Banning the Bulb: institutional evolution and the phased ban of incandescent lighting in Germany

Nicholas A. A. Howarth and Jan Rosenow

Manuscript of paper published in *Energy Policy*. Please quote as following:

Howarth, N.A.A., Rosenow, J. (forthcoming). Banning the Bulb: institutional evolution and the phased ban of incandescent lighting in Germany. *Energy Policy*

Abstract

Much academic attention has been directed at analysing energy efficiency investments through the lens of 'behavioural failure'. These studies have challenged the neoclassical framing regulation which emphasises the efficiency benefits of price-based policy, underpinned by the notion of rational individual self-mastery. The increasing use of a regulatory ban on electric lamps in many countries is one of the most recent and high profile flash points in this dialectic of 'freedom-versus-the-state' in the public policy discourse. This paper interrogates this debate through a study of electric lamp diffusion in Germany. It is argued that neoclassical theory and equilibrium analysis is inadequate as a tool for policy analysis as it takes the formation of market institutions, such as existing regulations, for granted. Further still, it may be prone to encourage idealistic debates around such grand narratives which may in practice simply serve those who benefit most from the status quo. Instead we argue for an evolutionary approach which we suggest offers a more pragmatic framing tool which focuses on the formation of market institutions in light of shifting social norms and political goals – in our case, progress towards energy efficiency and environmental goals.

Author contact details:

nicholas.howarth@smithschool.ox.ac.uk
School of Geography and Environment, Oxford University, Oxford, UK.

Key Words: Energy efficiency; politics

Title: **Banning the Bulb: institutional evolution and the phased ban of incandescent lighting in Germany**

Introduction

Introduced around 130 years ago, conventional incandescent lamps convert only around 5 to 10% of the energy they consume into light, the remainder being emitted as heat, and are far more inefficient than every other electric lamp on the market. The technological diffusion of compact fluorescent lamps (CFLs) is now progressing at a rapid pace worldwide.

After years of limited success with demand-side information and subsidy schemes and with climate change and energy efficiency concerns coming to the fore, many countries such as the United States, the European Union, Russia, Brazil, Argentina, Canada and Australia are implementing phased bans of incandescent lamps. The European Commission (EC) estimates that by 2012 its regulatory ban will save around 40 TWh, or roughly the electricity consumption of 11 million households, reduce CO_2 emissions by 15 million tonnes per year and contribute €5 to 10 billion into the economy (EUROPA, 2009). In contrast, the EC estimated that to achieve the equivalent behavioural change it would have to institute a ten-fold increase in taxation on incandescent lights.

For the consumer, lighting may represent up to a fifth of household electricity consumption. Although CFLs are costly up front, they can last up to 12 times longer and can reduce the average household's total electricity consumption by up to 10-15% and save around €50 each year, assuming 20 traditional lamps in the household are switched over to CFLs, taking into account the higher CFL purchase price (European Commission, 2009). The most common concerns with CFLs are their higher purchase price and the 'cold' white aesthetic of their light.

The use of a regulatory ban has been criticised by some as restricting consumers' basic freedom to choose and of forcing an immature technology onto the market which does not meet consumer needs. For example, German MEP Holger Krahmer of the FDP party criticised the move as 'light-bulb socialism', and in the United States a 'Light Bulb Freedom of Choice Act' has been proposed in response to the ban.

This suggests the use of the incandescent lamp ban has created a powerful flash-point in the debate between a market-based 'free-to-choose' policy view point versus more structured regulation.. Using theoretical insights drawn from neoclassical, evolutionary, institutional and behavioural economics this paper interrogates this debate and investigates the diffusion of CFLs in Germany as a case study.

To position this paper's contribution in the wider climate change literature, in the first section the standard welfare neoclassical equilibrium approach to climate policy is contrasted with the evolutionary approach. Next, empirical evidence from energy efficiency studies is reviewed to highlight how observed systematic behavioural 'anomalies' demonstrate how the neoclassical conception of an economy in equilibrium is misguided as a basis for public policy making. Indeed, it is argued that a neoclassical framing of environmental policy may encourage debates around idealistic notions of 'freedom versus the state', whereas an evolutionary approach more clearly focuses on the shifting nature of social norms and policy objectives which make up 'the market' and which are taken for

granted in the neoclassical approach; rg This is not to deny the importance of individual market decision-making, but to acknowledge that the natural state of the world is one where often profound technological and social path-dependent processes are the norm (Simon, 1957, 1991; David, 1985; Arthur, 1994; Gigerenzer, 2003).

The second section interrogates this theoretical debate through the exploration of CFL diffusion in Germany. This involves an analysis of lamp consumption data, public awareness indicators, and a survey of 1711 households investigating CFL purchasing behaviour. The findings suggest that after years of little growth, a significant upswing in CFL sales and a drop off in incandescent sales corresponded with announcement and implementation of the phased ban. The strong response to the ban *in advance of its implementation*, suggests that the ban served as a powerful framing device on the CFL purchase decision. However, one interesting observation, highlighting the forces of social lock-in, is that while CFL sales steadily rise over the period following the ban, sales of incandescent bulbs temporarily pick up in the lead up to the ban's actual implementation due to what has been attributed to 'Glühbirnen hamstern' or hording behaviour, literally - light bulb hamsters.

In conclusion, it is argued that it may be more useful for policy makers to move past idealistic dualisms such as 'markets' versus the 'state' or 'liberty' versus 'control'. Rather, it is suggested a more constructive approach is to view technology policy, such as the ban on incandescent lamps, as an instance where society has evolved an institution to help achieve a 'good outcome' and to correct for observed information overload and self-defeating behaviour. Such institutions are particularly important when dealing with decision making problems where path dependent processes are strongly exhibited and where public goods are present, such as in the area of energy efficiency and climate change.

It is not the purpose of this paper to offer its own normative prescription on the 'correct balance' in formulating policies to support energy efficiency. Rather, it is to make the point that the formation of such market-governing institutions is best played out as part of a social learning process with transparent review, evaluation and public discussion through accessible, accountable political structures. Indeed, drawing on the empirical evidence of this paper it is suggested that this public debate may be just as powerful a 'policy instrument' as the actual ban itself. This finding serves as an important warning to government against focusing exclusively on technocratic market-led solutions based on 'policy-optimality' criteria and implemented in a top-down matter. It also gives some insight into the moral power of regulatory bans, which may – especially if supported by the community – serve as a more efficient path to technological transformation than a more values neutral pricing approach.

Freedom versus the state and the drive for greater energy efficiency

The 'revolution in energy efficiency' began in the 1970s stemming from the fear of fuel shortages following the first oil crisis. Whereas previously energy efficiency was of very limited political concern, this changed suddenly with the oil crisis (Eyre, 1997), creating an unprecedented conservationist approach to energy use (Perez-Guerrero, 1975). In the United States, President Jimmy Carter appeared on television symbolically wearing a sweater indoors, declaring that the energy crisis was the moral equivalent of war. Public

unease around energy security led to aggressive policies in areas such as product standards, building codes and renewable energy subsidies. However, through the 1980s and into the 1990s as energy prices decreased and the perception of shortage lessened, so too did the imperative for strong interventionist government action. Combined with the general move to liberalise energy markets, the focus shifted to demand management - informing and supporting the decisions of consumers, rather than supply-side solutions involving manufacturers and retailers (Blumstein, Goldstone and Lutzenhiser, 2000).

