/.

[3] Hard Paternalism: governmental requirements and prohibitions (Kirchgässner 2014)
Soft Paternalism: taxes and subsidies (Kirchgässner 2014)

[4] Gerarden et al. (2015:1) definieren diese Lücke "[…]as the apparent reality that some energy-efficiency technologies that would be socially efficient are not adopted."

prevented as far as possible, and the discrepancy between people thinking and acting of the population drifts apart, alternative solutions to minimize the gap are in the discourse.

One of these approaches is based on the latest findings of behavioral economics is the idea of a libertarian paternalism which was brought up by Richard H. Thaler and Cass R. Sunstein in 2003. Their jointly published book "Nudge: Improving Decisions on Health, Wealth and Happiness", published in 2008, has met with the utmost popularity in economic policy and encourages more researchers from all fields to contribute to it. The authors suggest that people are not always able to make their own optimal decisions, and every now and then need a "nudge" to help them subconsciously in the decision-making. Particularly in the case of complex decisions, such as investment decisions, the government sees itself as obliged to offer assistance to people, in such a way that they are better off after the influenced decision, setting their own standards as benchmark.

The focus of this paper is the analysis of the extent to which the "energy efficiency gap" can be closed with the help of this new behavioral economic approach. The light-emitting diode (LED) will be the main subject of the investigation, as it is extremely energy efficient, relatively cheap, and the change to LED bulbs is technically very easy to implement for any household.

In the next section, we will state the theory behind the libertarian paternalism and its justification. Afterwards, several libertarian paternalistic instruments will be introduced. Since the literature already contains a broad variety of such instruments, this paper will focus on those, who delivered robust results in experiments and can be linked with energy consumption. We conclude this paper in the final section with a summary of the main findings and a lookout for what is to come.

Theory and justification of libertarian paternalism

The main target of libertarian paternalism is the improvement of the well-being of individuals. This is not achieved by imposition of prohibitions by the governance, but by trying to influence the decision-making behavior. In doing so, the decision-making

framework is constructed in such a way that human errors are minimized as far as possible, without restricting the decision-making and freedom of choice of the individuals. Sunstein & Thaler (2011) give a well-known example: in order to promote the health of canteen visitors, food is placed in such a way that it is eaten as healthy as possible. This was achieved by placing fruit and salad in front of the unhealthy food. This resulted in significant behavioral changes. Only on the basis of the constructed decision-making framework, people more often consumed fruit and salad although sweets and high-calorie food were still an option, as before.

The actor who develops this design is called the Choice Architect (Sunstein & Thaler, 2011) and thus has the power to steer decisions in the right direction.

In order to understand the reasons of governmental libertarian-paternalistic interventions, it is necessary to examine relevant assumptions of the rational choice theory:

The basic assumption of the rational choice theory is that every decision making actor has a stable and consistent preference order. Preferences are called stable if the preferences for particular goods are not flexible, are exogenous and that a change in preferences is only possible if the conditions and restrictions change (Kirchgässner 2000). A consistent preference order, inducing transitivity, means that each individual has a fixed ranking for a given set of goods. If an individual prefers good A over good B, and good B over good C, it must follow that the individual prefers good A over good C.

Another important assumption underlying the rational choice theory is the complete information of people, which allows the knowledge about every single alternative in decision-making situations. The resulting consequences can be accurately evaluated. Under the strict assumptions of the rational choice theory, an individual acts rational if it, under complete information about all environmental conditions and consequences and on the basis of consistent, selfish and temporally stable preferences, selects the alternative that will maximize his own expected net benefit, weighing up advantages and disadvantages. (Neumann 2013).

If these assumptions were applicable in reality, libertarian paternalistic interference of the governance would not be necessary or justifiable. However, real people have cognitively limited capacities and only very limited information available in decision-making situations (e.g. Simon, 1957). Kahneman & Tversky (1974) conducted a large number of experiments to

examine decision-making under uncertainties and incomplete information. In doing so, a variety of decision making weaknesses were discovered, which in particular violated the assumptions of the rational choice theory. Incorrect expectations led to wrong cost-benefit analysis. Information visualization influenced decision-making behavior, which contradicted the assumption of stable preferences. In addition, the assumption of transitivity was refuted. Another finding was that individuals used heuristics when deciding on uncertainty that did not necessarily maximize their utility.

Because of these identified distortions in human decision-making, libertarian paternalistic interventions can be justified. In the further course of this paper, some of those possible interventions will be presented and explained.

Libertarian paternalistic instruments for the purpose of energy savings through the usage of LEDs

After discussing the theory, hereinafter selected strategies and instruments of libertarian paternalism are examined in more detail. It will be shown how these tools can be used to promote sustainable consumption and provide incentives to invest in energy-efficient LEDs.