In the energy efficiency literature there has been a long tradition of research on the cost effectiveness of energy efficiency tools (see Gillingham, 2000; and the MURE database for reviews in the context of the United States and European Union, respectively). The case for energy efficiency is powerful: if cost effective investments are available to reduce energy and save money, then the market should provide the incentives necessary to facilitate this, especially in the context of rising fossil fuel related energy prices. However, numerous barriers exist which discourage these investments (Eyre, 1997; Sorrel et al., 2004), suggesting some form of government intervention may be necessary.

For example, Howarth and Anderson (1993) and Howarth and Sanstad (1995) investigated how consumers have employed discount rates of between 20% and 200% in making energy efficiency decisions when buying appliances. This work exposed the shortcomings of the rational model: faced with product selection decisions a rational individual with complete information would not pass up an efficiency investment which could yield a considerable return. Furthermore, higher discount rates were observed particularly among the poor who *a priori* would have the most to gain from paying less on the life cycle costs of appliances. Applied across a wide range of energy efficient investments, such empirical observations have given rise to the so-called 'energy efficiency paradox' – the systematic existence of unexploited opportunities for improving energy efficiency (DeCanio, 1998).

Although there are some notable exceptions (Jaffe and Stavins, 1994), this paradox is underplayed in the mainstream economic analysis of climate change which is grounded in the welfare economics of Arthur Pigou (1912). This approach has focused on establishing the costs and benefits of a policy target y and the optimal or most cost effective way to achieve it: usually through the comparison of the merits of either a system of tradable quotas (emissions trading); or through taxation of carbon intensive goods (e.g. Nordhaus, 2007; Weitzman, 1974; Delbeke, et al. 2010). Once targets are set and carbon pricing put in place, in typical neoclassical models of competitive markets, perfectly informed consumers weigh up the costs and benefits of alternative products when making their purchases. Having 'internalised the externality of pollution' through such 'market mechanisms', the problem of energy policy is thus reduced to ensuring that energy prices reflect the full social costs of energy production and utilization.

Market-mechanisms also have the advantage of providing incentives for continuous improvement, whereas firms are seen to generally have no incentive to exceed the environmental mark set by a regulatory standard (Baumol, 1972). The so called 'command-and-control' approach traditionally takes the form of legal regulations such as the special zoning of polluting activities, quantitative limits on the physical volumes of pollution, technology standards and so on. These are often criticised as not providing incentives for innovation beyond the standard.

Within the climate change and environmental literature, the standard welfare equilibrium approach has been criticised for paying too little attention to the historical, geographical, legal, cultural and political context of pollution abatement decisions (IPCC, 2007; Stern, 2006; Williams and Baumert, 2003; Victor, 2007, Carraro, 2007) and also of sidestepping the problems of path dependency (Unruh, 2000, 2002, 2006).

Michael Porter and Claas Van der Linde's (1995) work has also played an important role in challenging this mainstream approach by highlighting the positive role environmental regulations can play in promoting environmentally beneficial innovation and supporting economic competitiveness at the firm, sector and nation-state level (Palmer, Oates and Portney, 1995). That tighter environmental standards can not only reduce costs directly, but also spur further cost reducing innovation, boosting competitiveness – the so called Porter hypothesis – has inspired a large body of supportive empirical studies (e.g. Lanoie et al. 2008; Horbach, 2007; Costantini, and Crespi, 2007; and Kriechel and Ziesemer, 2009). However, others have rejected this case-study based approach by arguing such examples are special cases and that across the economy it is just as likely environmental regulations come at a net cost, as well as embodying a significant opportunity cost. For example, Jorgenson and Wilcoxen (1990) and Hazilla and Kopp (1990) use a dynamic general equilibrium model to show environmental regulations are necessarily cost adding because of the manner in which they depress other "productive" investment.

Other empirical research has shown that so-called 'behavioural anomalies' are systematic and strongly ingrained with human behaviour, suggesting we often act against our own self-interest giving rise to 'behavioural failure' (Shogren and Taylor, 2008). Led by Kahneman and Tversky (Kahneman et al., 1982) these empirical insights have had far reaching implications for economics and how we understand individual decision-making (Baron, 2008).

In a review article, Tom Tietenberg (2010) highlights how viewing energy efficiency through the lens of behavioral failure sheds important light on the energy efficiency paradox and why policy instruments such as information strategies and monetary incentives frequently prove insufficient to promote even the most cost-effective investments. These 'errors of judgement' are profound in that they derive from human cognition. At stake is the capacity of people whatever their circumstances, roles and responsibilities to take action in the rational manner assumed by typical neoclassical models (Kruger and Funder, 2004:317). For example, Table 1 summarizes a selection of the main behavioural biases which may have a bearing on the diffusion of CFLs.

Table 1: Major behavioural anomalies of the rational actor model

Familiarity bias: people value what is familiar over what is unfamiliar, even when they have no objective reason for doing so, giving them a strong preference for the status quo.
Ownership bias: people value something they own more than something they do not, even when it is the same object.
Confounding options: beyond a certain number of options, people make inferior decisions when presented with greater choice.

Impatience bias: people value time inconsistently using a high discount rate such as immediate outcomes are weighted more heavily than outcomes in the future. In other words, people find it hard to resist temptation and defer gratification, even when it is in their best interests to do so.

Herd behaviour: people are drawn towards the actions of others faced with the same decision, including strangers about whom they know nothing.

Framing bias: consumers choosing between product A and product B are influenced by the presence of product C, even if they have no interest in buying C.

Cooperative instinct: people frequently act knowingly against their own individual best interests by cooperating to achieve common goals because they take into account the interests of others.

Sense of justice: people will refuse offers that they perceive as unfair and will act to punish perceived unfair behaviour in others even if not directly involved and if the action involves sacrificing their own income.

Adapted from Clark and Urwin, 2009; Oxford Analytica, 2009

This can be read alongside Table 2 which reviews the empirical literature on CFL diffusion. Despite awareness of the life-cycle benefits of CFLs consumers many consumers still do not adopt them due to their high up-front cost relative to incandescent lamps (Palmer and Boardman, 1998). That is, even though they are aware CFLs are cheaper once operating costs are factored in, they place a significant emphasis on the upfront cost of the lamp in their purchase decision-making. These empirical studies suggest a strong presence of behavioural and path dependent processes are in play.

Table 2: The incentives and barriers to the diffusion of CFL technology

Incentives to adoption	**Barriers to adoption**
Lower running costs: up to 80% cheaper	CFLS are typically 5 to 10 times the price of an incandescent lamp
Longer bulb life of 6,000 to 10,000 hours compared with around 2,000 for a standard incandescent bulb.	CFLS take a few moments to warm up to achieve full luminescence and will gradually fade by up to 30% over their lifespan.
Lower CO_2 emissions	Information requirements of understanding a new product is costly
Less heat means lower burning risk	Limited range offered in stores means there are not always CFLs available for all sockets and aesthetic preferences
Versatility: both 'warm' and 'cold' light options are available	Some people think CFLs are 'ugly' and do not like the 'colder' light of standard CFL bulbs.
'Feel-good-factor' of pro-environmental action	Health concerns due to mercury content and flickering. CFLs should be specially recycled and flickering can adversely affect epileptics.

Sources: EUROPA, 2009; Bladh and Krantz, 2008; Vito, 2009

In this area, conservation psychology has also offered helpful empirical insights into the links between policy intervention, individual action and technological change (Geller 2002; Kaiser, Midden and Cervinka, 2008; Frantz and Mayer, 2009; Clayton and Brook, 2005; Van Lange and Joireman, 2008).

Writing in the *Journal of Environmental Psychology* Linda Steg and Charles Vlek (2009) review the wide ranging environmental agenda psychologists have engaged with. Regarding energy use, some studies have suggested that policies are more acceptable when they are perceived to be fair and when they do not seriously affect an individual's sense of freedom (Steg and Gifford, 2005). Policies also tend to be more acceptable to people who are highly aware of the problem being targeted and who feel a moral obligation to address it, suggesting consumer awareness is a critical ingredient of market transformation.

In the area of feedback strategies, Corinna Fischer (2008) has shown that people are also more likely to save energy when they understand their bills and know how individual appliances effect the total amount of energy consumed, highlighting the importance of providing good information. Some studies have also suggested that policies which aim at increasing the attractiveness of pro-environmental activities are more effective than those aimed at penalising environmentally harmful activities (Geller, 2002).

There is also a well-established discrepancy in social psychological research between how people think about issues (their attitude) and how they behave towards the issue. While some have argued that actions are the best indicator of attitudes (Campell, 1963; Kaiser, Hartig and Byrka, 2009) others place the emphasis on evaluative verbal statements (Eagly and Chaiken, 1993; Stern, 2000). This inconsistency between thoughts and actions offers an important insight into how individuals can pursue a plurality of values which may repeatedly come into conflict. This may help explain why people may vote in favour of a regulation that restricts their actions, for example drink driving or smoki ng laws, and in our case electric lamp purchases, despite the fact they could simply choose to alter their behaviour directly. Furthermore, such conflicts are difficult to transform into a common value to enable a coherent calculus of cost and benefit as assumed takes place in standard welfare economics.

Despite such empirical findings supporting the case for more interventionist or 'structured' policies, a narrative exists in some policy circles that the world is far too complex for politicians to 'select optimal policies' and, aside from providing some informational support or changing relative prices to correct for any externalities, it is best to leave people 'free to choose' and let 'the market decide' as much as possible. Market mechanisms fit comfortably within the rubric of neoclassical equilibrium analysis, where consumers select products in a way that maximises their own welfare, and by extension, best promotes the interests of society at large. Furthermore, collective action through regulations are often cast as 'political interventions' easily corrupted by the special interests of a small powerful minority, thus working against society at large as represented by the consumer (Olsen, 1965).

It is argued here that these two streams of thought, i.e. the mainstream equilibrium approach based on standard welfare economics and the more heterodox evolutionary approaches of behavioural and sociological studies, are behind much of the debate between 'freedom-versus-the-state' in a range of public policy issues. This debate is now interrogated in the context of the shift to energy efficient lighting in Germany.

Energy efficiency policy in Germany

Before the 1970s, energy policy had a fairly low priority in Germany. Energy was supposed to be secure and cheap (Häusler, 1991) and policy focused on the sources of energy that were perceived as being the most competitive (Mez, 2003). In the 1970s, concerns about energy security following the 1973 oil crisis dominated policy-making. The political response to the crisis consisted of policies aiming to diversify the fuel mix by using more domestic gas, coal and lignite, but also nuclear energy. Another central aim after the crisis was to reduce total energy consumption (Czakainski, 1993, Düngen, 1993, Reiche, 2005), which culminated in the adoption of the Energy Saving Acts passed by the German Bundestag.

However, falling energy prices in the 1980s took away some of the pressure and the more ambitious proposals for substituting oil with other fuels and energy conservation were dropped subsequently (Michaelis, 1993). Energy policy after 1990 was heavily influenced by concerns about climate change and the main goals of energy policy are now ensuring economic competitiveness, energy security, and environmental protection (Klag, 2003).

Throughout history, energy policy was firmly in the hands of the Federal Ministry of Economics (BMWi) and which is still the main department responsible for this area of policy making. However, with the creation of the Federal Environment Ministry (BMU), shortly after the Chernobyl disaster in 1986, the Federal Ministry of Economics had to negotiate energy policy where it affected environmental issues and in particular climate change policy. In general, energy policy still is within the realm of the BMWi, but certain policy areas with relevance for energy policy are dealt with by the BMU (Eichhammer et al., 2006). This includes climate policy, nuclear safety, and renewable energy policy. So far, energy efficiency policy has not come under the auspices of one single department.

The first energy efficiency targets where officially adopted in 2005 when the coalition of the CDU (Christian Democratic Union of Germany), CSU (Christian Social Union), and the SPD (Social Democratic Party of Germany) came into power. In the coalition contract they committed themselves to doubling energy efficiency per unit GDP by 2020 based on 1990 levels. Assuming continuous economic growth based on average growth rates 1990-2007, the required reduction of primary energy demand by 2020 based on 1990 levels needed to be 23%. In case of lower GDP growth rates the required reduction would be even higher.

In the 2010 Energy Concept, a white paper on energy policy mainly drafted in the context of extending the nuclear phase out, the new coalition government of the CDU/CSU and the FDP (Free Democratic Party) put in place two new targets: First, to reduce primary energy demand by 20% by 2020 and by 50% by 2050 based on 2008 levels. Second, to reduce electricity consumption by 10% by 2020 and by 25% by 2050 relative to 2008 levels. However, already two years later the Environment Minister, Peter Altmeier, questioned whether the electricity target was actually achievable.

The shift towards energy efficient lighting in Germany

Comprising around 12% of household electricity consumption, lighting generally represents the third most significant use of electricity in the home after heating and cooling in EU countries. The four main classes of household lamp technologies include: incandescent lamps, halogen lamps, CFLs, and linear (tubular) fluorescent lamps (LFLs). A tungsten

halogen light represents energy efficiency savings of up 30-50% depending on type compared to an incandescent light and a CFL up to 80% (Jacob, 2009). LFLs are also extremely efficient, lasting longer than most CFLs, and have been widely in use for some time, especially in areas demanding long operating hours such as in kitchens and industrial and public spaces (Aman et al., 2013).

As one of the largest and most energy efficient countries in Europe, Germany presents an important case study for the diffusion of energy efficient lighting. Studies suggest that Germany is characterised as an early-adopter of CFL technology (Bertoldi and Atanasiu, 2007), with market penetration in 2007 of 70% of households compared with 50% in the United Kingdom, 52% in France, 60% in Italy and an EU average of around 50% (figures refer to proportion of households using CFLs; market share of sales is lower). In these houses the average number of CFLs in use was seven in Germany, two in the United Kingdom, two in France and one in Italy. Not surprisingly, Germany had one of the lowest lighting-consumption as-a-share-of-total-household-electricity in 2007 at 8.13%, compared with 6.43% in France, 16% in the United Kingdom and 35% in Romania (ibid). Palmer and Boardman (1998) provide a separate stocktake for some of these values in 1997 showing how far each country has come over this ten year period. In 1997, the proportion of households with a CFL was 51% in Germany, 23% in the United Kingdom, 55% in Italy (with no data available for France) with the average household owning two, one and one CFL respectively. More recently the survey used in this paper estimated that German CFL market penetration late in 2009 was at 84% of households (Grass Roots, 2009).

A major early policy development was the Energy Labelling Directive (92/75/EEC) which, since 1998, has required manufacturers to indicate light bulb efficiency on packaging. CFL diffusion has also supported by a range of demand-side programs (for a review of German programmes see Fraunhofer ISI, 2006). For example, in Germany initiatives included: the Bright North Rhine Westphalia project where 80 utilities participated in a programme distributing 500,000 CFLs directly to customers who were then encouraged to buy more via a voucher programme; and a programme carried out by Stadwerke Hannover where consumers were given a €5.11 rebate for each CFL purchased.