Default-Option: The Status Quo Bias

Setting or changing default options can lead to remarkable changes in human decision-making. The default option is that alternative which is initially given in a decision situation and which becomes valid if the person concerned does not express the wish for a different regulation, while at least two alternative courses of action are available (Kirchgässner, 2000). In this context, assuming the postulate of complete rationality, the decision maker would choose the option that would benefit him the most, according to rational choice theory assumptions, regardless of which alternative was set as default by the choice architect. In reality, however, for convenience or inertia, an individual tends to remain in a status quo state in which it has a propensity not to change his actual state, although an alternative decision would yield a higher utility level.

This behavioral anomaly which violates the assumption of stable preferences and possibly the transitivity condition too, is known under the name of “Status Quo Bias” and has been

thoroughly investigated and proven (e.g. Samuelson and Zeckhauser, 1988; Johnson and Goldstein, 2003). Applied to environmental economics, “green defaults” have been identified as a possibility to induce a more energy efficient behavior.

In order to illustrate the efficiency of the default option in environmental policy, it is useful to study the decision-making behavior of the energy market. Daniel Pichert & Konstantinos V. Katsikopoulus (2008) discuss the effects of defaults when it comes to choosing the electricity tariff. They hypothesize that the choice of electricity tariff depends on the default option. The individual has the opportunity to select the more expensive "green power" which originates from renewable energy, or the cheaper "gray power", which draws the energy from nuclear and coal power plants. According to the authors, the majority will choose the type of electricity that has already been prescribed as the standard option. Some indications that their hypothesis could be correct are shown by two real examples.

In the small town of Schönau in southern Germany, after the nuclear catastrophe at Chernobyl in the 1980s, a referendum on basic energy supply through renewable energies was enforced (52% vs. 48%, voter turnout 90%) After the liberalization of the German energy market in 1998, the consumers could have used the opportunity to switch to the energy supplier and thus they could once again choose between green or gray power. More than 99% of the Schönau residents stuck to the status quo of green power, even 8 years later.

The energy supplier “Energiedienst GmbH” observed a similar phenomenon in 1999. It diversified its one-tariff stream into three tariff groups: expensive premium green electricity, less expensive green electricity and cheap gray power. They informed their customers in written form about the conversion, and gave them the opportunity to change the tariff, whereby the normal green electricity was set as default. Around 94% of customers did not respond to the letter and were therefore supplied with sustainable energy.

In order to support their thesis and to control for the stability of preferences, Pichert and Katsikopoulus conducted two laboratory experiments. 225 participants between the ages of 18 and 35 (63% students) were handed a questionnaire[5]. It described a fictitious scenario:

[5] The questionnaire can be found in attachment 1

Participants had to imagine to relocate to another town and to choose between two electricity providers: Acon, a provider of cheap conventional electricity, and EcoEnergy, a slightly more expensive supplier, which offers green electricity from renewable energy sources. Three different versions of the questionnaire were used for the study: In the first version, the gray power provider was set as the default supplier. Here, 41% of the participants chose to switch to the green provider. In the second version, where the supplier of the green electricity was set as default, 68% stayed with the provider. The third version was neutral and no standard was set. The result was quite similar to those of the second version with 67% of the participants choosing the eco-friendly green supplier. These outcomes confirm the authors' thesis, with the affinity of green electricity in the neutral version suggesting that participants have strong "green" preferences which are distorted within the "gray" representation of the status quo effect.
Consequently, we can conclude that the assumption of stable preferences is not met in reality. Libertarian paternalism could therefore be a cost-effective way to internalize unwanted externalities by "standardizing" green electricity.

Applied to the lighting market, when choosing between a variety of illuminants, the consumer can be cognitively overwhelmed, and therefore resorts to energy-inefficient products that are cheaper in the short term, but on the other hand, have a higher energy consumption and are therefore more expensive in the long term. Is it possible to nudge the consumer in the right direction by means of a "default option", so that the probability that he chooses energy-efficient light sources like the LED increases?
Dinner et al. (2011) conducted an experiment in order to answer this question. Two groups of subjects had the choice between two types of lamps. The 209 participants were presented the following fictitious scenario: The homes of the subjects are being extensively modernized and, depending on the presentation of the "default option" (Group 1 or 2), homes have already been equipped eighteen inefficient low-priced Bulbs (group 1) or eighteen energy-efficient more expensive energy saving lamps (group 2). Subsequently, the two groups of subjects were asked whether they would like to keep the bulbs used by the construction company without further consideration of switching costs or whether they want to use the other illuminants. Additional information on the characteristics of the lamps was provided for decision: The conventional light bulb has an expected lifespan of about 850

hours, costing $ 0.50 per piece, and with a total of 10,000 hours operating at 18 incandescent bulbs costs $ 49 annually. The energy-saving lamp, on the other hand, can last up to 10,000 hours at a price of $ 3 per piece, and states operational costs of $ 11 in electricity per 10,000 hours of use[6].

As in the case of the decision between green and gray energy, the choice of the default option had a significant influence on the decisions of the participants. 43.8% of the subjects opted for the classic light bulb if it was already installed (group 1). On the other hand, only 20.2% of the people in the second group opted for the light bulb and preferred their status quo of the energy saving lamp.

Considering that the LED technology is more energy efficient and offers even more advantages compared to the energy saving lamp, it can be assumed that the results could have been even more drastic[7].

Deriving from the above examples it can be stated that the default option can be an effective tool for the decision maker to overcome the inertia that is due to the general uncertainties, loss aversion[8] and endowment effect[9]. Apart from the general ban on bulbs in Europe and also in other parts of the world, an LED default option, e.g. being set up by construction companies, can be efficient, cost effective, and by saving energy contributes to minimizing CO2 emissions.

Framing Effects

Another way to nudge citizens towards sustainable energy consumption without hard paternalistic instruments such as bans is to optimize the provision of information - and in particular its design (Thaler & Sunstein, 2011). As mentioned before, the decision-making behavior exhibits various anomalies and can be effectively influenced by the choice of

[6] See attachment 2.

[7] Sallee (2014) confirms that the attention in decision-making is lower when the products are similar. The LED, as a technically superior product, would further increase the discrepancy, and vice versa, lead to greater attention, which would rather lead to an investment.

[8] The tendency for safe, smaller profits to be preferred over uncertain, larger profits (Kahneman et al., 1991).

[9] If the value of a good must be estimated, this value will increase significantly if the individual already possesses the good. This is also referred to as equipment effect or endowment effect (Kahnemann et al 1991).

information content, the scope of information and their creative presentation. The different perception and cognition of signals, information or symbols here influences the subjective definition of the situation, which represents the frame of the subsequent decision-making (Neumann, 2013).

Due to the diversity of subjects, their information processing in decision-making, and their use of heuristics, the challenge of the choice architect is to present the optimized information that minimizes the systematic errors of the individuals.

Information provision on packaging of energy-efficient products such as LEDs plays an important role, especially in the case of a local purchase. Newell & Siikamäki (2013) provide a study from the USA concerning that matter. They measure the efficiency of various energy labels as to what extent the labels influence energy-efficient behavior. Helpful conclusions about the current packing regulations of bulbs can be drawn.

The study observed 1,217 participants which were divided in 12 groups of about 100 subjects each. The participants faced five different choice decisions containing three different water heaters each. Depending on the label type, different information was displayed with varying presentation methods. The depicted information regarded purchase price, annual operating costs, CO2 emissions and operating costs relative to a range of comparable models[10].

The US-American label "EnergyGuide" served as reference for the twelve labels. This label is mandatory not only for water heaters but also for other devices with high energy consumption in the US (depicted as first label in Figure 1). It includes the estimated annual energy cost (here: $ 265), a scale showing the consumption costs of comparable products (here: $ 196 to $ 380), as well as the physical information of estimated annual therms (1 therm ~ 29.3 kilowatt hours).

Additionally, the Energystar[11] (label 8) as well as the European Union energy label (label 12) were customized and evaluated. The black footprint (label 11) is a reference to the British standard PAS 2050: 2008, which shows the carbon footprint for this product (here: 2.9 million tons of CO2).

[10] See attachment 3.

[11] An US Environmental Label awarded for energy-saving products.

Figure 1: labels used in the survey (Newell & Siikamäki, 2013)

The results of this study showed that the sole information on energy savings (i.e. annual operating costs) was the criterion that motivated participants the most to invest in energy-efficient products. The physical properties (consumption of kilowatt hours) came in second, followed by the CO2 emissions. It was also found that in addition to the numerical information, the logos with recognition features such as the EnergyStar or the European Union energy label had a significant impact, increasing the choice for more energy efficient products. Additional information, e.g. the comparative scale of energy costs with comparable models, had no significant impact.

It can be concluded that an individual, when choosing a product, can be significantly influenced by the amount of information as well as the representation. Too much information can overwhelm the consumer (Saaty, 2008). Additional colored illustrations on the other hand facilitate the decision for sustainable consumption. Loewenstein et al. (2014) therefore see the government as a possible decision-making architect of these labels "[to] reduce the number of less important disclosures so as to increase the salience of the most important ones" (Loewenstein et al., 2014: 22).

Applied to the illuminant market, when looking at the current information on the packages of LED bulbs (see Appendix 6), up to fourteen features are stated. The new regulation No. 2017/1369 of the energy consumption labeling could additionally overwhelm the consumer.

This psychological overstrain due to sensory overload could, according to the theory of status quo bias (Chapter 2.1), lead to the consumer reaching for a known product that may be inefficient. The most important information for the consumer, in addition to the purchase price, is the estimated annual energy costs (Newell & Siikamäki, 2013). Despite the high significance found, this feature has not been integrated in the EU among the 14 properties while it is mandatory in the US since 2012.