However, despite such efforts the European Commission stated in explanation of the decision to implement a phased ban that “consumers failed to significantly move towards the more efficient choice”. It was noted that, “the higher up-front purchase price constituted a psychological barrier, even though this initial investment paid off within a year and brought even more benefits over the complete life-cycle of the CFL” (EUROPA, 2009). This situation of stagnant CFL sales can be seen in Germany in Figure 1 as continuing up until 2005-2006.

A turning point in Figure 1 seems to occur in late 2006 - early 2007 with sales of CFLs increasing from around 100 million units to 150 million units and sales of incandescent lamps dropping from around 300 million to 200 million over the same period.

A major event which could help understand this was the increased media and public attention on CFLs following the announcement in February 2007 by the then Australian Minister for the Environment, Malcolm Turnbull, to ban the incandescent light bulb by 2010. For example, in an article in Der Spiegel on 20 February, 2007 Björn Hengst writes how Australia, the country that at that stage was rejecting the Kyoto Protocol and one of the

largest coal exporters in the world suddenly moved to ban inefficient light-bulbs in 2010 (Hengst, 2007):

> "Now, Australia wants to be world leader in banning conventional, inefficient light bulbs - the modern energy saving lamps are not only durable but are also four to six times more efficient. Even a small step can have a big effect, Turnbull stated: "If the rest of the world follows our lead, this will mean significant energy savings."

While the German media reflected a degree of indignation at being lectured on green policies by a perceived climate policy laggard, Turnbull's announcement sparked significant debate in Germany. The conservative-social democratic coalition government initially opposed a ban of incandescent light bulbs, particularly the conservative parties CDU and CSU, but shortly after the announcement by Turnbull the environment minister, Sigmar Gabriel, sent a letter to the European Commission. In his letter he stated that 'Europe cannot afford products such as incandescent light bulbs with an efficiency of just 5% any longer'. Gabriel's letter coincided with the beginning of the German Presidency of the Council of the European Union (January – June 2007).

Other European governments also expressed their support for the Australian policy. For example, the Irish Prime Minister Bertie Ahern was quoted by Reuters saying: "We are very impressed by the Australians and before we came to the summit, we had already been in touch with them and looking at the issue." (Reuters, 2007).

While some have argued that it was the Australian announcement and Gabriel's letter that eventually led to the ban at EU level (e.g. Bittner, 2009), the course of events was more complex than this and began earlier than February 2007. We have not done any primary research involving interviews and extensive document analysis to establish in-depth the political dynamics that led to the ban. However, it seems that a number of governments and major lighting industry players promoted the ban at the European level at the same time.

In December 2006, Philips Lighting, the world's largest lamp manufacturer announced its support of a global phase-out of incandescent light bulbs under certain conditions. Shortly after this event, in February 2007, the International Energy Agency (IEA) and the European Commission held a joint workshop in Paris on "CFL Quality and Strategies to Phase-out Incandescent Lighting" attended by policy makers and industry representatives. Major light bulb manufacturers supplying most of the light bulbs consumed in Europe expressed their support for the ban at the workshop including Philips, Osram-Sylvania and General Electric (Waide, 2007).

In March 2007, EU Council of Ministers (meeting of heads of state) called on the European Commission to establish a regulation addressing incandescent lighting by 2009 under the 2005 Eco-design Directive. A few weeks later, a cross-party group of members of the European Parliament expressed a similar position and urged EU governments and the European Commission to implement minimum standards for lighting. The lighting industry responded: In June 2007, the European Lamp Companies Federation, an industry association which includes Philips, Osram, GE and Havells Sylvania set out a voluntary proposal to phase-out incandescent light bulbs. Just a day after the announcement was made the G8 summit at Heiligendamm, Germany, endorsed an IEA recommendation that Governments

should move to phase-out the most inefficient incandescent bulbs as soon as commercially and economically viable (ibid.).

Independent of any EU policy, the British Chancellor of the Exchequer at the time, Gordon Brown, announced in March 2007 that the UK would be one of the first countries in the world to phase out incandescent light bulbs. UK Environment Secretary Hilary Benn told the Labour Party conference in September 2007 that

> "[w]e need to turn them [incandescent light bulbs] off for good. And so our aim is for traditional 150-watt light bulbs to be phased out by January next year, 100-watt bulbs the year after, 40-watt bulbs the year after that and all high-energy light bulbs by 2011." (BBC, 2007).

The proposals were supported by the Energy Retail Association (trade body for the energy suppliers), the Lighting Association (representing the lighting industry) and the British Retail Consortium. Retailers and government subsequently created a voluntary agreement with a timeline for the phase-out by December 2011 (DEFRA, 2007). In the period March to May 2007 the governments of Ireland, Portugal, Belgium and the Netherlands announced similar policies (Waide, 2007).

In conclusion, the combination of a number of influential European governments and leading lamp manufacturer supporting the ban seems to have led to the adoption of European legislation obliging member states to phase out incandescent light bulbs rather than the singular event of the Australian announcement and the letter sent by the German Federal Minister for the Environment. Following the standard regulatory procedures, this resulted eventually in the proposal of an incandescent light bulb ban receiving final approval by the responsible comitology committee in December 2008 and in April 2009 the respective Commission Regulation (EC) No 244/2009 came into force phasing out incandescent light bulbs in all EU member states (Table 3).

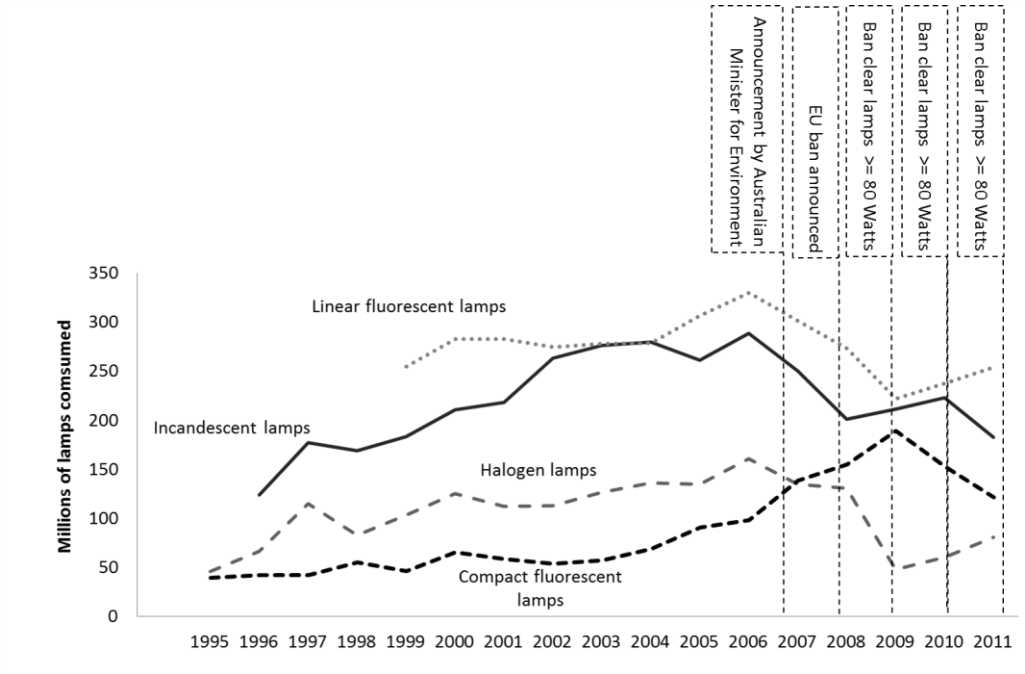
Table 3 Simplified table for European incandescent lamp phase out

Phase		The future distribution of the following lamps will be prohibited
1	September 1st, 2009	Frosted lamps (exception: EEL Class A bulbs) Clear lamps >= 80 Watts
2	September 1st, 2010	Clear lamps >65 Watts
3	September 1st, 2011	Clear lamps >45 Watts
4	September 1st, 2012	Clear lamps > 7 Watts
5	September 1st, 2013	Increase of quality standards
6	September 1st, 2014	Lamps with EEL Class C

Source: Bross and Pirgov, 2010

Figure 1 plots the consumption of the different types of light bulbs in Germany since 1995. It shows that the following the announcement of the Australian ban of incandescent light bulbs and the staged EU phase-out the consumption of incandescent light bulbs decreased by almost 40% since consumption was at its peak in 2006. At the same time, CFL consumption more than doubled from 2006 to 2009. However, in more recent years consumption levels declined which is probably a result of the longer lifetime of CFLs compared to incandescent light bulbs. The number of consumed CFLs per year might drop even further in future years once most incandescent light bulbs have been replaced and existing stocks depleted.