Comparing two alternatives with this designation as shown in Figure 5 could lead to a more favorable decision of the consumer. Here, the economic sense of the consumer is being addressed. With a constant brightness of approximately 800 lumen, the consumer saves $ 6.03 in the first year, which already exceeds the difference in the purchase price.

The design of illuminant labeling information could be further optimized in the EU to give buyers a nudge to invest in energy-efficient LEDs. A recent online study (Rodemeier et al., 2017) confirms that the LED is still receiving insufficient attention and significantly underestimated in terms of cost savings potential. As information on lifetime costs increases, the measured willingness to pay increases according to this study. Although the 1,083 participants knew about the advantages of the LED, they were still insufficiently informed. However, further field experiments would be necessary to determine to what extent a change in the current label has a significant influence on the decision-making behavior of illuminants.

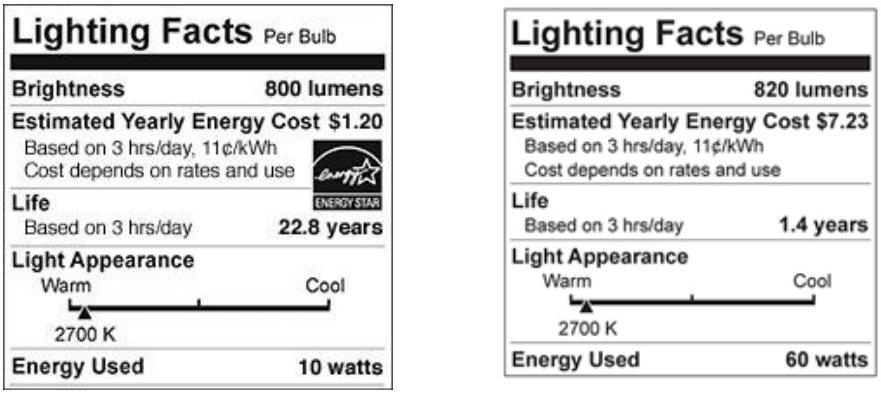

Figure 2: Comparison of displayed information on LED and light bulb packages in the US[12]

[12] http://www.snopud.com/Site/Content/Images/ee/LightingFacts_LED.jpg and http://www.bulbs.com/images/resource_section/ftclabel.png

Time inconsistency and the „energy-efficiency-gap“

In the rational choice theory, future benefits are exponentially discounted in the present value calculation. The expected present value is calculated as follows:

$$U_t = \sum_{t=1}^{n} \delta_t * u_t(x_t)$$

with *t* as time index, $\delta_t = \left(\frac{1}{1+\mathrm{i}}\right)^{\mathrm{t}}$ as discount factor and $u_t(x_t)$, as utility with respect to *x* (Beck, 2014).

Here δ is less than one as future benefits are weighted less than today's. The discount factor decreases exponentially. The individual is e.g. indifferent between a present benefit of 10 (t = 0) or a benefit of 11 in (t = 1), with a discount factor of ~ 0.909.

Figuratively, this would mean that humans would count today's "loss" (purchase price of a light source) against the exponentially discounted increase in utility (energy savings) in the future – a behavior which would cause an energy efficiency gap as the superior new LED technology is not fully adopted because of a higher buying price although it would lead to larger energy savings.

This thesis will be analyzed using the following modified formal-analytical approach by Allcott (2015).

Consumers have the choice between two light sources with $j \in \{E, I\}$. Illuminant *E* is more energy efficient than I, with energy consumption of $e_E < e_I$. The price are depicted as p_j, the time index is *t* and the bulbs have a shelf life of *T* years. The exogenous use of the product is given with *m* per use; *g* stands for the energy costs, and the consumers discount with the factor δ. The expected total energy costs (*G*) are therefore as follows:

$$G_j = \sum_{t=0}^{T} \delta^t * e_j * m * g$$

(Allcott, 2015)

Product *j* yields a utility of v_j. Differences are defined as follows:

$p = p_{E-}\ p_I$, $G = G_E - G_I$, $v = v_E - v_I$.

The homo oeconomicus buys product *E* only if the net benefit is greater than the relative purchase price, i. E. $v - G > p$. Since $G < 0$, due to the better energy efficiency of *E*, the left side of the equation increases, so a higher price of *E* is accepted due to the cost savings. This

would suggest that for moderate uses *m*, the exponential discount factor δ, and a price difference *p* of around € 2.50, it would be always rational to opt for the more energy efficient LED.

However, behavioral economics came to different conclusions in reality. Despite the preferences for saving energy, individuals do not always opt for more energy-efficient options (Steg, 2008).

This happens due to to behavioral anomalies (Allcott, 2015), which will be further investigated in order to analyze for appropriate economic policy intervention.