Figure 1 Diffusion of major electric lamp types in Germany

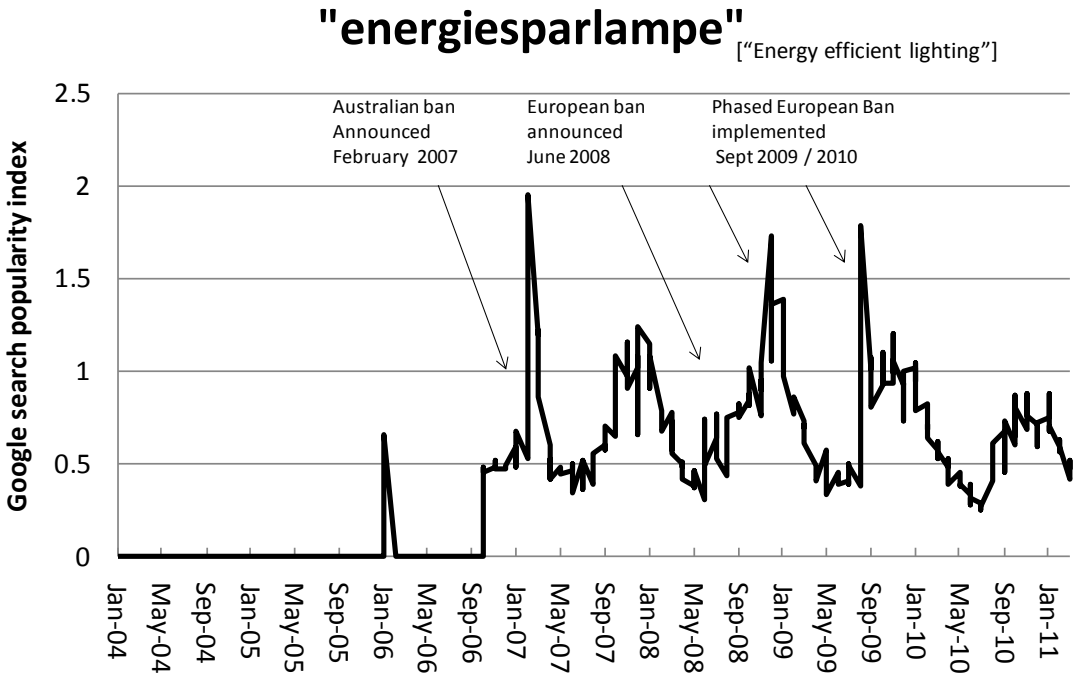


Source: Eurostat, 2010[1]

1 Data is sourced from the Prodcom Annual Sold (NACE Rev. 2) database; codes: 31501293 and 31501295 (Halogen lamps), 31501300 (Incandescent lights), 31501510 (Linear Fluorescent Lights), 31501530 (CFLs); Using the standard approach taken by the Commission,

Around this time, for March/April 2007 the sales growth rate of CFLs soared to 143% (compared to March/April the year before) and over the course of 2007, total sales value and volume climbed 91% and 73% respectively. These events have led some analysts to connect the Australian ban and spike in interest in CFLs in Europe (Bross and Pirgov, 2010). This theory seems supported by data from Googletrends (Figure 2) which shows spikes of public interest in energy efficient lighting corresponding to the announcement and implementation of the Australian and European bans.

Figure 2 Public interest in energy efficient lighting



Source: Googletrends, author

While some seasonal variation with peaks in December/January might be expected in this data due to the longer operating hours of electric lamps in Germany over the northern European winter and thus higher interest in lamp replacement and substitution, this background effect is unlikely to explain the large spikes in public interest evidenced by Googletrends for the months of February/March 2007, and September 2009/2010. It is noteworthy to observe that spikes in CFL purchasing correspond to the increased media attention and public interest that key points in the regulatory process generate such as in the month of September.

One interesting departure from this narrative of technological transformation in the light bulb market is that while CFL sales continued to rise as the implementation of the phased

apparent light bulb consumption is taken as domestic production + imports – exports; some production data not available for earlier years limiting the comparison for every product except for CFLs as Germany has no domestic production of this class of lamp. It is worth noting that despite being a significant global producer of other electrical lamps, Europe is not a significant producer of CFLs and sources its imports mostly from China. It is also worth noting that, as explained the report by Vito (2009), a substantial proportion of halogen lamp sales are in the commercial sector and maybe underreported in Eurostat because sales of 6 and 8 packs are counted as 1 lamp and sales along with luminaires are excluded (floor standing light fixtures).

ban was brought into effect, sales of incandescent lamps also experienced a spike. Over the first six months of 2009 leading up to the ban – GfK, a market research firm, observed that sales of incandescent lamps leapt up by 34% (Schäfer, 2009). This seems particularly significant given the declines in both halogen and LFLs over the same period and suggests that some consumers were reacting against the implementation of the ban by stockpiling the available incandescent bulbs which were about to be taken off the market.

In September 2009, corresponding with the first phase of the staged ban on incandescent bulbs, the international market research firm Grass Roots undertook a survey with closed-ended questions to evaluate public perceptions and the incentives and barriers to CFL adoption in Germany. Out of 9,500 people sent the survey via e-mail, 1,711 individuals responded. Participants were randomly drawn from the firm's consumer panel across Germany, the sample size was representative compared to the German population, and the age and gender profile of respondents corresponded to the overall German population.

While statistically representative, one limitation of the survey is that it was limited to participants with access to e-mail – likely to be a more technologically aware and flexible group. Furthermore, while the survey was close to being representative in terms of age and gender and the results have been weighted to account for any discrepancies, other attributes such as level of education and income were not taken into account. The results therefore have to be interpreted with come caution.

Questions asked focused on a variety of issues including:

- awareness of and reaction to light bulb ban;
- light bulb purchasing decisions;
- perceptions of cost savings and pay-back periods;
- perceived advantages and disadvantages of energy saving light bulbs; and
- importance of perceived disadvantages for not buying energy saving light bulbs.

Overall, 96% of those asked were aware of the phased ban, 87% were aware of the long life expectancy of CFLs and 65% aware of the higher environmental costs of recycling CFLs due to their mercury content. This last point in particular implies a relatively high level of refinement in public awareness of the advantages and disadvantages of using CFLs.

Several points from the Grass Roots survey results are worth highlighting. First, is the observation that although 87% of respondents were aware of the higher life expectancy of CFLs and 60% understood the payback period to be less than 12 months, with 73% aware of incandescent lamps' lower life expectancy, 90% of respondents saw the 'high price' of CFLs as a barrier to them purchasing them and correspondingly, 89% saw the low price of incandescent lamps as an advantage. These observations seem consistent with other studies mentioned earlier suggesting that consumers place significant attachment to the higher upfront cost of the lamp despite often being aware of the lower life-cycle costs of CFLs.