Present bias: humans are impatient and prefer to consume immediately rather than gaining more benefit in the future (Loewenstein, 1996). This is indeed rational as long as the discounted future utility is not exceeding the possible present utility. However, several studies (Laibson, 1997) have found that future increases in benefits are heavily discounted and people have very strong preferences for immediate consumption at a lower utility level. Figure 3 depicts the comparison between an exponential discounting and a hyperbolic discounting established by Laibson (1997). This effect is called time inconsistency, as the individual tends to overestimate the current expenses and underestimate future payoffs in terms of energy savings. It therefore decides only for *E* if *v - ß * G> p*, where the bias *ß* is dependent on its time preference.

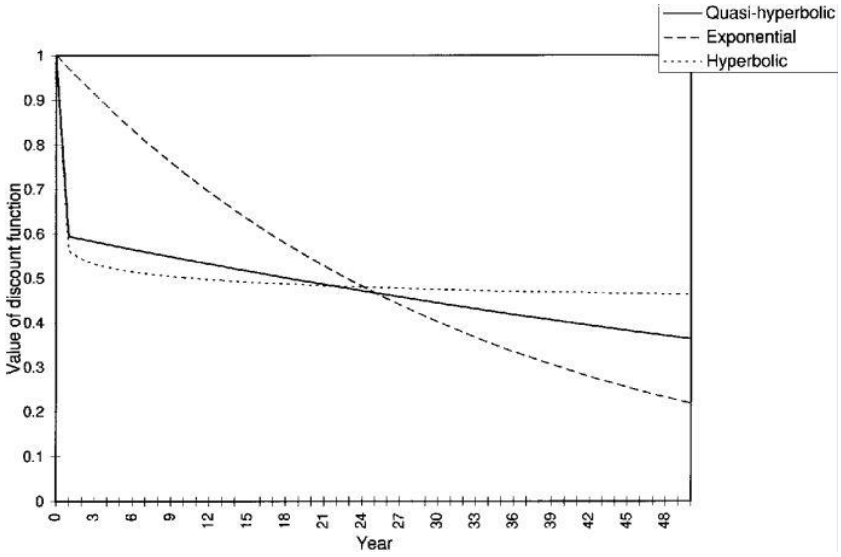

Figure 3: Exponential vs. hyperbolic discounting (Laibson, 1997)

Bias toward concentration: „[…]the bias toward concentration implies that an increase in the number of periods in which the future costs of current misbehavior are dispersed increases

present bias" (Köszegi and Szeidel, 2012) Future payoffs (here: because of lower energy costs) are given less attention than today's costs. Similar to the present bias, this underestimation is dependent on the bias factor β.

Biased Beliefs: Consumers are not really aware of energy prices and may perceive them as distorted with ϕ, so that buying E is only worthwhile if $v - \varphi G < p$. If energy prices are underestimated, buying a conventional light bulb is more likely.
We can conclude that the problem here is that humans do not think far ahead and because of the dynamic inconsistency, future savings are being neglected.

Another reason for the preference of short-term cost savings in terms of cheaper light bulbs is in the mental accounting. "Mental accounting is the set of cognitive operations used by individuals and households to organize, evaluate and keep track of financial activities" (Thaler, 1999).
If an individual has no budget for "lighting" in his mental accounting, it will probably only buy a replacement product if an old light bulb breaks and likely opt for the product that is the supposedly cheapest. This is also confirmed by a study by Gross & Souleles (2002). They found that US households have about $ 5,000 in cash, mostly at low interest rates in the savings account. On the other hand, on average they have $ 3,000 in debt, which must be paid off at a much higher rate of interest. Many are aware of this, but do not shift the money between the accounts and thus make losses just because of their mental accounting.

In addition to the provision of information, time inconsistency in the context of energy saving must also be overcome by a certain degree of self-control, such as mental accounting. Thaler & Sunstein (2011) name two different sides of the inner self that influence self-regulation in connection with the self-control.
On the one hand, there is the "planner", who is interested in long-term benefits (e.g. savings or a healthy BMI). On the other hand, the "doer" prefers the short-term temptations (e.g. new shoes, chocolate) despite the long-term negative consequences. The struggles between these two internal mechanisms are carried out on a daily basis, and the temptations that increase short-term benefits must be resisted. If the "doer" holds the greater power, he will

not be interested in energy savings as it yields few benefits in the short term. Therefore, self-regulation is important in order to achieve long-term goals and to encourage energy savings.

In order to achieve an efficient self-control, a regular feedback which reminds the consumer how much electricity is consumed is necessary to adjust the behavior in future decisions. This is especially important for the element of electricity as it is an intangible product which is only noticeable on the annual electricity bill. Energy itself is invisible and therefore should be made visible to the consumer.