The survey also highlights how CFL purchasing behaviour is not a simple calculus about the most cost effective means to light a home. A significant number of respondents viewed the aesthetics of CFLs unappealing with 68% and 66% of people citing 'optics' and 'an unpleasant light colour' as disadvantages to adoption. Considerations such as 'the shape of the bulb' or 'the colour of the light' are thus also major influences on the adoption of CFL

technology. CFLs also take several seconds to reach full luminescence and fade by up to 30% in light intensity over their useful life. While early CFL design seems to have prioritised function over form, solutions to these aesthetic problems are increasingly available. For example, new bulb shapes with frosted glass and light fittings which obscure the shape of the CFL bulb and filter its light to a more aesthetically appealing hue are becoming increasingly available.

Another significant impediment to greater CFL adoption was concern over the need to recycle them due to their mercury content, with 65% referring to the higher environmental impact of recycling as a disadvantage. A typical CFL may contain up to 5mg of mercury per bulb as a vapour inside the bulb equivalent to about 1% of the mercury content in a thermometer (Aman et al., 2013). EU legislation sets a maximum of 2.5mg of mercury from January 2013 and some producers such as Philips offer CFLs that contain just around 1mg of mercury. While this is not a risk at the individual level, when accumulated in landfill or combusted in waste disposal systems it can lead to local health concerns (Aman et al., 2013). Mercury poisoning has also emerged as an issue of concern for workers engaged in the production of CFLs in some lightly regulated Chinese factories. Many people do not know what to do with their used CFLs and some are not aware of the need to specially recycle them. Under the industry's Lightcycle programme involving Germany's nine lamp producers (Osram, Philips, Havells Sylvania, GE, Radium, Auralight, Navra, BLV and Heraeus) 90% of all fluorescent lamps are reported to be recycled at the industrial level but only 10% at the household level. This is likely to remain an issue of concern due to the low payoff for collecting used bulbs, positioned alongside the overall relatively small proportion of mercury releases into the biosphere when compared to mercury emissions from incandescent lamps due to their higher electricity consumption and coal power generation (Welz et al, 2011). It is, however, likely to remain a concern for many consumers.

These non-price factors warn against reducing the decision to buy a CFL down to matters of price alone and explaining away consumers' choice to buy the more expensive option as simply 'irrational'. Individuals pursue a plurality of values which repeatedly can come into conflict and which may not be easily expressed in a common value – such as price. A consumer will weigh up matters relating to their personal aesthetic taste, motivation to address environmental issues as well as the function of light and unit cost when deciding to adopt CFLs.

Individuals may also express their values through different spheres of decision-making – for example, through their purchasing behaviour as consumers; and through voting behaviour, as citizens. Faced with such a plurality of desired outcomes and inherent path dependent and behavioural forces it is very unlikely that an analytic approach which sets the attainment of a single competitive equilibrium as its goal – as in the standard welfare approach -will capture the nature and drivers of technological change in play. Hence the imperative for an evolutionary economic approach which considers the institutional and behavioural barriers to adoption is crucial to understanding diffusion.

Conclusion: beyond 'freedom versus the state'

In this paper we have argued that the role of non-market-based instruments has been neglected in the mainstream standard welfare analysis of energy and climate policy, where the focus of research has concentrated on issues of 'optimality', 'least-cost mitigation' and

mechanisms for carbon pricing. Within this logic, 'regulation' has been given a bad name, generally labelled as a 'blunt' instrument, lacking dynamic incentives. This paper seeks to challenge this perspective by urging policy makers to consider looking beyond the parsimonious blinkers of equilibrium analysis to a richer evolutionary approach which brings into focus the normative political formation of market institutions themselves, as opposed to taking such institutions for granted.

In this area, research on behavioural anomalies has been influential focusing on those issues especially important when people make decisions under risk and uncertainty. This research program has gained momentum because of the implications it may have for understanding the nature and scope of individual rights and responsibilities in liberal democracies. The premise is that this deeper understanding into our behavioural biases may help policy makers design more effective solutions to societal problems and provide participants in the debate with a broader set of analytical tool for tackling big ticket issues such as 'freedom', 'democracy', 'general will' and 'social choice' which are all at play even for something as seemingly banal as a light-bulb ban.

For over a decade in Germany up until 2005 the level of CFL diffusion was stable and low. This was despite CFLs possessing significant advantages over incandescent lighting, the technology being available and the presence of numerous information and incentive-based initiatives. The major turning point in the diffusion of CFLs and the collapse of sales of incandescent lamps corresponds with a surge in public interest in CFLs off the back of the announcement and expectation of regulatory ban on incandescent lamps. While critics often point out that phasing out incandescent light bulbs does not make a big difference to overall electricity consumption, this step contributes to a long-term strategy to reduce electricity demand by 10% by 2020 and by 50% by 2050 based on 2008 levels. Although parts of the media condemned the policy, the evidence organised in this paper suggests the staged ban clearly resulted in substitutions of incandescent light bulbs with more efficient types.

Providing a regulatory lead period is also likely to have helped reduce the costs of switching to the new system of technology and behaviour by allowing supply chains to develop and by providing a clear signal to the market of the direction of technological change. While there were some demand side management schemes in place, it should be noted that this diffusion was achieved without artificially increasing the price of traditional lamps relative to CFLs or by taxing traditional bulbs which would be the usual *a priori* prescription of the standard welfare approach to encourage diffusion. If the European Commission's estimate that it would take a ten-fold increase in the price of traditional lamps is taken as a reference, the avoidance of these costs is substantial.

This study contributes to a broader research agenda reviewed by Clark and Urwin (2009) in economic geography generally and by Tietenberg (2010) in the energy efficiency and climate change literature to draw more strongly on evolutionary logic in the policy process. While of course there is a massive body of literature on freedom, the individual, society, law and the markets, much of this has been largely passed over by the equilibrium-based neoclassical viewpoint , and so a major aim of this paper is to point out the deficiencies of this approach and argue for a more evolutionary framework of analysis.

There is a rich vein of potential research in this area investigating comparative cases of electric lamp diffusion where countries have adopted regulatory bans, and where they have not as we move through this period of technological transition in the lighting market. It would be particularly interesting to evaluate the comparative effects of active government decision-making in this area (for example at the EU level) with non-decision making (although the number of countries without a ban in place is rapidly diminishing).

The implications of empirical studies which reveal the lack of take up of cost effective energy efficiency investments sit awkwardly with the notion of individual self-mastery which underpins many of the norms of regulation in liberal democratic states. These studies have provided a strong case for more structured government policy – and provided a policy flashpoint as pragmatic regulatory 'solutions', such as the ban on incandescent lamps, are implemented.

One way forward is to perhaps reframe this debate by re-injecting a sense of the political back into our understanding of what makes up the market. If regulation is seen as a learning process, played out as part of the democratic (or at least a consultative) process, with open and transparent collective decision making processes, then it is argued that regulation need not be viewed as a compromise to individual freedom, but rather a recognition that as human we have evolved a range of institutions to support collective action to achieve social goals – in this case increasing energy efficiency and reducing greenhouse gas emissions.

Public policy is replete with instances where individuals have chosen increased structure over laissez-faire in recognition of the broader social benefits of collective action – support for the welfare state, public health care and public infrastructure being the most obvious cases in point – not to mention the regulation of consumer 'public bads' such as smoking, alcohol or sexual or labour exploitation. These regulations are aimed at supporting public goods which are, in essence, the building blocks of a cohesive and productive society.

Indeed, we would go further to suggest that high-minded rhetoric about liberty and freedom is usually used as a smoke-screen to mask the real interests of those that are likely to lose economically from new regulation. Leaving 'things ' to the market is often a means of preventing something from happening.

In our example, if people have decided to try to reduce greenhouse gas emissions and voted for politicians with a mandate "to take action on climate change" or to "increase energy efficiency" then there seems to be a fairly clear role for the state to provide greater structure around the decision to buy light bulbs, which offer such obvious economic and environmental benefits. This should still hold despite observing the seemingly paradoxical actions of consumers who still want to purchase incandescent bulbs or even complain about the inferior light quality of CFLs. What is important in this case is the presence and strength of the political and social norm around climate change and the need to improve energy efficiency which legitimises the collective decision-making process.

To counter Rousseau's critique, this is not so much "forcing man to be free", but recognising that individuals over time have evolved collective decision-making institutions to reconcile situations involving conflicting individual values and where our desired or stated intentions may differ from our behaviour and actions.

This paper has also sought to show is that the political process itself is an important way in which society learns about and adapts its institutional structure. For example, public deliberation in Europe following the announcement of a ban on CFLs can be seen as having had a significant impact on diffusion in advance of the announcement and implementation of the EU's own ban. Support for the formation of such social learning is vital because if the shift to a low carbon economy is to truly take place, it will not be because of the implementation of an emissions trading scheme, or even regulatory bans on specific technologies, but because the foundation of social norms on the issue have shifted - people's attitudes towards the environment, the economy and their sense of responsibility regarding greenhouse gas pollution.

Bibliography

Aman M M, Jasmon G B, Mokhlis H and Bakar A H A, 2013 "Analysis of the performance of domestic lighting lamps" *Energy Policy* 52: 482-500

Arthur W B, 1994 *Increasing returns and path dependence in the economy* (University of Michigan Press, Ann Arbor)

Baron J, 2008 *Thinking and deciding* 4th Edition (Cambridge University Press, Cambridge)

Baumol W 1972 "On taxation and the control of externalities" *American Economic Review* **62:3** 307-322

BBC (2007) Switch off for traditional bulbs. Online: http://news.bbc.co.uk/1/hi/uk/7016020.stm [accessed 01/11/2013]

Bertoldi P and Atanasiu B, 2007 *Residential lighting consumption and saving potential in the enlarged EU* a report prepared for the European Commission (DG Joint Research Centre, Institute for Environment and Sustainability, Brussels)

Bittner, J 2009 Ein Schlag auf die Birne. Die Zeit 36. Online: http://www.zeit.de/2009/36/Gluehbirne [accessed 01/11/2013]

Bladh M and Krantz H, 2008 "Towards a bright future? Household use of electric light: a micro-level study" *Energy Policy* **36:9** 3521-3530

Blumstein C, Goldstone S, and Lutzenhiser L, 2000 "A theory-based approach to market transformation" *Energy Policy* **28:2** 137-144

Brohé A, Eyre N, and Howarth N A A, 2009 *Carbon markets: An international business guide* (Earthscan/James and James, London)

Bross M and Pirgov A, 2010 "Do new types of Energy Saving Lamps change the markets?" in *Energy Efficiency in Domestic Appliances and Lighting* eds. Bertoldi P and Werle R Proceedings of the 5th International Conference Volume 2 (EEDAL'09 16-18 June, Berlin, Germany)

Campbell D T, 1963 "Social attitudes and other acquired behavioural dispositions" in Koch S (ed.) *Psychology: a study of science* **6** 94-172 (New York: McGraw-Hill)

Carraro C, 2007 "Incentives and Institutions. A Bottom-up Approach to Climate Policy" *Working Paper Department of Economics* (University of Venice, Venice)

Clark G L and Urwin R, 2009 "A resource-based approach to pension-fund governance" *Working Paper, Oxford University Centre for Work, Employment and Finance* (Oxford University School of Geography and Environment, Oxford)

Clayton S and Brook A, 2005 "Can psychology help save the world? A model for conservation psychology" *Analyses of Social Issues and Public Policy* **5:1** 87-102

Costantini V and Crespi F, 2007 "Environmental regulation and the export dynamics of energy technologies" *Ecological Economics* **66** 447- 460

Czakainski, M. 1993. Energiepolitik in der Bundesrepublik Deutschland 1960 bis 1980 im Kontext der außenwirtschaftlichen und außenpolitischen Verflechtungen. In: Hohensee, J. & Salewski, M. (eds.) Energie - Politik - Geschichte: nationale und internationale Energiepolitik seit 1945. Stuttgart: Steiner.

David P A, 1985 "Clio and the economics of QWERTY" *American Economic Review* **75** 332-337

DeCanio S J, 1998 "The efficiency paradox: Bureaucratic and organizational barriers to profitable energy-saving investments" *Energy Policy* **26:5** 441–54

DEFRA, 2007. Energy guzzling lightbulbs phase out to start next year. Online: http://webarchive.nationalarchives.gov.uk/20130123162956/http:/www.defra.gov.uk/news/2007/070927a.htm [accessed 01/11/2013]

Delbeke J, Kaassen G, van lerland T and Zapfel P, 2010 "The role of environmental economics in recent policy making at the European Commission" *Review of Environmental Economics and Policy* **4:1** 24-43

Düngen, H. 1993. Zwei Dekaden deutscher Energie- und Umweltpolitik: Leitbilder, Prinzipien und Konzepte. In: Hohensee, J. & Salewski, M. (eds.) Energie - Politik - Geschichte: nationale und internationale Energiepolitik seit 1945. Stuttgart: Steiner.

Eagly A H and Chaiken S, 1993 *The psychology of attitudes* (Harcourt Brace Jovanovich, Fort Worth, Texas)

Eichhammer, W., Schlomann, B. & Kling, N. 2006. Energy Efficiency Policies and Measures in Germany 2006. Karlsruhe: Fraunhofer Institute for Systems and Innovation Research.

Eyre, N, 1997. Barriers to energy efficiency more than just market failure. *Energy and Environment*, 8 25-43

EUROPA, 2009 *Frequently asked questions about the regulation on ecodesign requirements for non-directional household lamps*, Press Release 18 March 2009, Brussels

European Commission, 2009 *European lamps become more energy efficient* Director-General for Energy and Transport, European Commission, Brussels

Fischer C, 2008 "Feedback on household electricity consumption: a tool for saving energy?" *Energy Efficiency* **1:1** 79-104

Frantz C M and Mayer F S, 2009 "The emergency of climate change: why are we failing to take action" *Analyses of Social Issues and Public Policy* **9:1** 205-222

Fraunhofer ISI, 2006 *Energy efficiency policies and measures in Germany* (Fraunhofer Institute for Systems and Innovation Research, Karlsruhe, Germany)

Geller S E, 2002 "The challenge of increasing proenvironment behaviour" in Bechtel R B and Churchman A (eds.) *The Handbook of Environmental Psychology* (John Wiley and Sons: New York)

Gigerenzer G, 2003 "The irrationality paradox" *Behavioural and Brain Sciences* **27:3** 336-38

Gillingham K, Newell R G, Palmer K, 2004 *Retrospective examination of demand-side energy efficiency policies* Discussion Paper 04–19, June, rev. Sept (Resources for the Future, Washington D.C.)