There are a variety of studies in different countries where the effectiveness of feedbacks has been measured. In the study by Gleerup et al. (2010), 1.452 Danish households were informed by weekly energy consumption feedback via e-mail or text message if their energy consumption was too high. While this led to a 3% decline in energy consumption, it was not statistically robust enough. By contrast, a robust result was reported by Gans et al. (2013). The participants were not informed by e-mail or SMS about their energy consumption, but could track their current energy consumption in real time on a home-in-display. This resulted in savings of up to 18% and was highly significant. Other studies also show highly variable results, depending on method, sample size, short and long term outcomes.

The underlying technical implementation of real-time consumption controls are smart meters, an electricity meter that can send the consumption data over the wireless network and thus can be received from anywhere. The large-scale roll-out of these devices will take place e.g. in Germany over the next few years and can be seen as a libertarian paternalistic intervention when a mandatory smart meter can be considered technological advancement.

Considering the results of the above mentioned studies, we can assume that if households can realize their current consumption via an app and thereby analyze the resulting costs, they will pay more attention to potential (energy and cost) savings. It would be easier to set and control one's own goals (effective self-regulation). The motivation to achieve cost savings could lead to investments in energy-efficient products like the LED. The time inconsistency and thus the underestimation of future energy savings could thus be overcome.

Social influences

Another major influence which leads individuals in decision-making situations to not only include the subjective cost-benefit analysis is the behavior and actions of other people from the individual's social environment. Observations about other's behavior are subtly incorporated into the social-cognitive processing, and by comparison with other individuals, the alternatives are re-weighted. In this context the assessment of what is socially desirable is of great importance (Neumann, 2013). An individual's choice is therefore highly dependent on what the decision maker thinks and supposes about social norms. Therefore, social influences provide potential to raise awareness and attention for sustainable energy consumption.

In this context, Schultze et al. (2007) conducted a field experiment with 290 households in California. The research team informed households on a bi-weekly basis how much energy they had consumed (in kWh) in recent weeks. In addition, the researchers divided the households into two groups. Group 1 got additional information about the average power consumption of other households in addition to its own consumption so they knew whether they consumed below or above average energy. This information is cited by Cialdini et al. (1991) a "descriptive norm" information that does not require any additional evaluation. In the second group, households received a smiling emoticon in addition to this descriptive norm information when they consumed below average power or a sad emoticon when their energy consumption was above-average. This rating emoticon is called an "injunctive norm", which is intended to be a social endorsement or disapproval.

When looking at the results, it comes clear why descriptive norms alone may not lead to the desired outcome. Households in Group 1, which previously had above-average consumption, reduced their consumption by 1.22 kW / h per day while households which consumed below-average energy increased their consumption in the following days. This negative effect of social comparison is also referred to as "boomerang effect".
In Group 2, the energy consumption was reduced even more than in group 1 due to the extra smiley (1.72 kWh/day reduction). In addition, the boomerang effect could be

significantly reduced with the help of simple emoticons. These results remained robust over the long term (Figure 4).

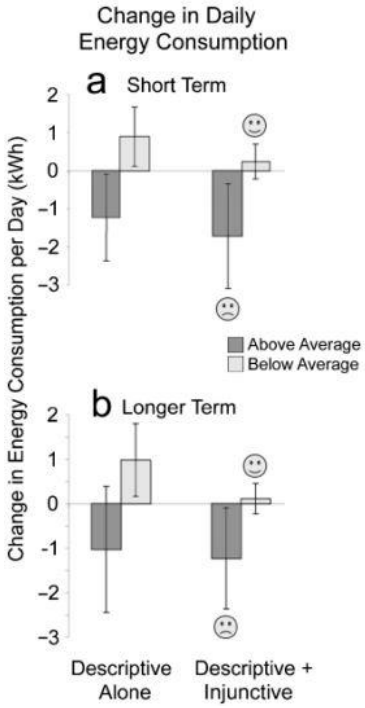

Figure 4: Results of the field experiment in short and long term (Schultze et al., 2007)

We can derive several conclusions from these findings and apply them for the lighting market.

It seems possible to encourage people to behave more energy efficient with a relatively simple social comparison, but we need to keep in mind that interpersonal comparisons can also cause negative effects, such as the boomerang effect. Although this negative effect can be reduced by socially approving information, it is a challenge to neutralize it completely.

If households restrict their energy consumption as consequence of a social comparison, an increase in the motivation to prematurely replace the old energy-inefficient lighting with LEDs may come along. More importantly, energy efficiency needs to penetrate people's consciousness in order to create a new social standard for energy efficiency. The German government is already utilizing liberal paternalism with information campaigns such as the "Deutschland macht's effizient" campaign in order to raise public awareness. But an increased investment in new technologies such as LEDs seems only achievable if interpersonal communication concerns relevant related topics like potential energy savings.

Another social leverage point for energy efficient behavior can be found in social punishments.

The homo oeconomicus is primarily interested in maximizing its self-interest. The game theory approach of the Prisoner's Dilemma confirms that an individual's best decision can be non-cooperation, although cooperation would lead to a better outcome (e.g. Kreps et al., 1982). Individual rationality could therefore lead to collective irrationality, which can e.g. prevent the provision of public goods, although the provision would raise everyone's utility. An exogenous governmental intervention would be necessary to solve this market failure. Empirically, however, self-implementing cooperations can be found in reality. Ostrom (2000) attempts to explain this using an evolutionary approach. The author distinguishes between "rational egoists", who are particularly successful when no information is available, and "norm using players", who behave cooperatively. Under perfect information, the norm using players could easily sanction egoists and thus prevent other individuals from behaving that way. We consider the existence of both types and additionally a hybrid form, wherein:

„[…]modern humans have inherited a propensity to learn social norms, similar to our inherited propensity to learn grammatical rules[…]. Social norms are shared understandings about actions that are obligatory, permitted, or forbidden […].Which norms are learned, however, varies from one culture to another, across families, and with exposure to diverse social norms expressed within various types of situations" (Ostrom, 2000).

Important for our analysis is how the "norm using players" were divided into two different types: "conditional cooperators", who have strong affinity to invest in the common good of the group. They are trustworthy, but disappointed when other group members do not contribute. The second subgroup, "willing punishers" have a willingness to pay to sanction other members of the group if they do not contribute to the common good. This finding of the "willing punishers" was reported by Sääksvuori et al. (2011) again in further laboratory experiments examined. The 288 participants were divided into different treatment groups. In 30 rounds, subjects had the option of depositing funds either on their own account or in the group account. The amount of the group account was doubled after each round, and divided among the group members. The decision to deposit money exclusively on one's own account was only of use to egoists and hurt the success of the group. In three of the five treatments it was possible to sanction the rationalists with point reductions, which also

meant a reduction of points for the individual who assigns the penalty. Additionally, in three treatments, the groups were in direct competition: the group with the highest community account at the end of the game wins.

The results of this laboratory experiment have revealed that competition between groups led to a significantly higher amount of group members willing to punish other group members for self-serving behavior, although at the same time this meant personal loss.
Competition can influence the behavior of all individuals involved. This incentive mechanism can lead to a rethink that could also work in the context of saving energy. If power consumption was instantly measurable with smart meters and there was e.g. a smartphone app that would measure the current power consumption of all districts in a city, a virtual competition could be started here. The district with the highest energy savings could e.g. receive an award. If this incentive causes citizens to suffer short-term losses in terms of investment in energy-efficient products to support the group (neighborhood), this could be a way to further promote LED sales without interfering with individual choice options.

Conclusion

We localized and analyzed the instruments of libertarian paternalism in the environmental context on the basis of the current state of research. We furthermore examined whether the associated behavioral changes had a significant (long-term) influence on the energy-efficiency gap in order to meet the government's energy saving goals.
The results have shown that sustainable energy consumption can be promoted through liberal paternalistic interventions, specifically targeting people's decision-making biases and weaknesses that would lead to suboptimal consequences. The use of the default option instrument, which addresses the human weakness of inertia and convenience, has proven to be particularly effective by stimulating the environmental consciousness within the preferences of individuals concealed by the status quo effect. This tendency to status quo was detected in individual’s illuminant buying decisions and therefore a sustainable default option like the LED promises positive results.

The framing effect has also revealed the attention deficit due to limited cognitive capacity of individuals. The decision-making results in the study of the various designed labels of high energy consumption products have confirmed that human beings are especially attentive to colorized labels and to labels containing monetary information. If annual energy costs are easy to compare, investment in energy efficient products is more likely. Here, the LED packaging regulations, which show no comparison of consumption costs, could be re-visualized by the EU.

The formal-analytical approach to the problem of time inconsistency identifies several human weaknesses. It points out that humans cannot objectively assess short-term costs and long-term payment returns (energy cost savings). Humans rate today's benefits much higher than future benefits which are heavily discounted. One way to overcome this weakness is a better provision of information about the long-term benefits of e.g. LEDs. Furthermore, interventions can be based on feedback in support of self-regulation. In particular, a mandatory installation of smart meters could be helpful to improve the self-control of individuals.

Another identified possibility of intervention is based on the idea of social influence. Households showed significant positive behavioral changes based on simple energy consumption comparisons. Using a game theory approach, it was also possible to show how social influences can affect consumer behavior, which could be useful promote the investment in LEDs in a broader sense.

It is doubtful that the energy saving targets can still be achieved by 2020. The government still has some leeway to "nudge" people in the direction of sustainable energy consumption.. The importance of investing in energy-efficient products, such as the LED as a future-oriented light source, plays an important role in closing the energy efficiency gap.

But it is not only important that the government provides the people with assistance in decision-making. Every individual itself should to do something good for the environment of their own free will. And if the government can kick-start such behavior without limiting individuals' freedom of choice, libertarian paternalism is an adequate instrument to promote the energy transition.