Grass Roots, 2009 *Abschied von der Glühlampe* (Düsseldorf, Germany)

Hazilla M and Kopp R, 1990 "Social cost of environmental regulations: a general equilibrium analysis" *Journal of Political Economy* **98:4** 853-73

Häusler, J. 1991. Energiepolitik. In: Nohlen, D. (ed.) Wörterbuch Staat und Politik. München: Piper.

Hengst B, 2007 "Grüne sagen Glühlampen den Kamf an" *Der Spiegel,* 20 February.

Horbach J, 2007 "Determinants of environmental innovation: new evidence from German panel data sources" *Research Policy* **37:10** 163-173

Howarth R B and Anderson B, 1993 "Market Barriers to Energy efficiency" *Energy Economics* **15:4** 262-272

Howarth R B and Sanstad A H, 1995 "Discount Rates and Energy Efficiency" *Contemporary Economic Policy* **13** 101-109

IPCC, 2007 *Fourth Assessment Report* Intergovernmental Panel to the Convention on Climate Change, Working Group 3 (World Meteorological Organisation and the United Nations Environment Program, Geneva)

Jacob, B, 2009 "Lamps for improving the energy efficiency of domestic lighting". *Lighting Research and Technology* 41: 219–228.

Jaffe, A. B. and Stavins, R. N. (1993) "The energy paradox and the diffusion of conservation technology", *Resource and Energy Economics*, 16: 19-122.

Jorgenson D W and Wilcoxen P J, 1990 "Environmental Regulation and US Economic Growth" *Rand Journal of Economics* **21:2** 314-40

Kahneman D, Slovic P and Tversky A 1982 *Judgement under uncertainty: heuristics and biases* (Cambridge University Press, Cambridge)

Kaiser F G, Midden C and Cervinka R, 2008 "Evidence for a Data-Based Environmental Policy: Induction of a Behaviour-Based Decision Support System" *Applied Psychology* **57:1** 151-172

Kaiser, F. G., T. Hartig, and K. Byrka, (2009), 'Reviving Campbell's paradigm for attitude research' *Personality and Social Psychology Review* **14:4** 351-367

Klag, N. D. 2003. Die Liberalisierung des Gasmarktes in Deutschland, Marburg, Tectum.

Kriechel B and Ziesemer T, 2009 "The environmental Porter hypothesis: theory, evidence, and a model of timing of adoption" *Economics of Innovation and New Technology* **18:3** 267-294

Kruger J I and Funder D C, 2004 “Towards a balanced social psychology: causes consequences, and cures for the problem seeking approach to social behaviour and cognition” *Behavioural Brain Sciences* **27:3** 313-27

Lanoie P, Patry M and Lajeunesse R, 2008 “Environmental regulation and productivity: testing the Porter hypothesis” *Journal of Productivity Analysis* **30:2** 121-128

McCloskey, D. N. (1998) The Rhetoric of Economics, University of Wisconsin Press, 2nd edition.

Mez, L. 2003. Energiepolitik. In: Andersen, U. & Woyke, W. (eds.) Handwörterbuch des politischen Systems der Bundesrepublik Deutschland. Opladen: Leske+Budrich.

Michaelis, H. 1993. Die Energiepolitik in der Bundesrepublik Deutschland 1970 bis 1990. In: Hohensee, J. & Salewski, M. (eds.) Energie - Politik - Geschichte: nationale und internationale Energiepolitik seit 1945. Stuttgart: Steiner.

MURE Database, *Measures d’utilisation rationelle de l’énergie* www.mure2.com Intelligent Energy Programme of the European Commission

Nordhaus W 2007 “To tax or not to tax: Alternative approaches to slowing global warming” *Review of Environmental Economics and Policy* **1:1** 26–44

Olson M, 1965 *The Logic of Collective Action* (Harvard University Press, Cambridge, MA)

Oxford Analytica 2009 ‘International: Behavioural economics charts new course’, *Daily Brief*, June 2, 2009, Oxford.

Palmer J and Boardman B 1998 *DELight Domestic Efficient Lighting* Final Report, Energy and Environment Programme (Environmental Change Institute, University of Oxford, Oxford)

Palmer K, Oates W E and Portney P R, 1995 “Tightening environmental standards: the benefit cost or the no-cost paradigm” *Journal of Economic Perspectives* **9:4** 119-132

Perez-Guerrero, M, 1975 “Energy, styles of life, and distributive justice” *Journal of Energy and Development* 38-44

Pigou A C, 1912 *Wealth and Welfare* (Macmillan, New York)

Porter M E and van der Linde C, 1995 “Toward a new conception of the environment-competitiveness relationship” *Journal of Economic Perspectives* **9:4** 97-118

Reiche, D. T. (ed.) 2005. Grundlagen der Energiepolitik, Frankfurt am Main: Lang.

Reuters (2007). EU leaders to make Europe change lightbulbs. Online: http://www.reuters.com/article/2007/03/09/dcbrights-energy-eu-lightbulbs-dc-idUSL0966634620070309 [accessed 01/11/2013]

Schäfer D, 2009 “Germans fail to see the light on bulbs” *Financial Times*, August 22, 2009

Shogren J F and Taylor L O, 2008 “On behavioral-environmental economics” *Review of Environmental Economics and Policy* **2:1** 26–44

Simon H A, 1957 *Administrative behavior: A study of decision-making processes in administrative organization* (MacMillan, New York)

Simon H A, 1991 "Organisations and markets" *Journal of Economic Perspectives* **5:2** 25-44

Sorrell S, O'Malley E, Schleich J and Scott S, 2004 *The economics of energy efficiency: barriers to cost-effective investment* (Edward Elgar, Cheltenham)

Steg L and Vlek C, 2009 "Encouraging pro-environmental behaviour: An integrative review and research agenda" *Journal of Environmental Psychology* **29:3** 309-317

Steg L and Gifford R, 2005 "Sustainable transport and quality of life" *Journal of Transport Geography* **13:1** 59-69

Stern N, 2006 *The Economics of Climate Change* The Stern Review (Cambridge University Press Cambridge UK)

Stern P, 2000 "Psychology and the science of human-environment interactions" *American Psychologist* **55:5** 523-530

Teitenberg T, 2010 "Reflections – Energy efficiency policy: pipe dream or pipeline to the future" *Review of Environmental Economics and Policy* **3:2** 304-320

Unruh G C, 2000 "Understanding carbon lock-in" *Energy Policy* **28** 817-830

Unruh G C, 2002 "Escaping carbon lock-in" *Energy Policy* **30** 317-325

Unruch G C, 2006 "Globalising carbon lock-in" *Energy Policy* **34** 1185-1197

Van Lange P A M and Joireman J A, 2008 "How we can promote behaviour that serves us all in the future" *Social Issues and Policy Review* **2:1** 127-157

Victor D G, 2007 "Fragmented carbon markets and reluctant nations: implications for the design of effective architectures" in *Architectures for Agreement: Addressing Global Climate Change in the Post-Kyoto World* Resources for the Future (Cambridge University Press, Cambridge)

Vito, 2009 "Final Report: Lot 19 Domestic Lighting, Prepatory Studies for Eco-Design Requirements of EUPs" Study for the European Commission (DGTREN, Brussels)

Waide, P, 2007. Global Efforts to Phase-Out Incandescent Lamps. IEA Open Energy Technology Bulletin Issue 45, October 2007

Williams S and Baumert K, 2003 *Institutional Capacity and Climate Actions* (OECD, Paris)

Weitzman M L, 1974 "Prices versus quantities" *Review of Economic Studies* **41:4** 477–491

Welz T, Hischier R and Hilty L M, 2011 "Environmental impacts of lighting technologies — Life cycle assessment and sensitivity analysis" *Environmental Impact Assessment Review* 31:3 334-343