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Attachments

Attachment 1: (Pichert und Katsikopoulos, 2008)

Grey condition: "Imagine you have to relocate to another town. After you move into your new flat, you receive a letter from the electric power supplier, *Acon*. You are told that by moving into your new flat you became an *Acon* customer: '*Acon* is pleased to welcome you as a new customer. We are responsible for the basic electricity supply in this residential area. *We offer low-priced electricity tariffs—you cannot beat our prices. Save money with Acon!* Your monthly premium is €25'. You are kindly asked to fill in some personal data on an attached document, which you do. A couple of days later a contract is sent to you.

Some weeks later you find a flyer in you mailbox, advertising offers from the electric power supplier *EcoEnergy*: 'Switch to *EcoEnergy*! Did you know that you can easily switch your electricity supplier? *EcoEnergy sells clean electricity, generated from renewable energy sources. Contribute to climate protection and environmental protection!* Your monthly premium will be €30"'.

What do you do? (please check box)
☐ Stay with Acon
☐ Switch to Ecoenergy

Green condition: The vignette described the reverse situation; that is, the default company offered 'green' power and the advertisement was for cheaper electricity (see text). Although premiums for electricity vary according to individual consumption, participants were told by the experimenter to accept the premiums as given for the sake of simplicity.

Neutral condition: Here, the vignette had slightly different wording: "Imagine you have to relocate to another town. After you move into your new flat, your landlord kindly asks you to choose a power supplier. In this building, two electric power companies offer electri-

Options in the first laboratory experiment

Company name	Information given	Monthly costs
EcoEnergy	EcoEnergy sells clean electricity, generated from renewable energy sources. Contribute to climate protection and environmental protection!	€30 (ca. $39)
Acon	We offer low-priced electricity tariffs—you cannot beat our prices. Save money with Acon!	€25 (ca. $32)

Attachment 2: (Dinner et al., 2011)

Imagine that you are undergoing a significant amount of remodeling on your home. On the last day of work the contractors clean up all leftover dust, dirt, and paint. Before leaving, one of the workers tells you that the head contractor will be back tomorrow for a final inspection of the house.

Tomorrow evening the head contractor comes by your home to discuss the last aspects of the addition. After showing you one of the newly installed light fixtures he mentions that all 18 bulbs in the new fixtures have been outfitted with incandescent bulbs, which cost a total of $9. He then asks you if these bulbs are ok, or if you would prefer Compact Fluorescent (CFL) bulbs which will cost $54. If you prefer to switch, he will send over a contractor to switch the bulbs tomorrow. There will be no labor charge for switching the bulbs.

	You Now have:	You may switch to:
	Incandescent Bulb  (60 Watts)	Compact Fluorescent Bulb  (14 Watts)
Attributes	- Light quality is often considered "warm" or "soft." - Full brightness arrives immediately. - Turning bulbs on and off won't affect lifetime of incandescent bulbs - Incandescent bulbs can be disposed of anywhere - Bulbs last roughly 750 hours - Costs $49 in electricity per 10,000 hours.	- Light quality is sometimes considered "cold" or "bluish" - Full brightness takes 1-3 minutes to achieve - Lifetime of a CFL bulb is *significantly* shortened if it is only turned on a few minutes at a time. - Contains Mercury, so must be disposed of with caution. - Bulbs last up to 10,000 hours - Costs $11 in electricity per 10,000 hours of use
Cost	$0.50 per bulb $9 Overall	$3.00 per bulb $54 Overall

In this situation what will you do?

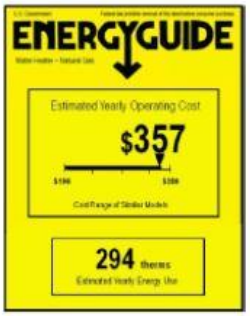
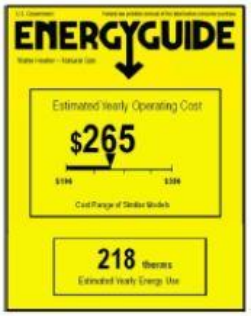
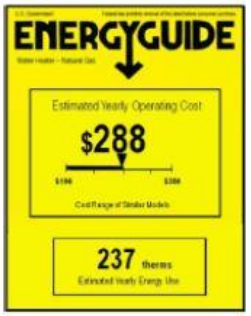
Choose only one of the following

- (●) I will tell the contractor to leave the Incandescent Bulbs
- ( ) I will tell the contractor to switch to Compact Fluorescent Bulbs

Attachment 3: (Newell & Siikamäki, 2013)

Consider choosing between the following three water heater options. Please think that these are the only options available to you and you have to make the purchase.

Water Heater Decision 1

	Water Heater A	Water Heater B	Water Heater C
Purchase price	$400	$650	$550
Energy Use			
Your choice from these options?	☐ A	☐ B	☐ C